
CGPA
BOOSTER

Unit 4
Analysis of Trusses

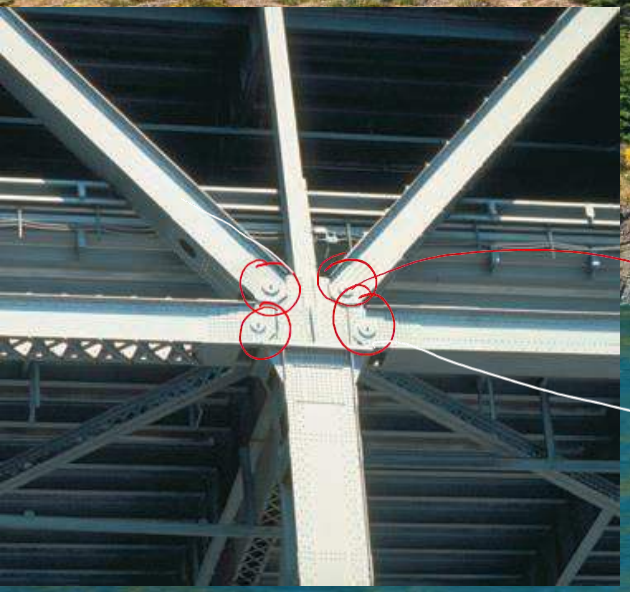
Structures

Link → moving member.

Linkages – combination of

Load

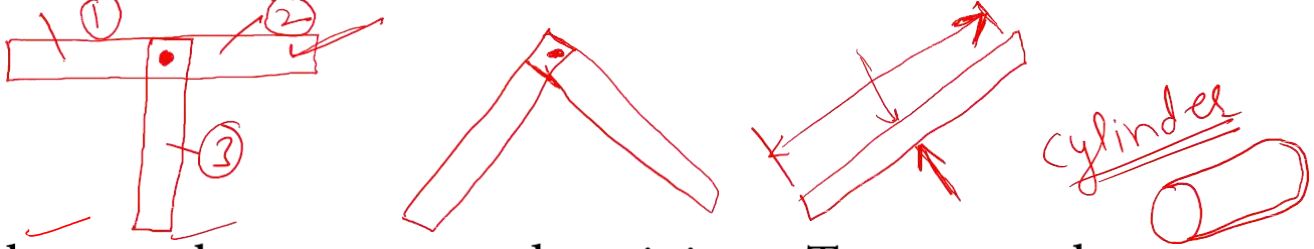
member



Joints

Joints.

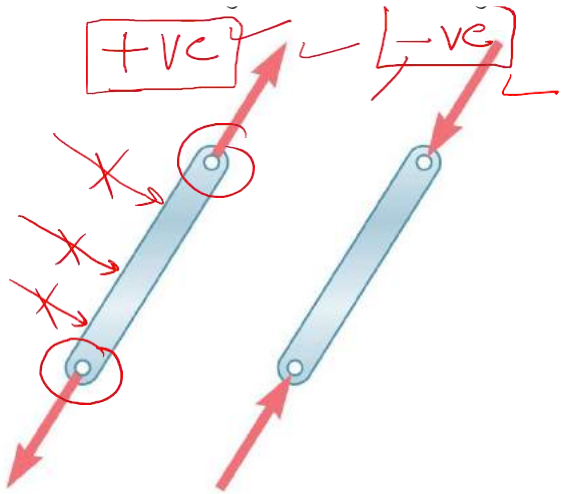
Introduction

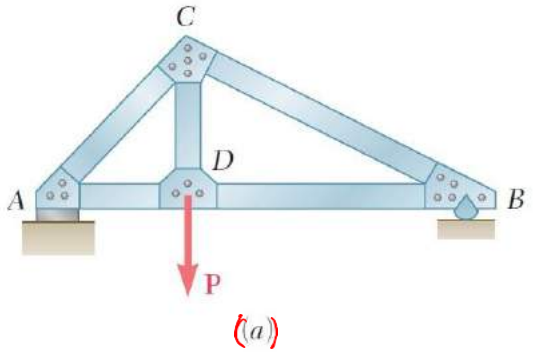


- A truss consists of straight members connected at joints. Truss members are connected at their extremities only; thus no member is continuous through a joint.
- The members of a truss are slender and can support little lateral load; all loads, therefore, must be applied to the various joints, and not to the members themselves.

