

FUNDAMENTALS OF STRUCTURAL ANALYSIS

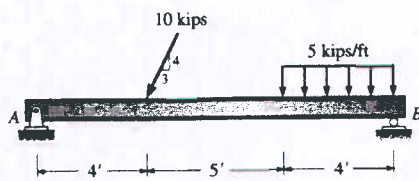
3rd Edition

Kenneth M. Leet, Chia-Ming Uang, and Anne M. Gilbert

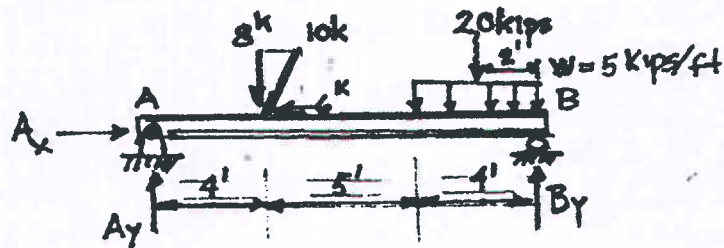
SOLUTIONS MANUAL

CHAPTER 3: STATICS OF STRUCTURES- REACTIONS

P3.1 Determine the reactions for the structure.



P3.1

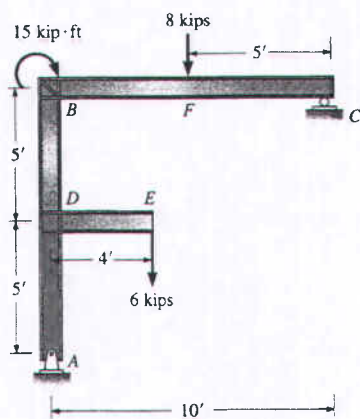


$$\begin{aligned} \sum M_A &= 0; \\ 8^k(4') + 20^k(11') - B_y(13') &= 0 \\ \underline{B_y = 19.38 \text{ kips} \uparrow} \end{aligned}$$

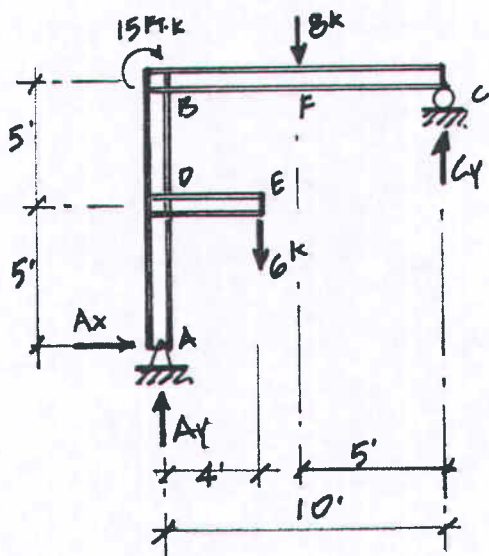
$$\begin{aligned} \sum F_x &= 0; \\ A_x - 6^k &= 0 \\ \underline{A_x = 6^k \rightarrow} \end{aligned}$$

$$\begin{aligned} \sum F_y &= 0; \\ A_y - 8^k - 20^k + 19.38^k &= 0 \\ \underline{A_y = 8.62^k \uparrow} \end{aligned}$$

P3.2 Determine the reactions for the structure.



P3.2



$$\sum \curvearrowleft M_A = 0;$$

$$15 \text{ k}\cdot\text{ft} + 8 \text{ k}(5') + 6 \text{ k}(4') - C_y(10') = 0$$

$$\underline{C_y = 8.5 \text{ k} \uparrow}$$

$$\sum F_y = 0;$$

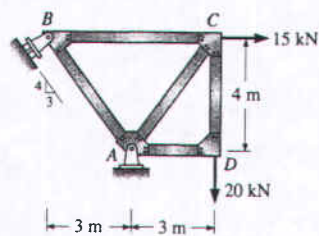
$$-8 \text{ k} - 6 \text{ k} + 8.5 \text{ k} + A_y = 0$$

$$\underline{A_y = 5.5 \text{ k} \uparrow}$$

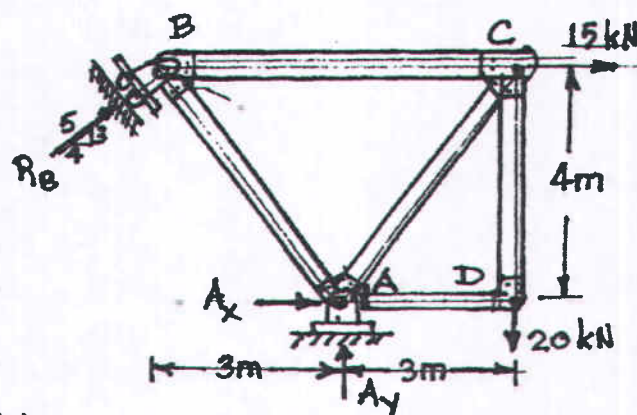
$$\sum F_x = 0;$$

$$\underline{A_x = 0}$$

P3.3 Determine the reactions for the structure.



P3.3



$$\begin{aligned} \curvearrowright + \\ \Sigma M_A = 0; \quad R_B 5_m + 15^{kN}(4_m) + 20^{kN}(3_m) = 0 \\ R_B = \underline{\underline{-24 \text{ kN}}} \end{aligned}$$

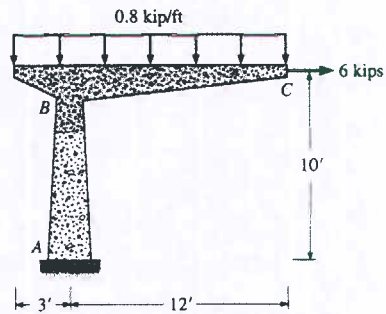
$$\frac{R_{Bx}}{4} = \frac{R_{By}}{3} = \frac{24}{5}$$

$$R_{Bx} = \underline{\underline{19.2 \text{ kN}}}; \quad R_{By} = \underline{\underline{14.4 \text{ kN}}}$$

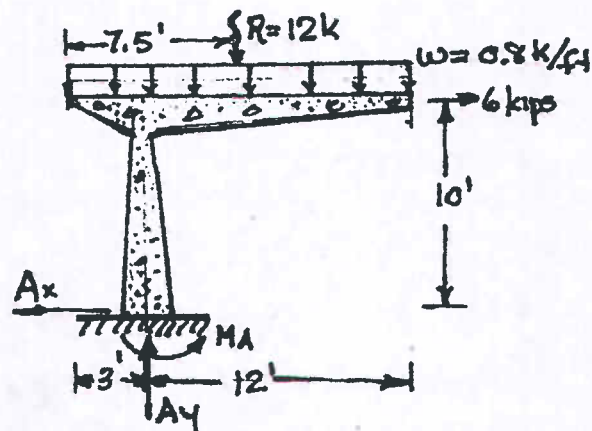
$$\begin{aligned} \rightarrow + \\ \Sigma F_x = 0; \quad 15^{kN} - 19.2^{kN} + A_x = 0 \\ \underline{\underline{A_x = 4.2 \text{ kN}}} \rightarrow \end{aligned}$$

$$\begin{aligned} + \\ \Sigma F_y = 0; \quad -14.4^{kN} + A_y - 20^{kN} = 0 \\ \underline{\underline{A_y = 34.4 \text{ kN}}} \uparrow \end{aligned}$$

P3.4 Determine the reactions for the structure.



P3.4



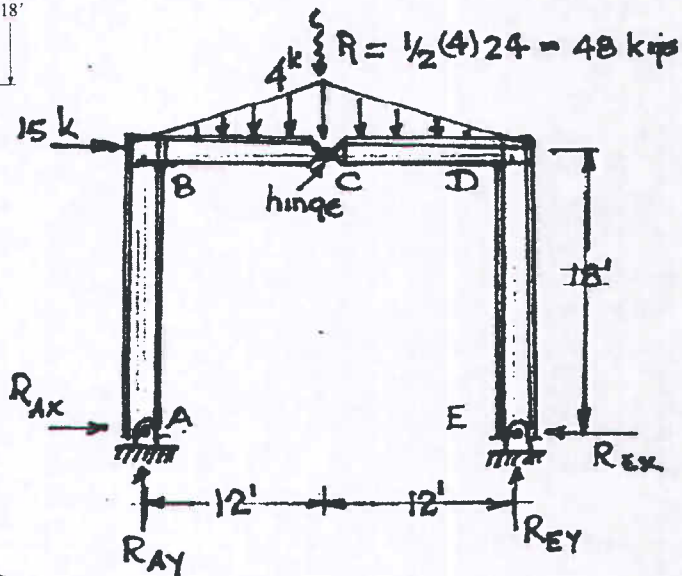
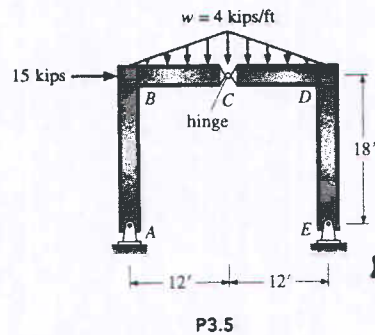
$$\rightarrow + \quad \sum F_x = 0; \quad 6 - A_x = 0 \quad \underline{A_x = 6 \text{ kips} \leftarrow}$$

$$+ \uparrow \sum F_y = 0; \quad A_y - 12 = 0 \quad \underline{A_y = 12 \text{ kips} \uparrow}$$

$$\curvearrowright \sum M_A = 0; \quad 12^k(15-3) + 6^k(10) - M_A = 0$$

$$\underline{M_A = 114 \text{ kip}\cdot\text{ft} \curvearrowright}$$

P3.5 Determine the reactions for the structure.



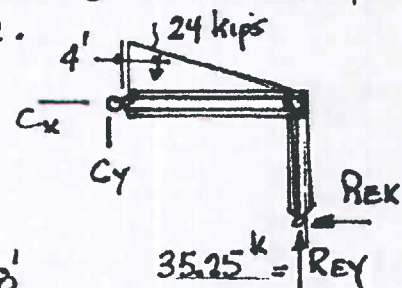
$$\sum M_A = 0; 15 \times 18' + 48 \times 12' - R_{Ey} \times 24' = 0$$

$$R_{Ey} = 35.25 \text{ kips} \uparrow$$

$$\sum F_y = 0; R_{Ay} + R_{Ey} - 48 \text{ k} = 0$$

$$R_{Ay} = 48 \text{ k} - R_{Ey} = 12.75 \text{ kips} \uparrow$$

COMPUTE R_{Ex} . CONSIDER FREEBODY TO RIGHT OF C.



$$\sum M_C = 0; 24 \times 4' + R_{Ex} \times 18' - 35.25 \times 12 = 0$$

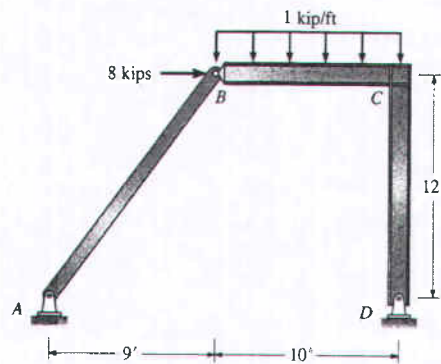
$$R_{Ex} = 18.167 \text{ kips} \leftarrow$$

COMPUTE R_{Ax} ; $\sum F_x = 0$ (SEE TOP FIG)

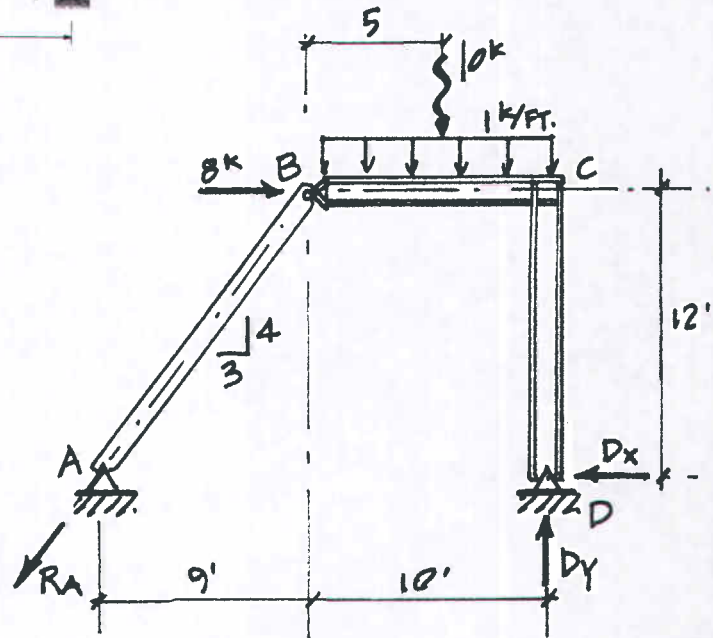
$$R_{Ax} + 15 \text{ k} - R_{Ex} = 0$$

$$R_{Ax} = 18.167 \text{ k} - 15 \text{ k} = 3.167 \text{ kips} \rightarrow$$

P3.6 Determine the reactions for the structure.