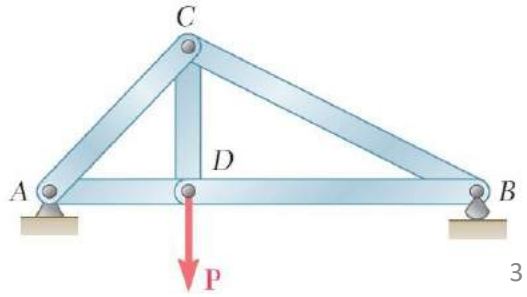
structural frame or frame.

- Most actual structures are made of several trusses joined together to form a space framework. Each truss is designed to carry those loads which act in its plane and thus may be treated as a two-dimensional structure.
- When forces tend to pull the member apart, it is in *tension*. When the forces tend to compress the member, it is in *compression*.

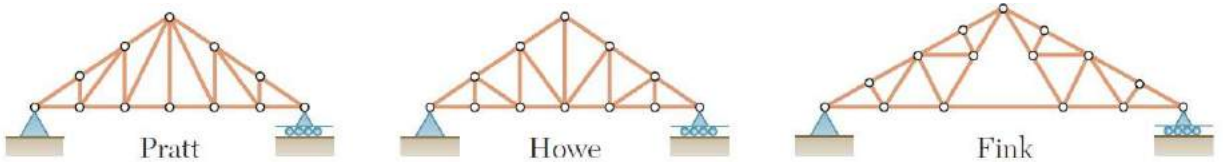




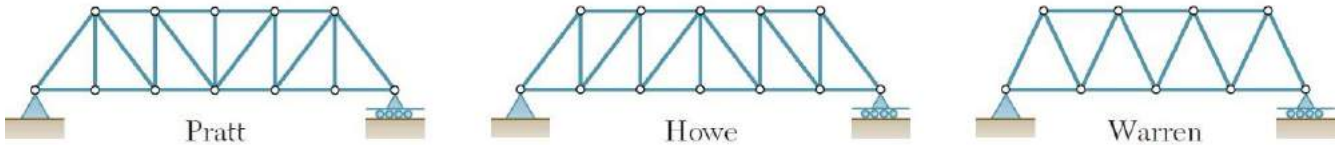
(a)