P3.6



$$+\circlearrowleft \sum M_A = 0 ; 8 \times 12 + 10 \times 14 - D_y(19) = 0$$

$$\underline{D_y = 12.42 \text{ kips} \uparrow}$$

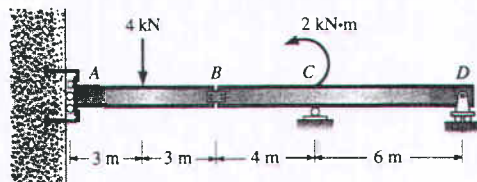
$$+\uparrow \sum F_y = 0 ; \frac{4}{5}(-R_A) + 12.42 - 10 = 0$$

$$\underline{R_A = 3.025 \text{ kips} \downarrow}$$

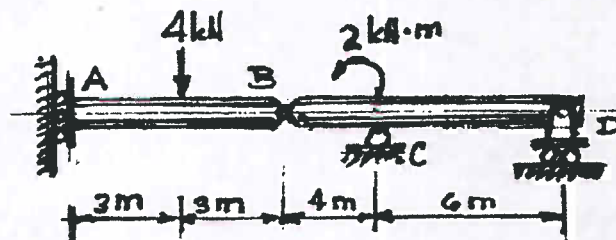
$$+\rightarrow \sum F_x = 0 ; \frac{3}{5}(-3.025) - D_x + 8 = 0$$

$$\underline{D_x = 6.185 \text{ kips} \leftarrow}$$

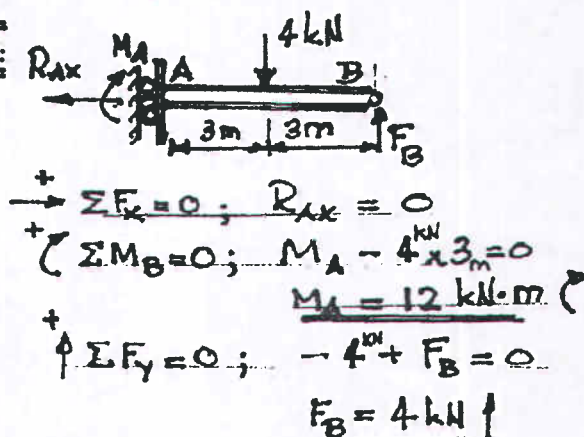
P3.7. The support at A prevents rotation and horizontal displacement, but permits vertical displacement. The shear plate at B is assumed to act as a hinge. Determine the moment at A and the reactions at C and D.



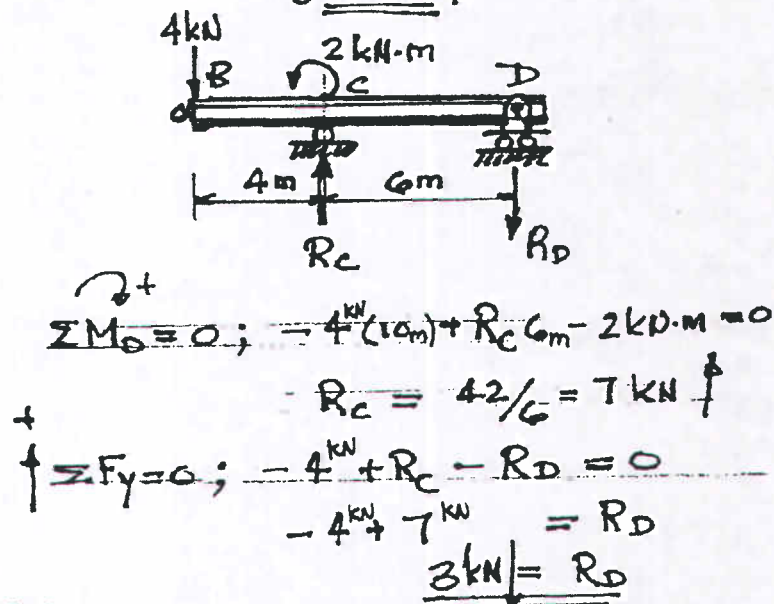
P3.7



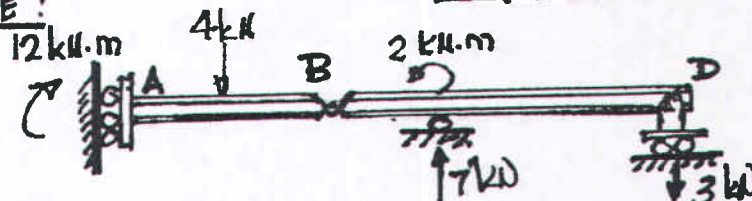
FREE BODY OF MEMBER "AB":



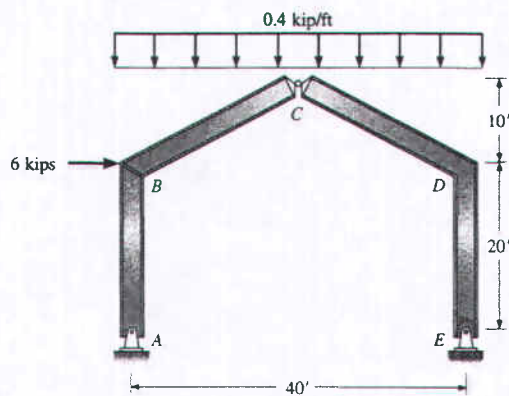
FREE BODY OF MEMBER "BD":



ENTIRE STRUCTURE:

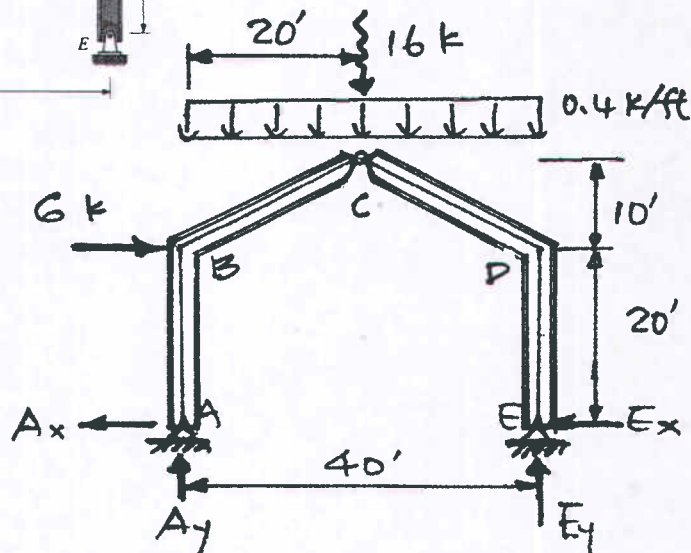


P3.8 Determine the reactions for the structure.
All dimensions are measured from the centerlines of members.



P3.8

ENTIRE STRUCTURE:



$$+\circlearrowleft \sum M_A = 0; 16^k(20') + 6^k(20') - E_y(40') = 0$$

$$E_y = 11 \text{ kips} \uparrow$$

$$+\uparrow \sum F_y = 0;$$

$$A_y + 11^k - 16^k = 0$$

$$A_y = 5 \text{ kips} \uparrow$$

FREE BODY
RIGHT SIDE OF
HINGE @ 'C':

$$+\circlearrowleft \sum M_C = 0;$$

$$8^k(10') - 11^k(20') + E_x(30') = 0$$

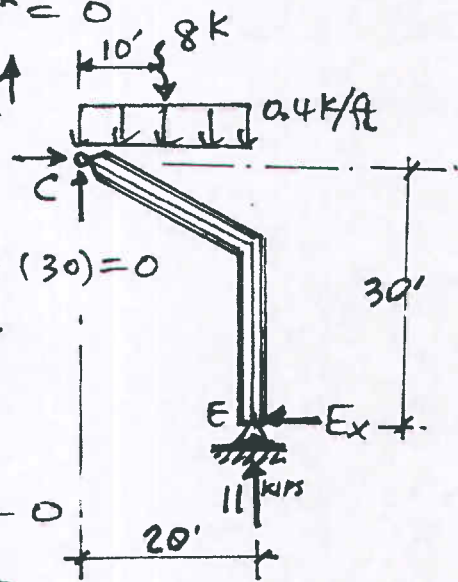
$$E_x = 4.67 \text{ kips} \leftarrow$$

ENTIRE STRUCTURE

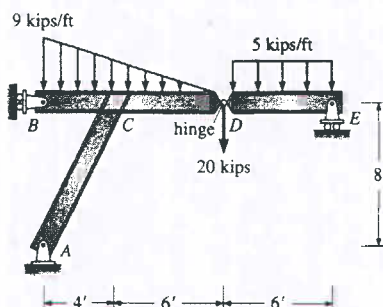
$$+\rightarrow \sum F_x = 0;$$

$$6^k - 4.67^k - A_x = 0$$

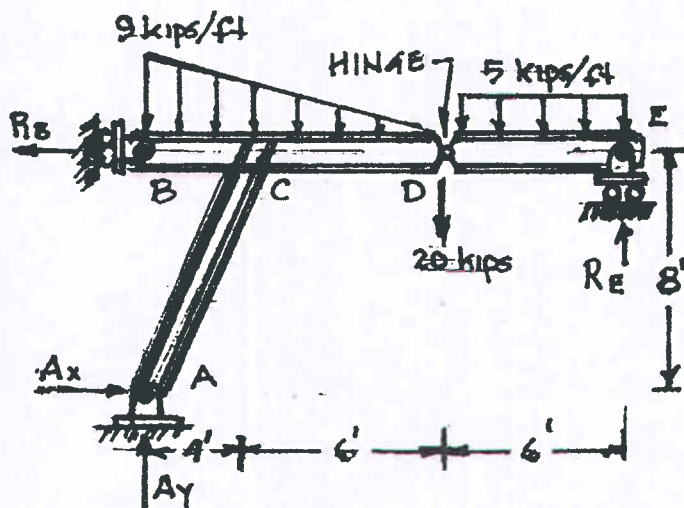
$$A_x = 1.33 \text{ kips} \leftarrow$$



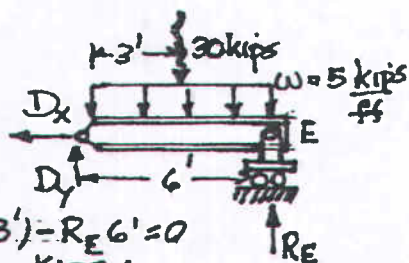
P3.9 Determine the reactions for the structure.
All dimensions are measured from the centerlines
of members.



P3.9



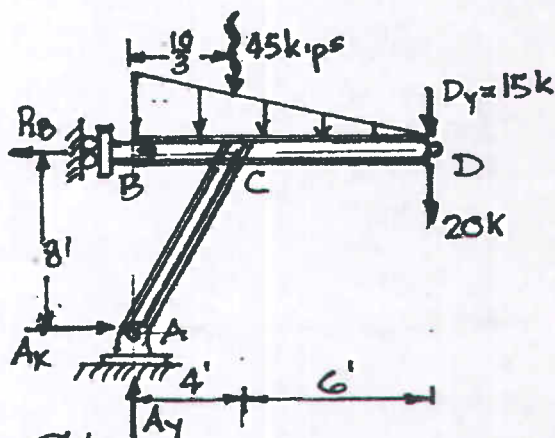
FREEBODY DIAGRAM RIGHT OF HINGE D:



$$\begin{aligned} \sum M_D = 0; & \quad 30^k(3') - R_E(6') = 0 \\ & \quad R_E = 15 \text{ kips} \uparrow \end{aligned}$$

$$\begin{aligned} \sum F_y = 0; & \quad D_y - 30^k + R_E^{15^k} = 0 \\ & \quad D_y = 15 \text{ kips} \uparrow \end{aligned}$$

FREEBODY DIAGRAM LEFT OF HINGE:

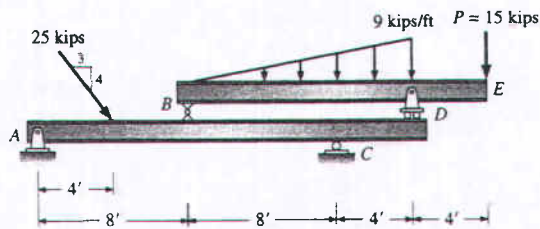


$$\begin{aligned} \sum M_A = 0; & \quad -R_B(8') + 45^k(10/3) + 35^k(10') = 0 \\ & \quad R_B = 62.5 \text{ kips} \leftarrow \end{aligned}$$

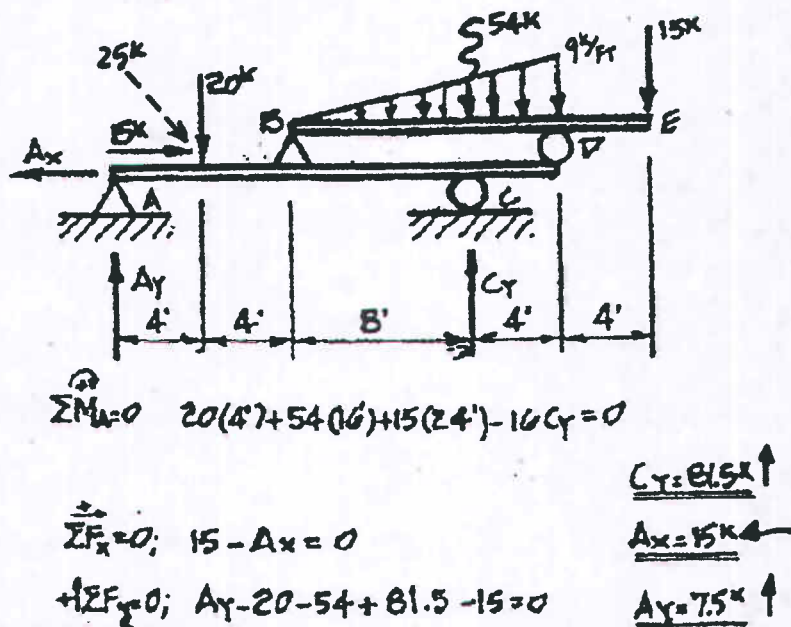
$$\begin{aligned} \sum F_x = 0; & \quad A_x - R_B = 0 \\ & \quad A_x = 62.5 \text{ kips} \rightarrow \end{aligned}$$

$$\begin{aligned} \sum F_y = 0; & \quad A_y - 45^k - 15^k - 20^k = 0 \\ & \quad A_y = 80 \text{ kips} \uparrow \end{aligned}$$

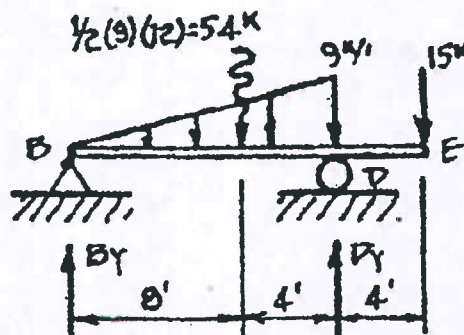
P3.10 Determine the reactions for the structure.
All dimensions are measured from the centerlines of members.



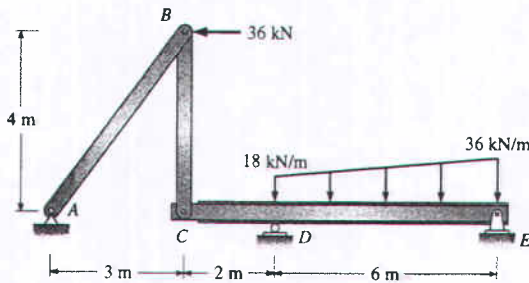
P3.10



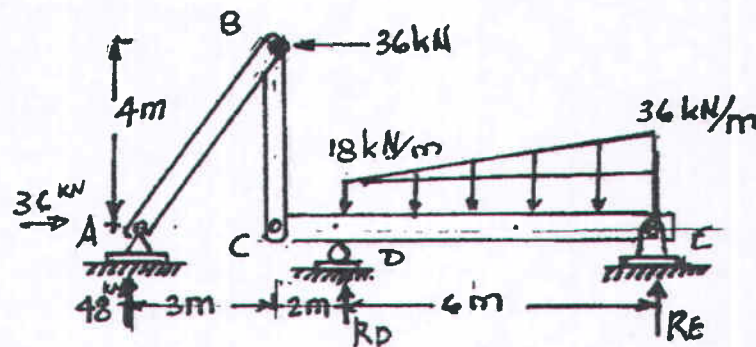
ISOLATE MEMBER BE



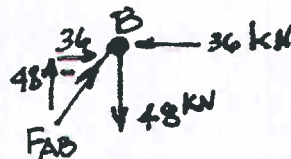
P3.11. Determine all reactions. The pin joint at C can be treated as a hinge.



P3.11



JOINT B

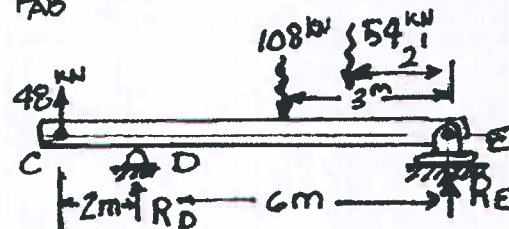


$$\sum F_x = 0; F_{ABx} - 36 \text{ kN} = 0$$

$$F_{ABx} = 36 \text{ kN} \rightarrow F_{AB} = \frac{4}{3}(36 \text{ kN})$$

$$F_{AB} = 48 \text{ kN} \uparrow$$

Bm CDE



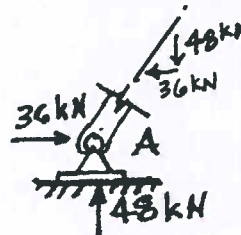
$$\sum M_D = 0; 48 \text{ kN}(2 \text{ m}) + 108 \text{ kN}(3 \text{ m}) + 54 \text{ kN}(4 \text{ m}) - R_E(6 \text{ m}) = 0$$

$$R_E = 106 \text{ kN} \uparrow$$

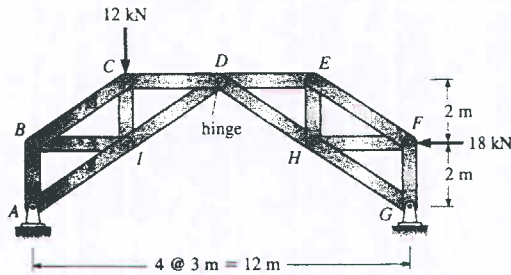
$$\sum F_y = 0; 48 \text{ kN} + R_D - 108 \text{ kN} - 54 \text{ kN} + 106 \text{ kN} = 0$$

$$R_D = 8 \text{ kN} \uparrow$$

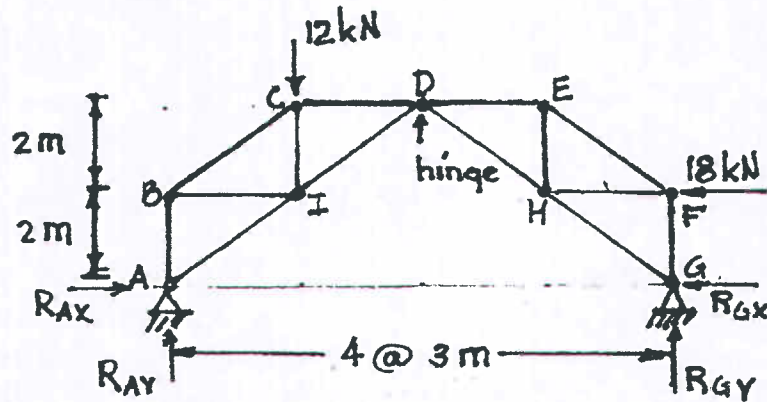
JOINT A



P3.12. Determine all reactions. The pin joint at D acts as a hinge.



P3.12



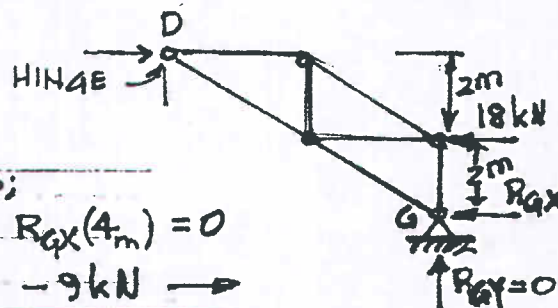
ENTIRE STRUCTURE:

$$\sum M_A = 0; \quad 12^{\text{kN}} \times 3\text{m} - 18^{\text{kN}} \times 2\text{m} - R_{GY} \times 12\text{m} = 0$$

$$\underline{\underline{R_{GY} = 0}}$$

$$\sum F_y = 0; \quad R_{AY} - 12 = 0 \quad \therefore \underline{\underline{R_{AY} = 12\text{ kN}}}$$

FREE BODY DIAGRAM RIGHT SIDE OF HINGE @ :



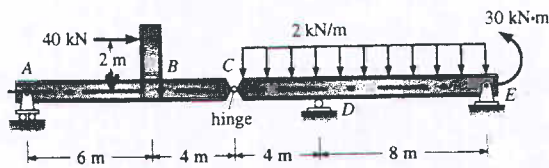
$$\sum M_D = 0; \quad -18^{\text{kN}}(2\text{m}) + R_{GX}(4\text{m}) = 0$$

$$\underline{\underline{R_{GX} = -9\text{ kN} \rightarrow}}$$

$$\sum F_x = 0; \quad R_{AX} + R_{GX} - 18^{\text{kN}} = 0$$

$$\underline{\underline{9\text{ kN} = R_{AX}}}$$

P3.13. Determine the reactions at all supports and the force transmitted through the hinge at C.



P3.13

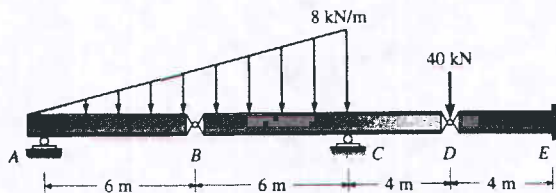
FBD MBR 'AC':

$\sum M_C = 0; 40 \times 2 - R_A \times 10 = 0 \quad R_A = 8 \text{ kN} \downarrow$
 $\sum F_x = 0; 40 \text{ kN} - C_x = 0 \quad C_x = 40 \text{ kN} \leftarrow$
 $\sum F_y = 0; -8 + C_y = 0; C_y = 8 \text{ kN} \uparrow$

FBD MBR 'CE':

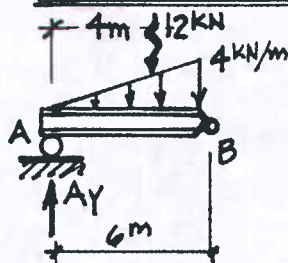
$\sum M_D = 0; 2 \times 24 - 30 - 8 \times 4 - R_{Ey} \times 8 = 0$
 $8 R_{Ey} = 48 - 30 - 32$
 $R_{Ey} = -\frac{14}{8} = -1.75 \text{ kN} \downarrow$
 $\sum F_y = 0; -8 + R_D - 24 - 1.75 = 0$
 $R_D = 33.75 \text{ kN} \uparrow$
 $\sum F_x = 0; 40 \text{ kN} - R_{Ex} = 0 \quad R_{Ex} = 40 \text{ kN} \leftarrow$

P3.14. Determine the reactions at supports A, C, and E.