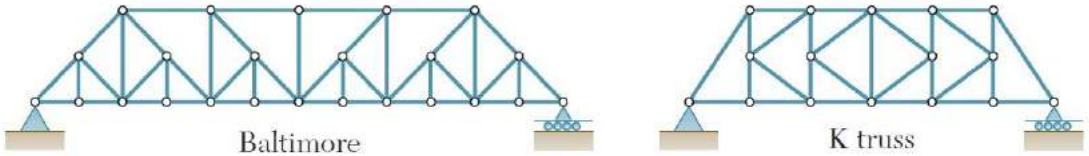


Types of Trusses

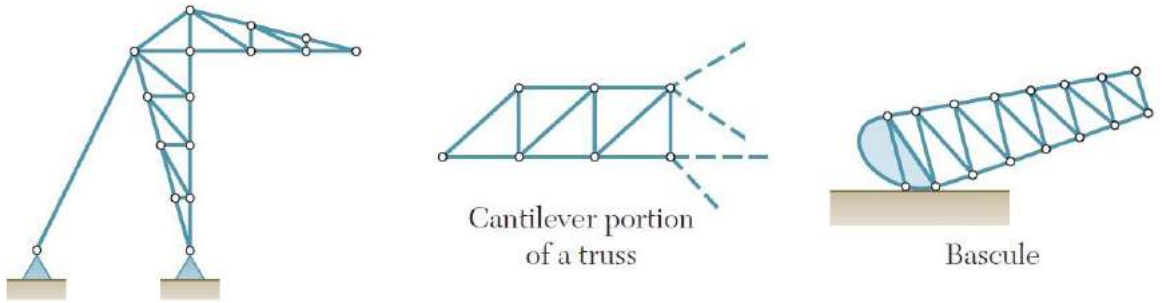


Typical Roof Trusses





Typical Bridge Trusses



Other Types of Trusses

Types of Trusses/Frames

- A pin-jointed truss which has got just sufficient number of members to resist the loads without undergoing appreciable deformation in shape is called a ***perfect truss***.
- A truss is said to be ***deficient*** if the number of members in it are less than that required for a perfect truss. Such trusses cannot retain their shape when loaded.
- A truss is said to be ***redundant*** if the number of members in it are more than that required in a perfect truss. Such trusses cannot be analyzed by making use of the equations of equilibrium alone. Thus, a redundant truss is statically indeterminate.

$$n = 2j - 3$$

n = No. of members

j = No. of joints

If LHS = RHS (Perfect)

LHS < RHS (Deficient)

LHS > RHS (Redundant)

(1) $3 = (2 \times 3) - 3$

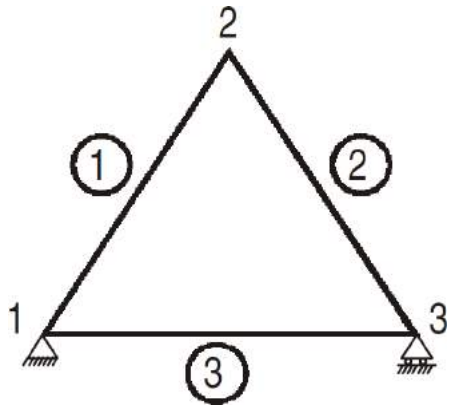
$3 = 3$ (Perfect)

(2) $5 = (2 \times 4) - 3$

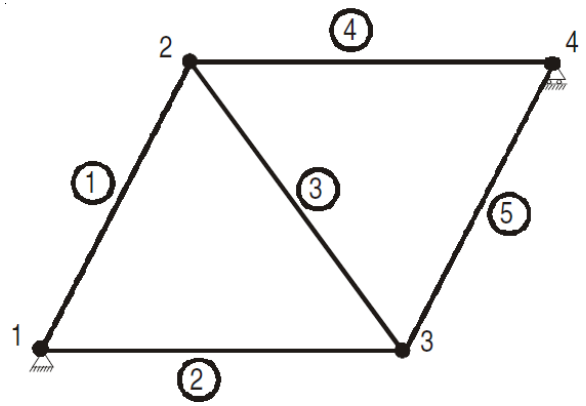
$5 = 5$ (Perfect)

(3) $7 = (2 \times 5) - 3$

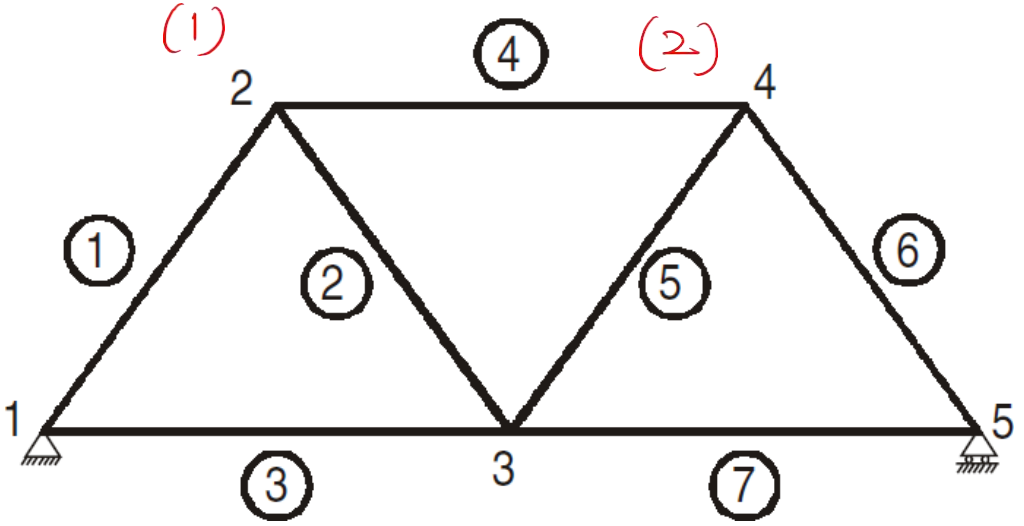
$7 = 7$ (Perfect)