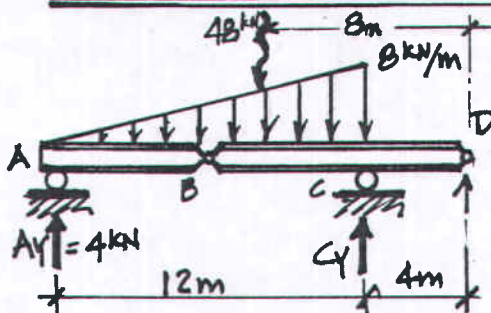
P3.14

FREEBODY DIAGRAM MBR AB



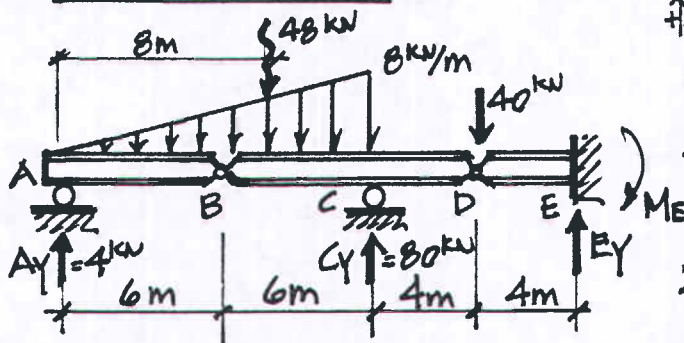
$$\begin{aligned}\sum M_B &= 0; \\ -12\text{ kN}(2\text{ m}) + A_y(6\text{ m}) &= 0 \\ \underline{A_y = 4\text{ kN} \uparrow}\end{aligned}$$

FREEBODY DIAGRAM MBR AD



$$\begin{aligned}\sum M_D &= 0; \\ -48\text{ kN}(8\text{ m}) + 4\text{ kN}(16\text{ m}) + C_y(4\text{ m}) &= 0 \\ \underline{C_y = 80\text{ kN} \uparrow}\end{aligned}$$

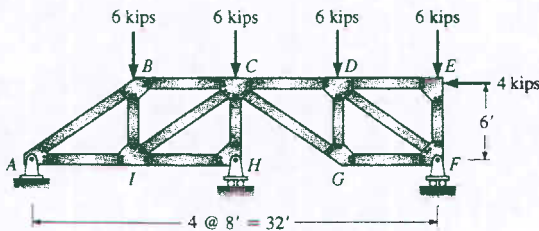
ENTIRE STRUCTURE



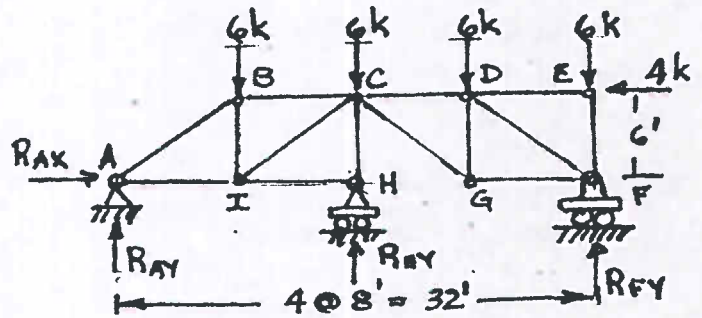
$$\begin{aligned}\sum F_y &= 0; \\ 4\text{ kN} + 80\text{ kN} + E_y - 48\text{ kN} - 40\text{ kN} &= 0 \\ \underline{E_y = 4\text{ kN} \uparrow}\end{aligned}$$

$$\begin{aligned}\sum M_E &= 0; \\ 4\text{ kN}(20\text{ m}) + 80\text{ kN}(8\text{ m}) - 48\text{ kN}(12\text{ m}) \\ - 40\text{ kN}(4\text{ m}) + M_E &= 0 \\ \underline{M_E = 16\text{ kN}\cdot\text{m} \curvearrowright}\end{aligned}$$

P3.15. Determine all reactions. Joint C can be assumed to act as a hinge.



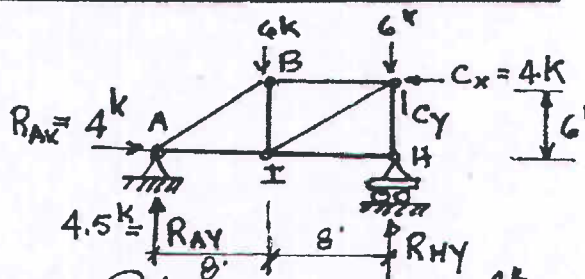
P3.15



ENTIRE STRUCTURE, COMPUTE R_{Ax} :

$$\sum F_x = 0; \quad R_{Ax} - 4 = 0 \quad \underline{R_{Ax} = 4 \text{ kips}}$$

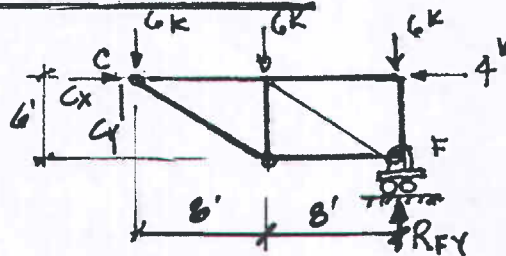
FREE BODY DIAGRAM LEFT OF "C":



$$\sum M_C = 0; \quad R_{Ay}(16) - R_{Ax}(6) - 6(8) = 0 \quad \underline{R_{Ay} = 4.5 \text{ kips} \uparrow}$$

$$\sum F_x = 0; \quad 4 - C_x = 0 \quad \underline{C_x = 4 \text{ kips} \leftarrow}$$

FREEBODY DIAGRAM RIGHT OF "C":

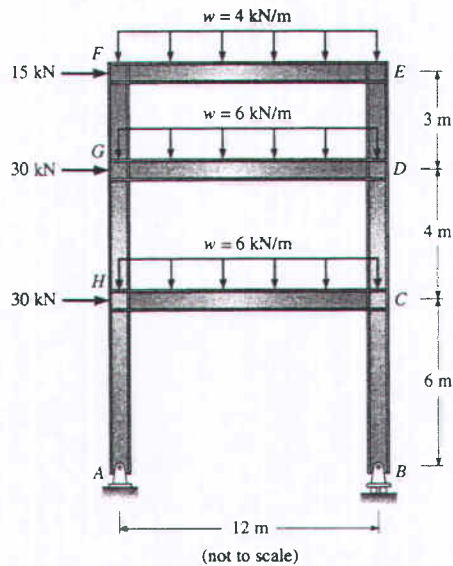


$$\sum M_C = 0; \quad (6)(8) + (6)(16) - R_{Fy}(16) = 0 \quad \underline{R_{Fy} = 9 \text{ kips} \uparrow}$$

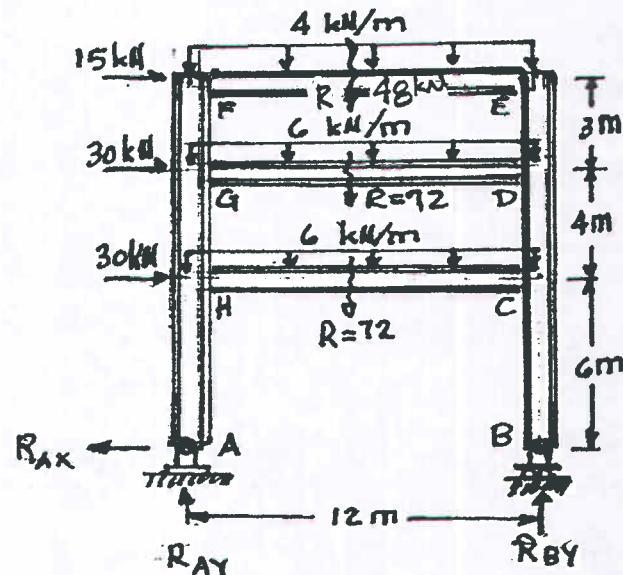
COMPUTE R_{Hy} USING ENTIRE TRUSS

$$\sum F_y = 0; \quad -6(4) + 4.5 + R_{Hy} + 9 = 0 \quad \underline{R_{Hy} = 10.5 \text{ kips} \uparrow}$$

P3.16. Determine all reactions. The uniform load on all girders extends to the centerlines of the columns.



P3.16

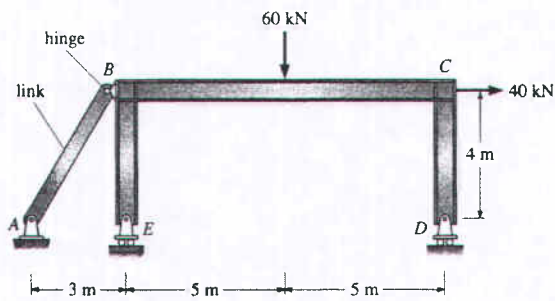


$$\begin{aligned} \rightarrow + \quad \Sigma F_x &= 0; \quad 15 + 30 + 30 - R_{AX} = 0 \\ R_{AX} &= 75 \text{ kN} \leftarrow \\ \curvearrow + \quad \Sigma M_A &= 0; \quad 30 \times 6 + 30 \times 10 + 15 \times 13 \text{ m} \\ &\quad + 72 \times 4 + 72 \times 6 + 48 \times 6 - 12 R_{BY} = 0 \end{aligned}$$

$$R_{BY} = 152.25 \text{ kN} \uparrow$$

$$\begin{aligned} \uparrow + \quad \Sigma F_y &= 0; \quad 152.25 - (72 + 72 + 48) + R_{AY} = 0 \\ R_{AY} &= 39.75 \text{ kN} \uparrow \end{aligned}$$

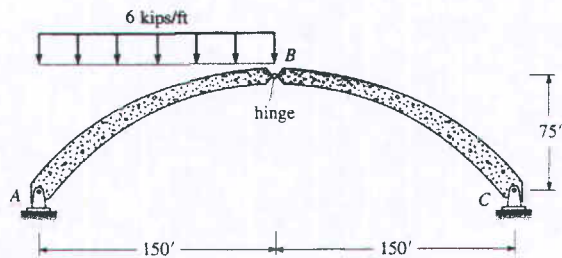
P3.17 Determine all reactions.



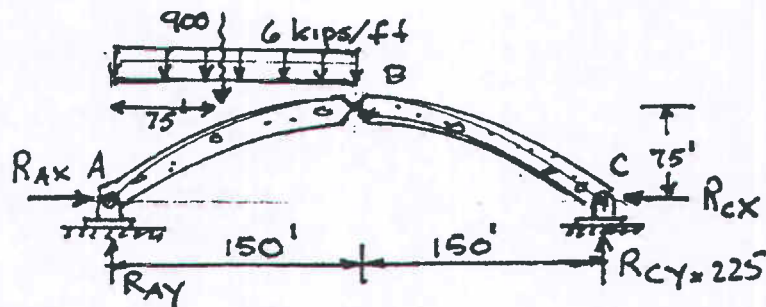
P3.17

$$\begin{aligned} \sum F_x = 0 &= 40 \text{ kN} - A_x \text{ and } \underline{A_x = 40 \text{ kN}} \\ \frac{A_x}{3} &= \frac{A_y}{4} \therefore A_y = \frac{4}{3} A_x = \frac{4}{3} (40) = 53.33 \text{ kN} \\ \sum M_B = 0 &= -60(5) - D_y(10) \\ D_y &= 30 \text{ kN} \uparrow \\ \sum F_y = 0 &= -A_y + E_y + D_y - 60 \\ E_y &= 53.33 + 60 - 30 \\ \underline{E_y = 83.33 \text{ kN} \uparrow} \end{aligned}$$

P3.18 Determine all reactions.



P3.18



$$\begin{aligned} \curvearrowright + \\ \sum M_A = 0; \quad 900 \times 75 - R_{Cy} \cdot 300 = 0 \\ R_{Cy} = \underline{225 \text{ kips}} \uparrow \end{aligned}$$

$$\begin{aligned} + \\ \sum F_y = 0; \quad -900 + R_{Ay} + 225 = 0 \\ R_{Ay} = \underline{675 \text{ kips}} \uparrow \end{aligned}$$

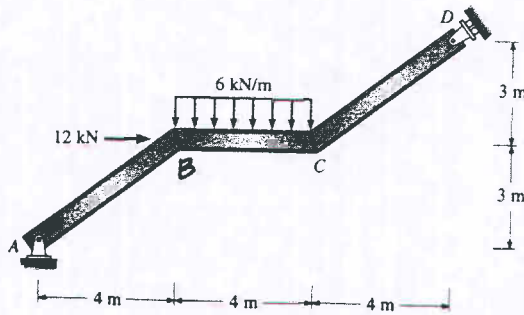
FREEBODY DIAGRAM RIGHT OF HINGE @ B:

$$\begin{aligned} \curvearrowright + \\ \sum M_B = 0; \\ 0 = R_{Cx} \cdot 75 - 225(150) \\ R_{Cx} = \underline{450 \text{ kips}} \leftarrow \end{aligned}$$

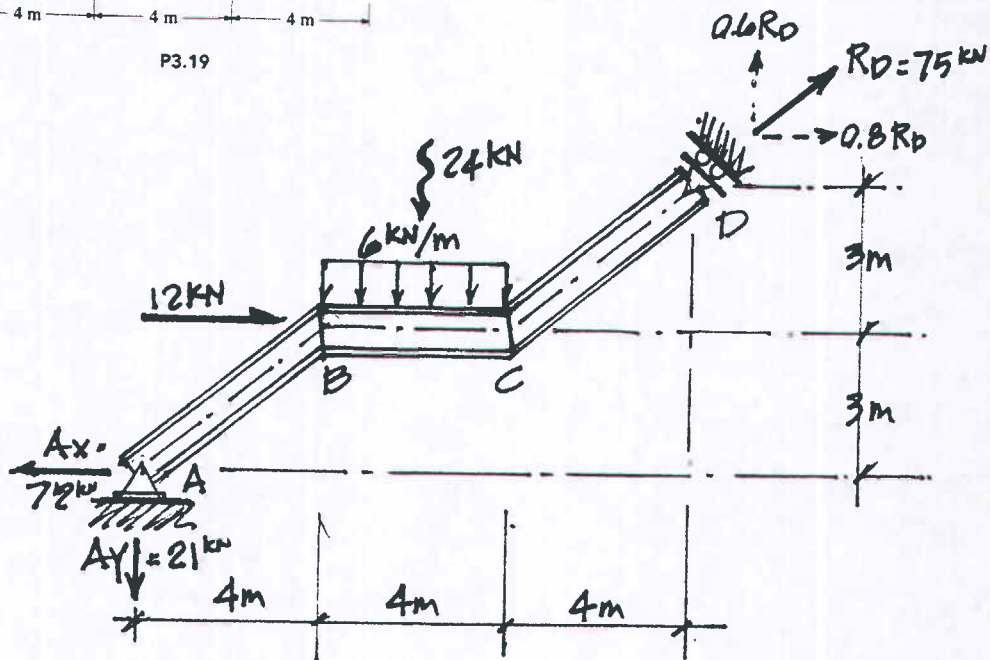
$$\begin{aligned} \rightarrow + \\ \sum F_x = 0; \quad R_{Ax} - 450 = 0 \end{aligned}$$

$$\underline{R_{Ax} = 450 \text{ kips}} \rightarrow$$

P3.19 Determine all reactions.



P3.19



$$+\circlearrowleft \sum M_A = 0;$$

$$12 \times 3 + 24 \times 6 + 0.8 R_D (6) - 0.6 R_D (12) = 0$$

$$\underline{R_D = 75 \text{ kN} \nearrow}$$

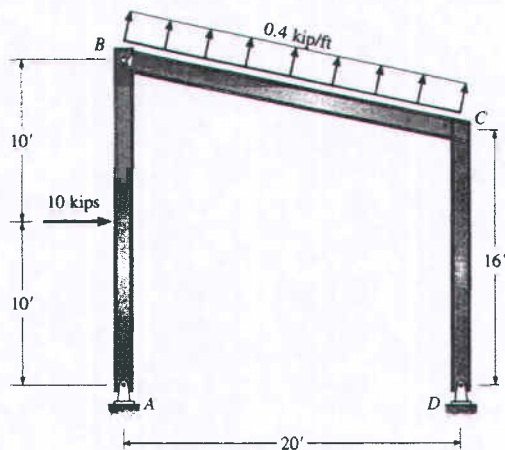
$$+\rightarrow \sum F_x = 0; -A_x + 12 + 0.8 (75) = 0$$

$$\underline{A_x = 72 \text{ kN} \leftarrow}$$

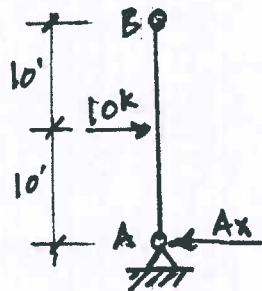
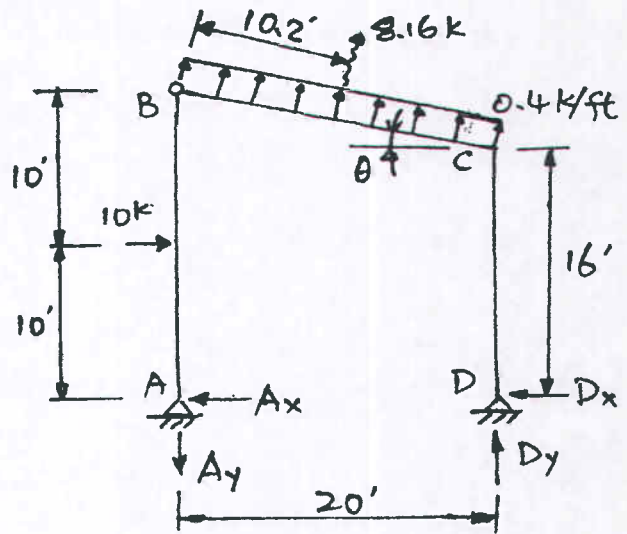
$$+\uparrow \sum F_y = 0; A_y - 24 + 0.6 (75) = 0$$

$$\underline{A_y = -21 \text{ kN} \downarrow}$$

P3.20 Determine all reactions.



P3.20



Take member AB as a free-body
and sum moment about B:

$$\sum M_B = 0; -10 \times 10' + A_x (20') = 0$$

$$A_x = 5 \text{ kips} \leftarrow$$

$\sum F_x = 0$ of entire structure:

$$10 + 8.16 (\sin \theta) - 5 - D_x = 0$$

$$D_x = 10 + 1.6 - 5 = 6.6 \text{ kips} \leftarrow$$

Take BCD as a free-body
and sum moment about B:

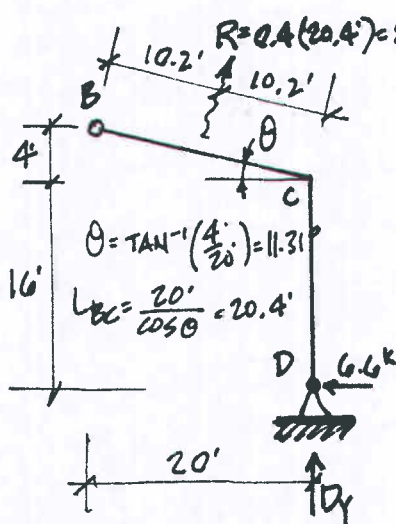
$$\sum M_B = 0; -8.16 \times 10.2' + 6.6 \times 20' - D_y (20) = 0$$

$$D_y = 2.44 \text{ kips} \uparrow$$

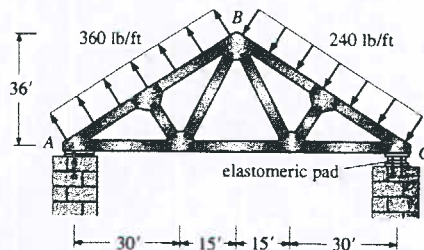
$\sum F_y = 0$ of entire structure:

$$8.16 (\cos \theta) + 2.44 - A_y = 0$$

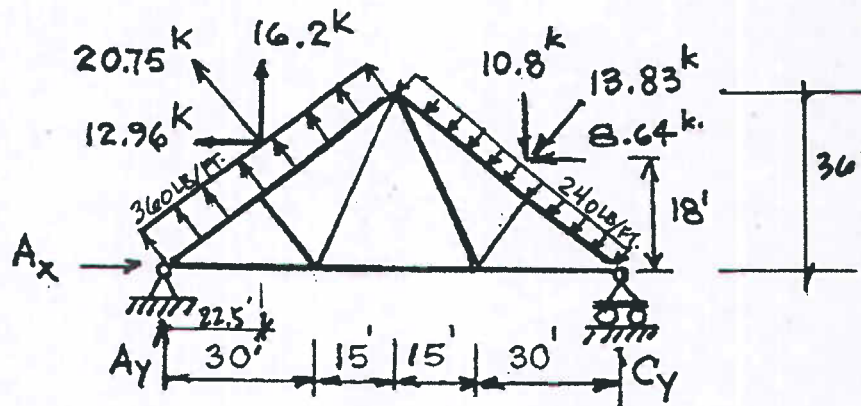
$$A_y = 8.00 + 2.44 = 10.44 \text{ kips} \downarrow$$



P3.21. The roof truss is bolted to a reinforced masonry pier at A and connected to an elastomeric pad at C. The pad, which can apply vertical restraint in either direction but no horizontal restraint, can be treated as a roller. The support at A can be treated as a pin. Compute the reactions at supports A and C produced by the wind load.

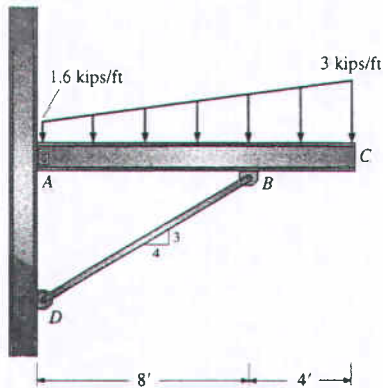


P3.21

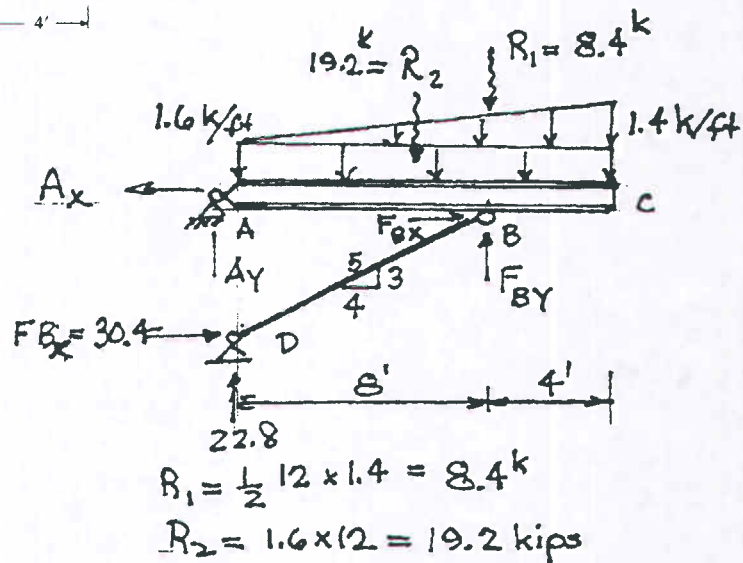


$$\begin{aligned} \rightarrow + \\ \Sigma F_x = 0; & A_x - 12.96^k - 8.64^k = 0 \\ & \underline{A_x = 21.6 \text{ kips}} \\ \curvearrowright + \\ \Sigma M_A = 0; & -12.96^k(18) - 8.64(18) - C_y 90' \\ & + 10.8(67.5) - 16.2(22.5) = 0 \\ & \underline{C_y = -0.27 \text{ kips} \downarrow} \\ \Sigma F_y = 0; & A_y + 16.2 - 10.8 - 0.27 = 0 \\ & \underline{A_y = -5.13 \text{ kips} \downarrow} \end{aligned}$$

P3.22. The clip angle connecting the beam's web at A to the column may be assumed equivalent to a pin support. Assume member BD acts as an axially loaded pin-end compression strut. Compute the reactions at points A and D.