(1)



(2)



(3)

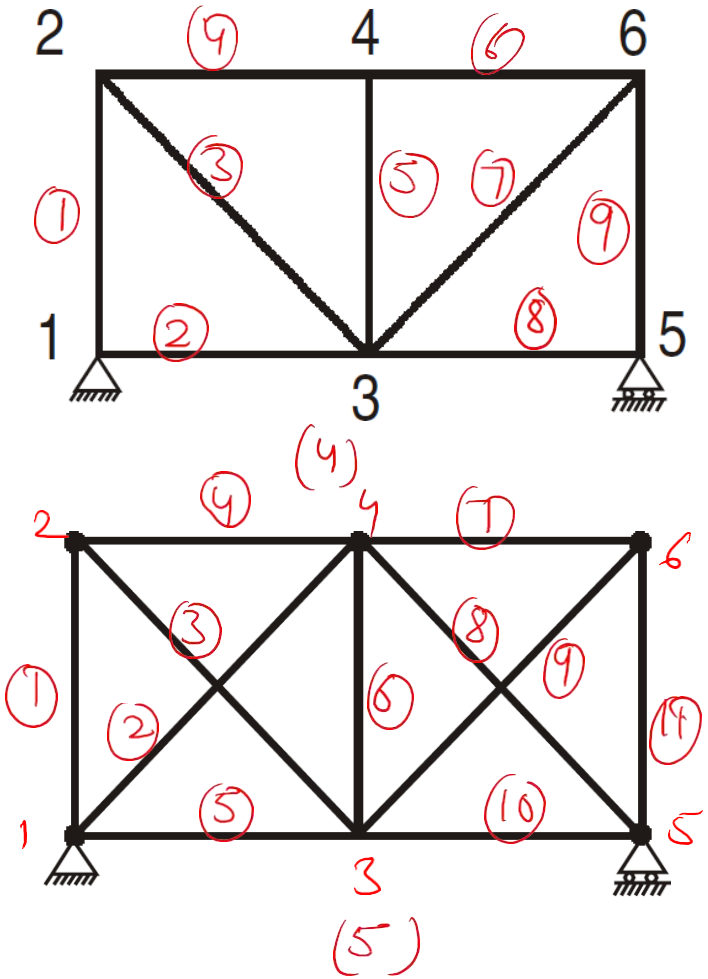
(4) $9 = (2 \times 6) - 3$

$9 = 9$ (Perfect)