P3.22



CONSIDER BEAM ABC:

$$\sum M_A = 0; \quad 19.2 \times 6 + 8.4 \times 8 - 8F_{By} = 0$$

$$F_{By} = \underline{22.8 \text{ kips}} \uparrow$$

$$\frac{F_{Bx}}{4} = \frac{(F_{By} = 22.8)}{3}$$

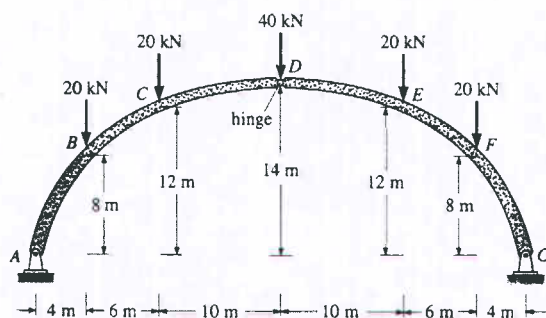
$$F_{Bx} = \frac{4}{3}(22.8) = \underline{30.4 \text{ kips}} \rightarrow$$

$$\sum F_x = 0 = 30.4 - A_x \therefore \underline{A_x = 30.4 \text{ kips}} \leftarrow$$

$$\sum F_y = 0; \quad A_y + 22.8 - 19.2 - 8.4 = 0$$

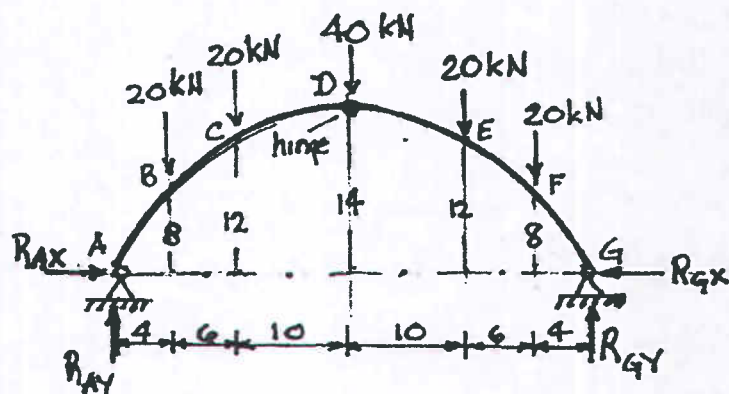
$$A_y = \underline{4.8 \text{ kips}} \uparrow$$

P3.23. Compute the reactions at supports A and G, and the force applied by the hinge to member AD.

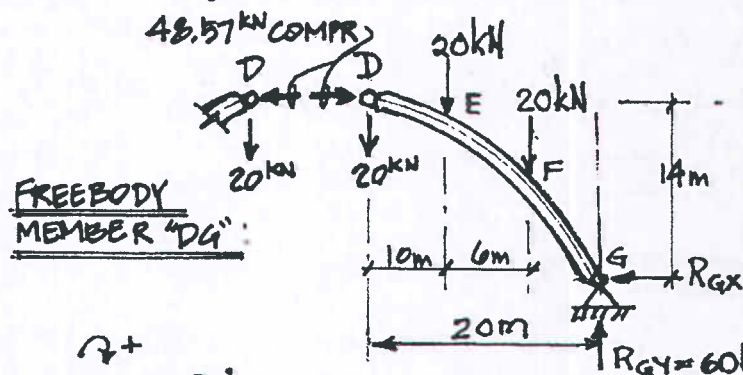


P3.23

DIMENSIONS IN METERS



symmetry : $R_{Ax} = R_{Gx} = 60 \text{ kN}$



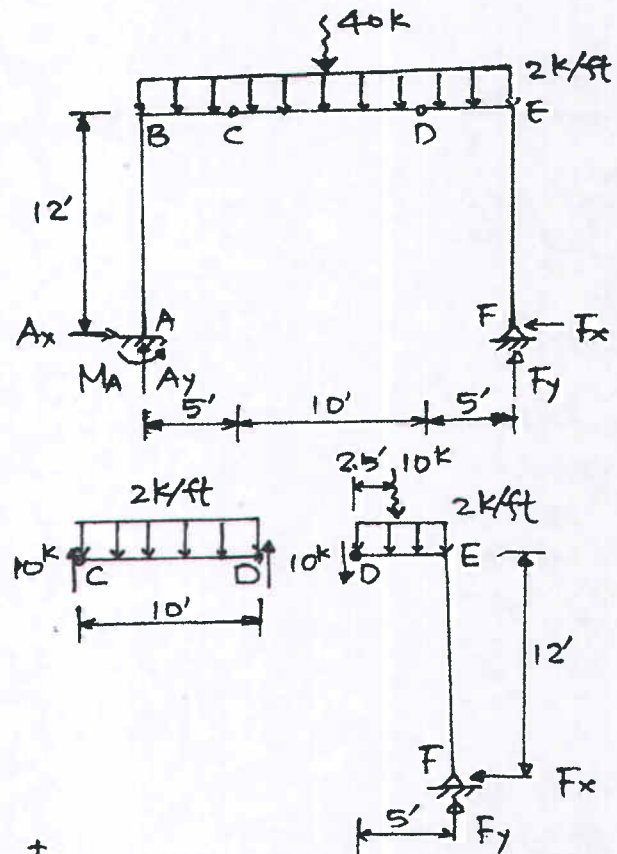
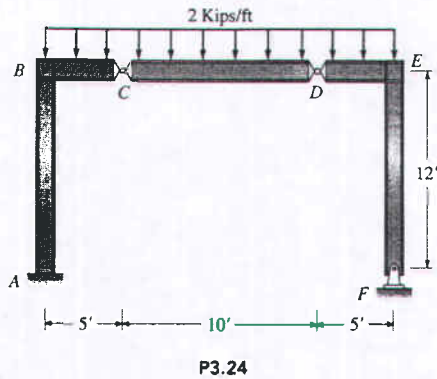
FREEBODY MEMBER "DG"

$$\sum M_D = 0;$$

$$20 \times 10 + 20 \times 16 - 60 \times 20 + R_{Gx} \times 14 = 0$$

$$\underline{R_{Gx} = 48.57 \text{ kips} = R_{Ax}}$$

P3.24. Compute all reactions.



$\uparrow \Sigma F_y = 0$ of free-body DEF:

$$-10 - 10 + F_y = 0$$

$$\underline{F_y = 20 \text{ kips} \uparrow}$$

$\uparrow \Sigma M_D = 0$;

$$10 \times 2.5 - 20 \times 5 + F_x (12) = 0$$

$$\underline{F_x = 6.25 \text{ kips} \leftarrow}$$

Consider the entire structure as a free-body.

$$\rightarrow \Sigma F_x = 0 ; A_x - 6.25 = 0$$

$$\underline{A_x = 6.25 \text{ kips} \rightarrow}$$

$$\uparrow \Sigma F_y = 0 ; A_y - 40 + 20 = 0$$

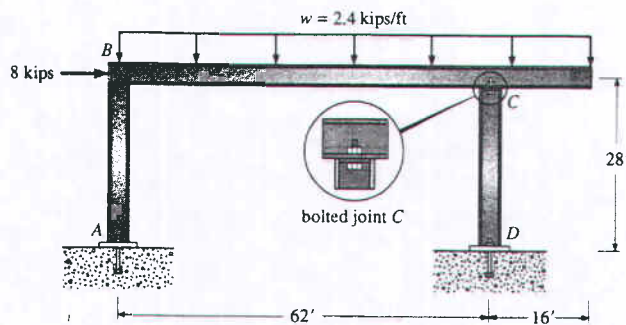
$$\underline{A_y = 20 \text{ kips} \uparrow}$$

$\uparrow \Sigma M_A = 0$;

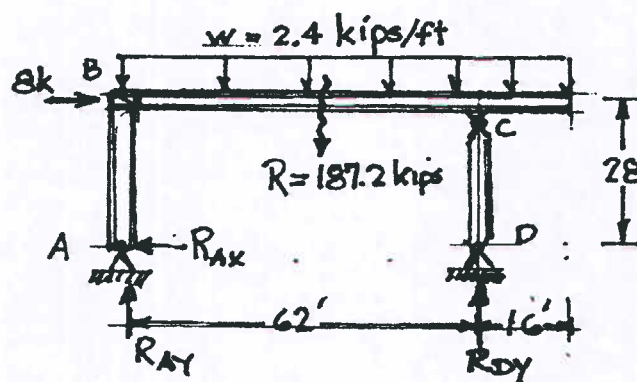
$$40 \times 10 - 20 \times 20 - M_A = 0$$

$$\underline{M_A = 0 \text{ kip-ft}}$$

P3.25. The baseplates at the bottoms of the columns are connected to the foundations at points A and D by bolts and may be assumed to act as pin supports. Joint B is rigid. At C where the bottom flange of the girder is bolted to a cap plate welded to the end of the column, the joint can be assumed to act as a **hinge** (it has no significant capacity to transmit moment). Compute the reactions at A and D.



P3.25



$$\sum M_A = 0; \quad 187.2 \times \frac{78}{2} + 8 \times 28 - R_{Dy} \times 62 = 0$$

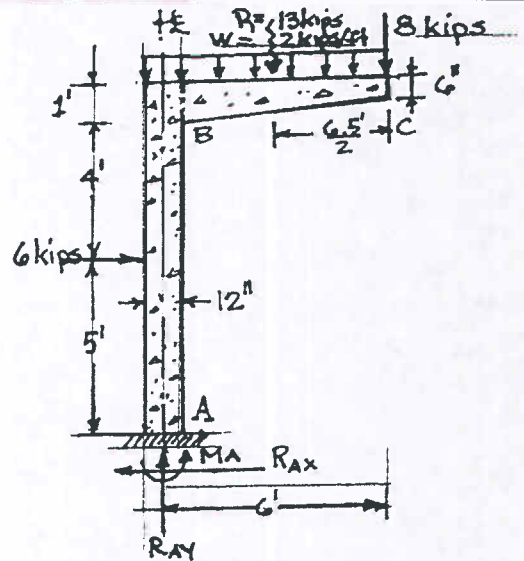
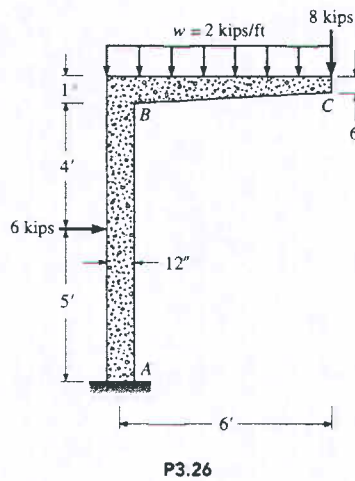
$$R_{Dy} = \underline{121.37 \text{ kips} \uparrow}$$

$$\sum F_y = 0; \quad R_{Ay} + R_{Dy} - 187.2 = 0$$

$$R_{Ay} = 187.2 - 121.37 = \underline{65.83 \text{ k} \uparrow}$$

$$\sum F_x = 0; \quad -R_{Ax} + 8 = 0 \therefore R_{Ax} = \underline{8 \text{ k} \leftarrow}$$

P3.26. Draw free-body diagrams of column AB and beam BC and joint B by passing cutting planes through the rigid frame an infinitesimal distance above support A and to the right and immediately below joint B. Evaluate the internal forces on each free body.

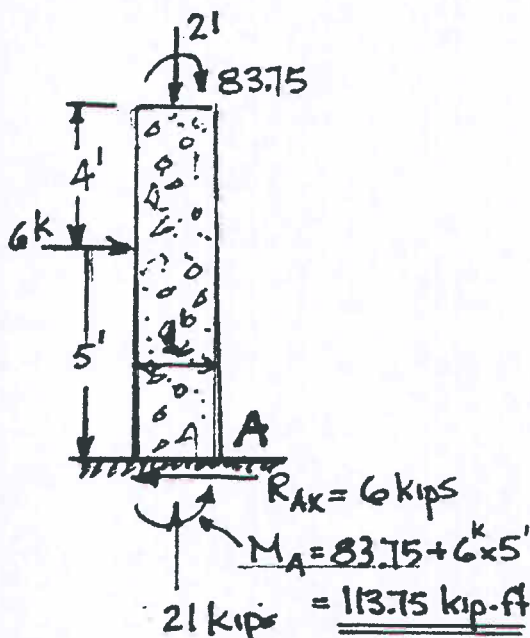


COMPUTE REACTIONS AT SUPPORT A

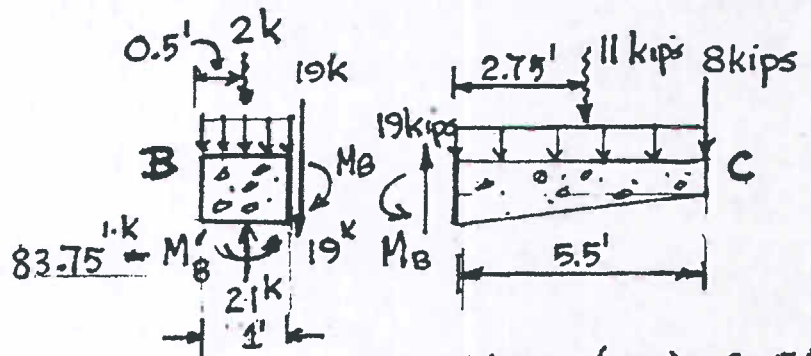
$$\begin{aligned} \sum F_x = 0; \quad 6 - R_{Ax} = 0 \therefore R_{Ax} &= 6 \text{ kips} \rightarrow \\ \sum F_y = 0; \quad R_{Ay} - 2 \text{ kips/ft} (6.5') - 8 &= 0 \\ \therefore R_{Ay} &= 21 \text{ kips} \uparrow \end{aligned}$$

$$\begin{aligned} \sum \text{MOMENTS about } \& \text{ of BASE AT "A"} \\ \sum M_A = 0; \quad 8 \times 6 + 13^k \times (6 - 0.5/2) + 6 \times 5 - M_A &= 0 \\ \therefore M_A &= 113.75 \text{ kip}\cdot\text{ft} \end{aligned}$$

FREEBODY DIAGRAM
MEMBER 'AB'

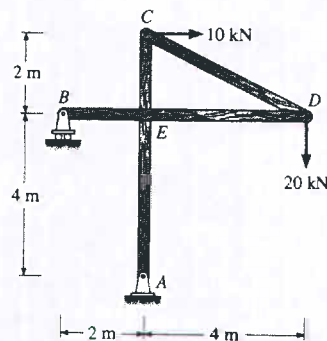


FREEBODY DIAGRAMS MEMBER 'BC' & JT. 'B'

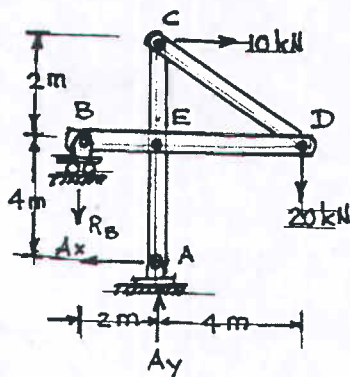


$$\begin{aligned} M_B &= 11(2.75) + 8 \times 5.5 \\ &= 74.25 \text{ kip}\cdot\text{ft} \\ M'_B &= 74.25 + 19 \times \frac{1}{2} \\ &= 83.75 \text{ kip}\cdot\text{ft} \end{aligned}$$

P3.27. The frame is composed of members connected by frictionless pins. Draw free-body diagrams of each member and determine the forces applied by the pins to the members.



P3.27



COMPUTE REACTIONS

$$\sum M_A = 0; -R_B(2\text{ m}) + 10(6\text{ m}) + 20(4\text{ m}) = 0$$

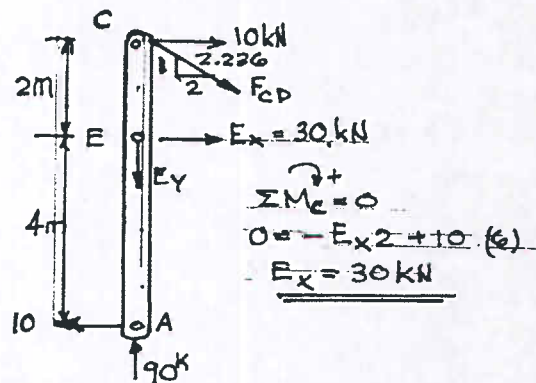
$$R_B = 70\text{ kN} \downarrow$$

$$\sum F_x = 0; -A_x + 10 = 0; A_x = 10\text{ kN} \leftarrow$$

$$\sum F_y = 0; A_y - 10 - 20 = 0; A_y = 30\text{ kN} \uparrow$$

FREE BODY DIAGRAMS

NOTE: BAR CD IS A TWO-FORCE MEMBER.



$$\sum M_C = 0$$

$$0 = -E_x(2) + 10(6)$$

$$E_x = 30\text{ kN}$$

$$\sum M_E = 0; 10(4) + 10(2) + \frac{2}{2.236} F_{CD}(2) = 0$$

$$F_{CD} = -33.54\text{ kN} \quad (\text{COMPR})$$

$$\sum F_y = 0; 90 - E_y + \frac{33.54}{2.236} = 0$$

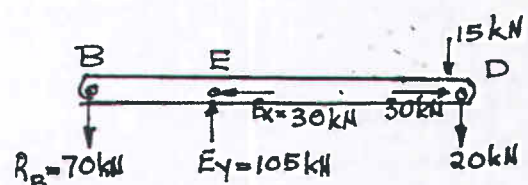
$$E_y = 90 + 15 = 105\text{ kN} \uparrow$$

CHECK:

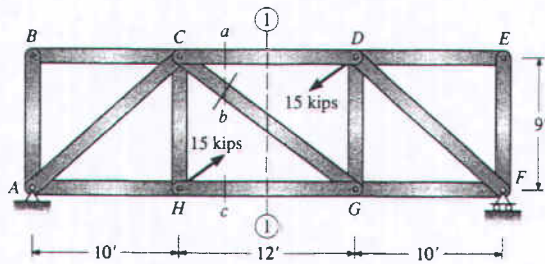
$$\sum F_x = 0; -10 + 10 + \frac{2(-33.54)}{2.236} + E_x = 0$$

$$E_x = 30\text{ kN} \quad \checkmark$$

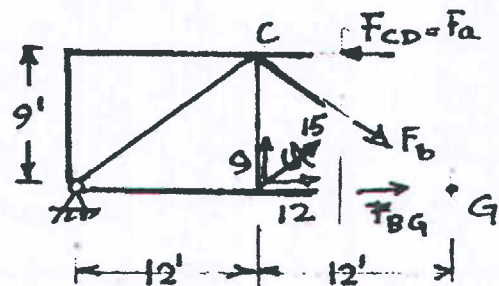
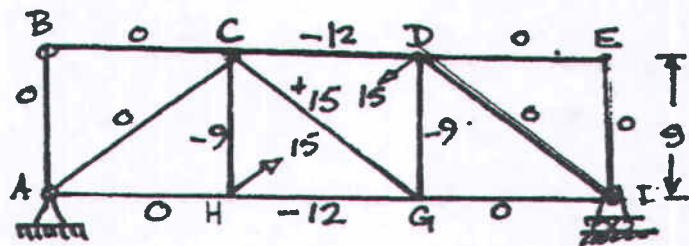
BAR BED



P3.28. The truss in Figure P3.28 is composed of pin-jointed members that carry only axial load. Determine the forces in members, *a*, *b*, and *c* by passing vertical section 1-1 through the center of the truss.



P3.28



$$\sum M_A = 0; -F_{CD} \cdot 9' + 9k \cdot 12' = 0$$

$$F_a = F_{CD} = 12 \text{ kips compr.}$$

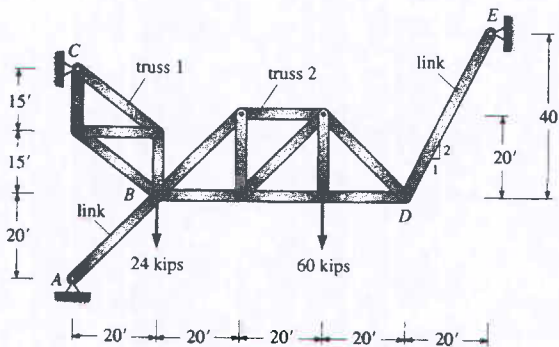
$$\sum F_y = 0; 9k - F_{by} = 0$$

$$F_b = \frac{5}{3} F_{by} = \frac{5}{3} (9) = 15 \text{ kips (T)}$$

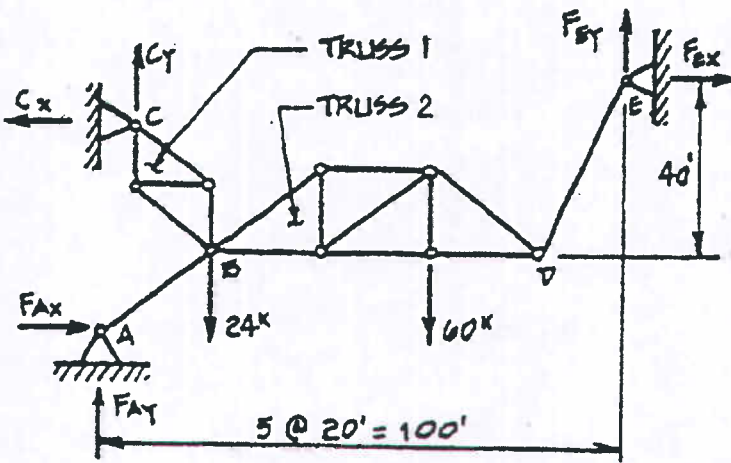
$$\sum M_C = 0; -12k \cdot 9' - F_{HG} \cdot 9' = 0$$

$$F_c = F_{HG} = -12 \text{ kips} \therefore \text{compr.}$$

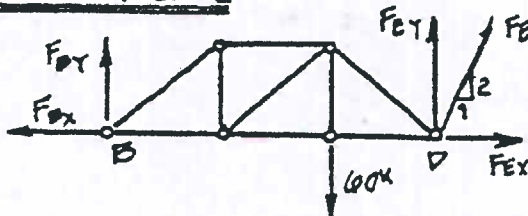
P3.29. (a) In Figure P3.29 trusses 1 and 2 are stable elements that can be treated as rigid bodies. Compute all reactions. (b) Draw free-body diagrams of each truss and evaluate the forces applied to the trusses at joints C, B, and D.



P3.29



F.B.D. 1 TRUSS 2



$$\sum M_B = 0; 60(40) - F_{Dy}(60) = 0$$

$$F_{Dy} = 40 \text{ k}$$

$$F_{Dy} = F_{By}$$

$$F_{By} = 40 \text{ k}$$

$$\sum F_x = 0; 20 - F_{Bx} = 0$$

$$F_{Bx} = 20 \text{ k}$$

$$\sum F_y = 0; 40 - 60 + F_{By} = 0$$

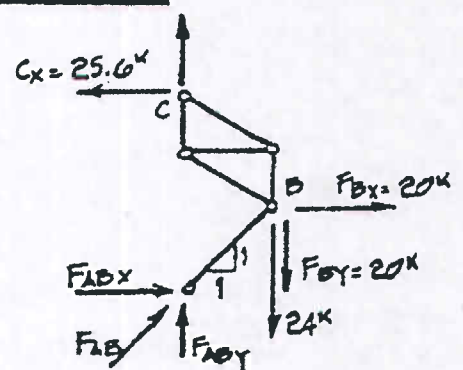
$$F_{By} = 20 \text{ k}$$

ENTIRE STRUCTURE

$$\sum M_A = 0; 24(20) + 60(60) + 20(60) - 40(100) - C_x(50) = 0$$

$$C_x = 25.6 \text{ k}$$

F.B.D. 2 TRUSS 1



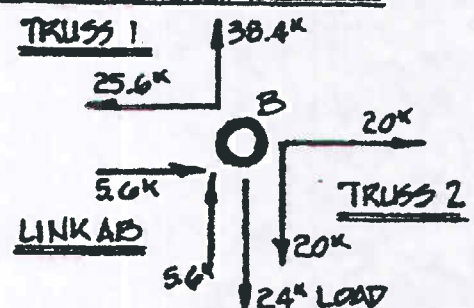
$$\sum M_C = 0; (20)(24)(20) - 20(30) - F_{Ax}(50) = 0$$

$$F_{Ax} = F_{Ay}$$

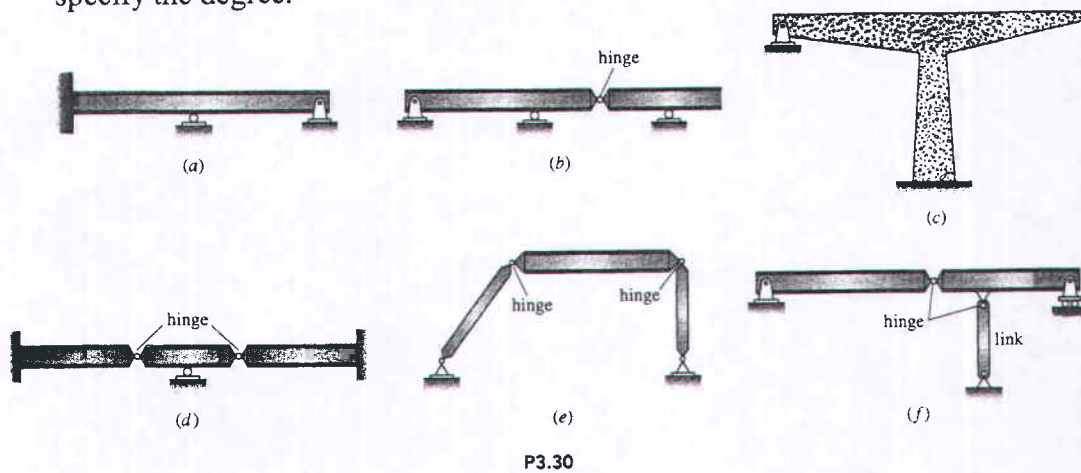
$$F_{Ax} = 5.6 \text{ k}$$

$$F_{Ay} = 5.6 \text{ k}$$

F.B.D. 3 PIN DETAIL @ B

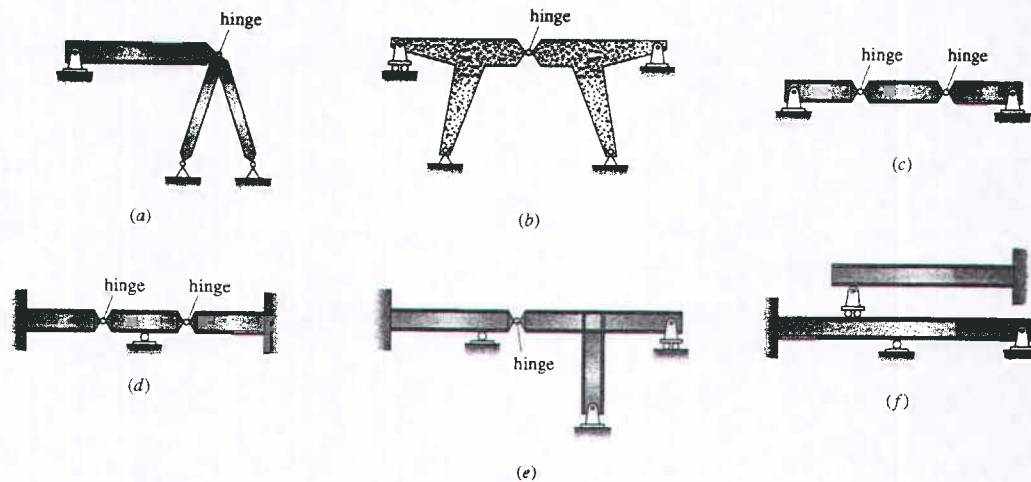


P3.30 Classify the structures in Figure P3.30. Indicate if stable or unstable. If unstable, indicate the reason. If the structure is stable, indicate if determinate or indeterminate. If indeterminate, specify the degree.



- (a) indet 3°
 (b) determinate
 (c) indet. 2°
 (d) indet. 2°
 (e) Unstable ($R < 3 + C$)
 (f) determinate

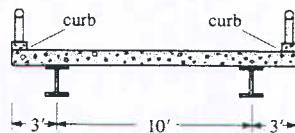
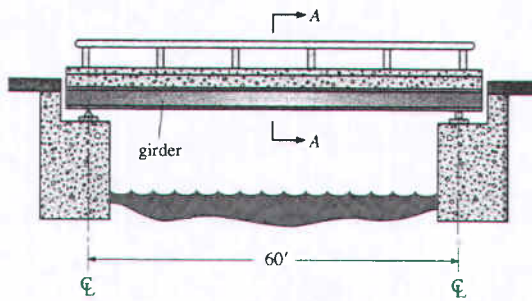
P3.31 Classify the structures in Figure P3.31. Indicate if stable or unstable. If unstable, indicate the reason. If the structure is stable, indicate if determinate or indeterminate. If indeterminate, specify the degree.



P3.31

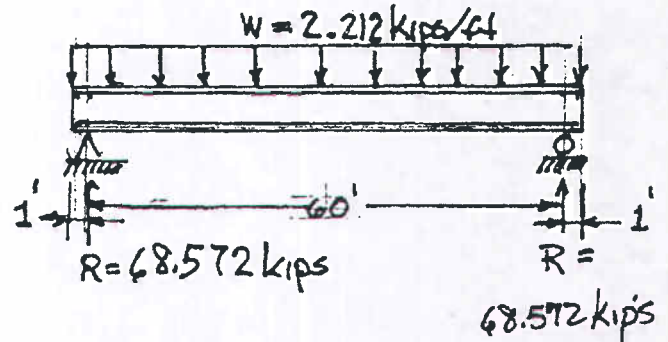
- (a.) indet 1°
 (b.) indet 3°
 (c.) unstable ($R < 3 + C$)
 (d.) indet 2°
 (e.) indet 3°
 (f.) indet 4°

P3.32. Practical application: A one-lane bridge consists of a 10-in-thick, 16-ft-wide reinforced concrete slab supported on two steel girders spaced 10 ft apart. The girders are 62 ft long and weigh 400 lb/ft. The bridge is to be designed for a uniform live load of 700 lb/ft acting over the entire length of the bridge. Determine the maximum reaction applied to an end support due to dead, live, and impact loads. The live load may be assumed to act along the centerline of the deck slab and divide equally between the two girders. Each concrete curb weighs 240 lb/ft and each rail 120 lb/ft. Stone concrete has a unit weight of 150 lb/ft³. Assume an impact factor of 0.29.



Section A-A

P3.32



DEAD WT of BRIDGE/ft (Table 2.1)

$$10'' \text{ slab} = 150 \text{ lb/ft}^3 \times 10'' \times 16' = 2000 \text{ lb}$$

12

$$\text{WT of 2 CURBS } 240 \times 2 = 480 \text{ lb}$$

$$\text{WT of 2 RAILS } 120 \times 2 = 240 \text{ lb}$$

$$\text{TOTAL} = 2720 \text{ lb/ft}$$

$$\text{LOAD TO EACH GIRDER} = \frac{2720 \text{ kips/ft}}{2} = 1.36 \text{ k/ft}$$

$$\text{WT/ft of GIRDER} = 0.4 \text{ k/ft}$$

$$\text{Total Dead wt} = 1.76 \text{ k/ft}$$

$$\text{LIVE LOAD + IMPACT} = \frac{0.7 \times 1.29}{2}$$

$$= 0.452 \text{ k/ft}$$

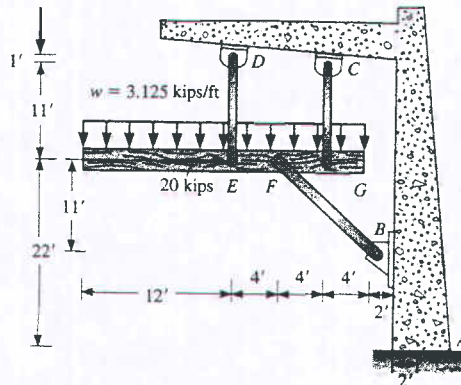
$$\text{Total LOAD (D+L)} = 1.76 + 0.452$$

FT

$$= 2.212 \text{ kips/ft}$$

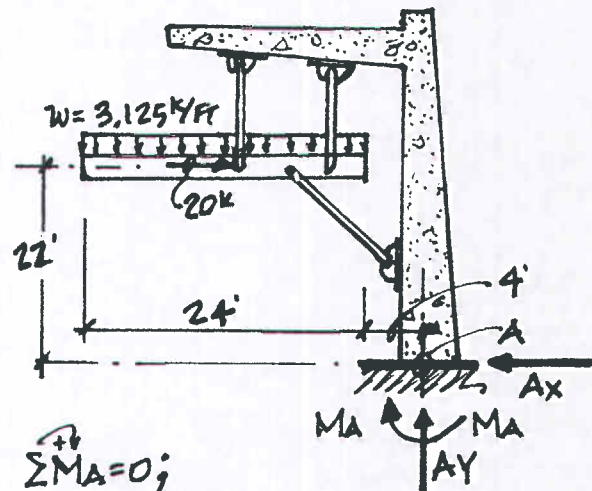
$$\text{REACTION each girder} = \frac{2.212 (62)}{2} = 68.572 \text{ kips}$$

P3.33. A timber member supported by three steel links to a concrete frame has to carry the loads shown in Figure P3.33. (a) Calculate the reactions at support A. (b) Determine the axial forces in all links. Indicate if each link is in compression or tension.



P3.33

ENTIRE STRUCTURE, COMPUTE REACTIONS



$$\sum M_A = 0;$$

$$20k(22') - 3.125k/ft(24')(16') + M_A = 0$$

$$M_A = 760'k$$

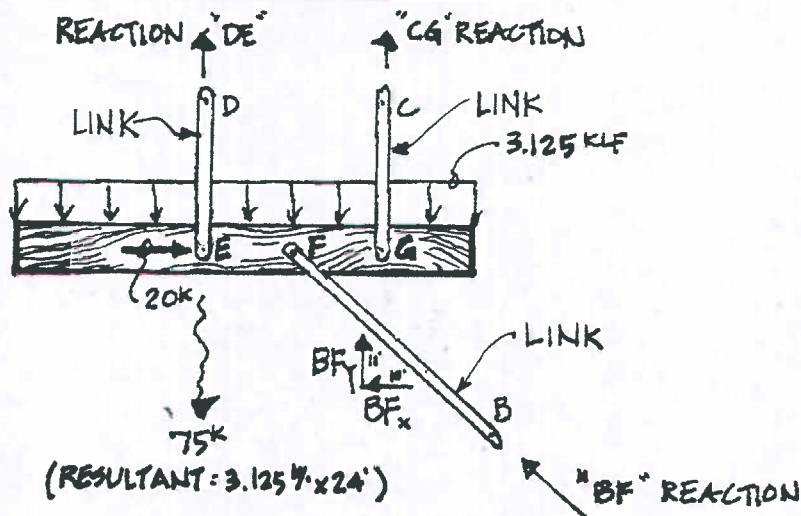
$$\sum F_x = 0; \quad 20k - A_x = 0$$

$$A_x = 20k \leftarrow$$

$$\sum F_y = 0; \quad -3.125k(24') + A_y = 0$$

$$A_y = 75k \uparrow$$

FREE BODY: TIMBER MEMBER



$$\sum F_x = 0;$$

$$20k - BF_x = 0;$$

$$BF_y/11' = BF_x/10'$$

$$BF = \sqrt{BF_x^2 + BF_y^2} = \sqrt{(20)^2 + (22)^2}$$

$$\sum M_E = 0;$$

$$-BF_y(4') - CG(8') = 0$$

$$-22k(4') - CG(8') = 0$$

$$\sum F_y = 0;$$

$$DE + CG + BF_y - 75k = 0$$

$$DE - 11k + 22k - 75k = 0$$

$$BF_x = 20k \leftarrow$$

$$BF_y = 22k \uparrow$$

$$BF = 29.73k \text{ COMPRESSION IN THE LINK.}$$

$$CG = 11k \downarrow \text{ COMPRESSION IN THE LINK.}$$

$$DE = 64k \uparrow \text{ TENSION IN THE LINK.}$$