(5) $11 = (2 \times 6) - 3$

$11 = 9$

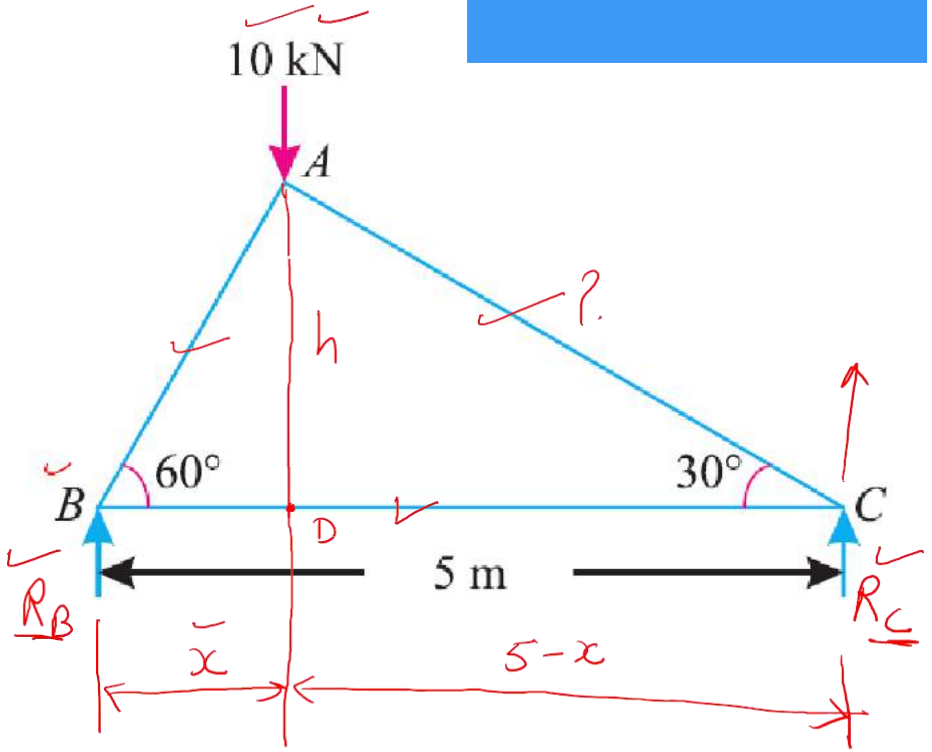
LHS > RHS (Redundant)



Find the forces in all the members.

$\Sigma F = 0$

$\Sigma M = 0$



Sol: $R_B + R_C = 10\ KN$

Taking moments about B

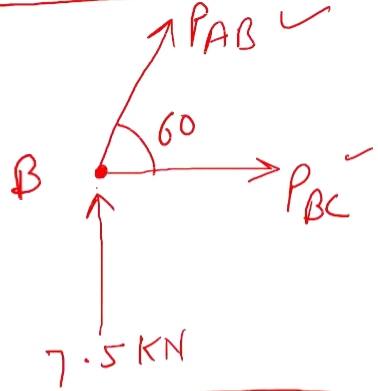
CW = ACW

$(10 \times 1.25) = R_C \times 5$

$R_C = 2.5\ KN$

$R_B = 10 - R_C$

$R_B = 7.5\ KN$

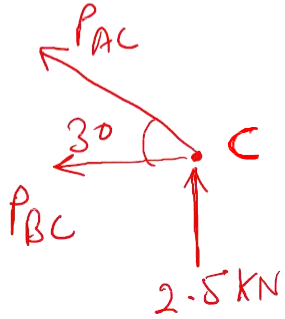


$7.5 + P_{AB} \sin 60 = 0$

$P_{AB} = -8.66\ KN$

$P_{BC} + P_{AB} \cos 60 = 0$

$P_{BC} = 4.33\ KN$



$2.5 + P_{AC} \sin 30 = 0$

$P_{AC} = -5\ KN$

$\frac{h}{x} = \tan 60$ -①

$\frac{h}{5-x} = \tan 30$ -②

$x = 1.25\ m.$

Sol:

$R_A + R_D = 6\ KN$

Taking moments about A

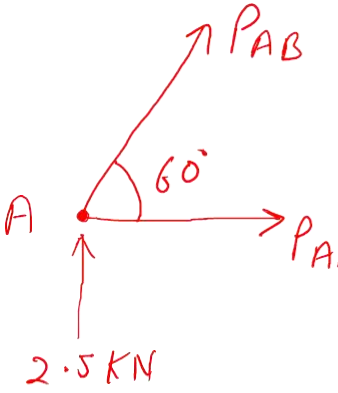
CW = ACW

$(2 \times 1.5) + (4 \times 4.5) = R_D \times 6$

$R_D = 3.5\ KN$

$R_A = 6 - R_D$

$R_A = 2.5\ KN$

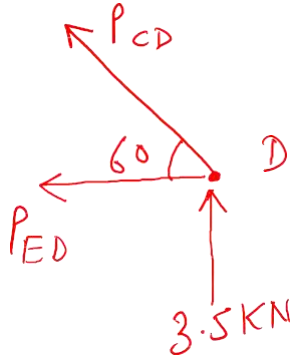


$2.5 + P_{AB} \sin 60 = 0$

$\boxed{P_{AB} = -2.88\ KN}$

$P_{AE} + P_{AB} \cos 60 = 0$

$\boxed{P_{AE} = 1.44\ KN}$

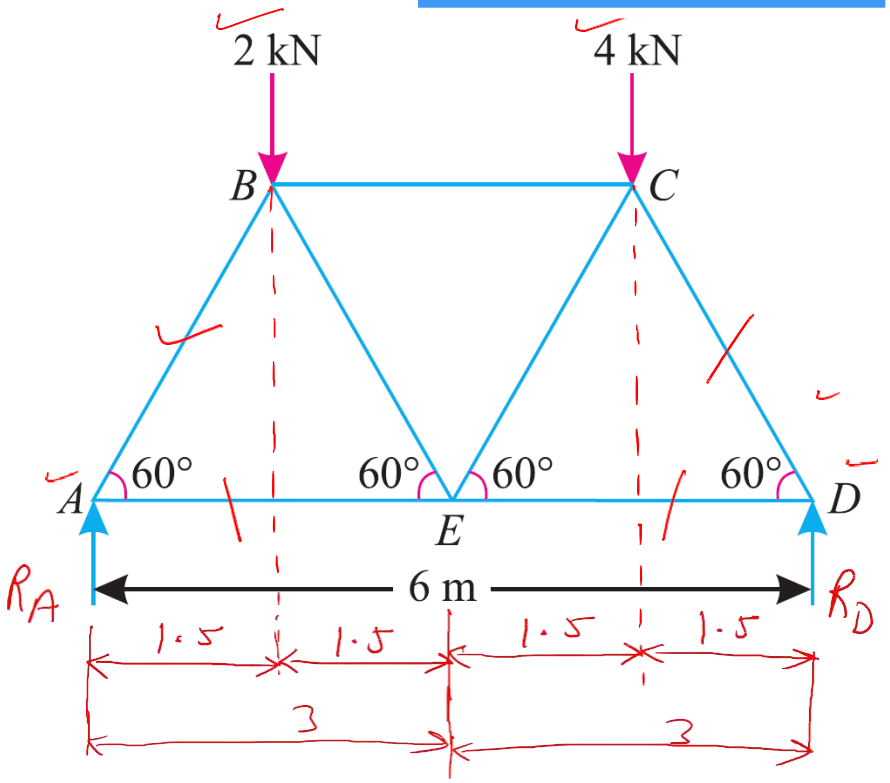


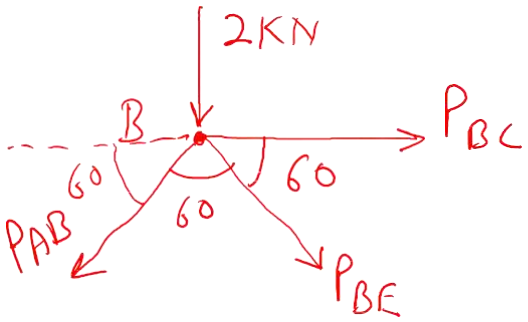
$3.5 + P_{CD} \sin 60 = 0$

$\boxed{P_{CD} = -4.041\ KN}$

$P_{ED} + P_{CD} \cos 60 = 0$

$\boxed{P_{ED} = 2.02\ KN}$



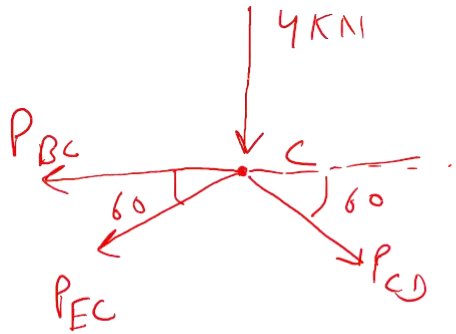


$$2 + P_{AB}\sin 60 + P_{BE}\sin 60 = 0$$

$$\boxed{P_{BE} = 0.577\ KN.}$$

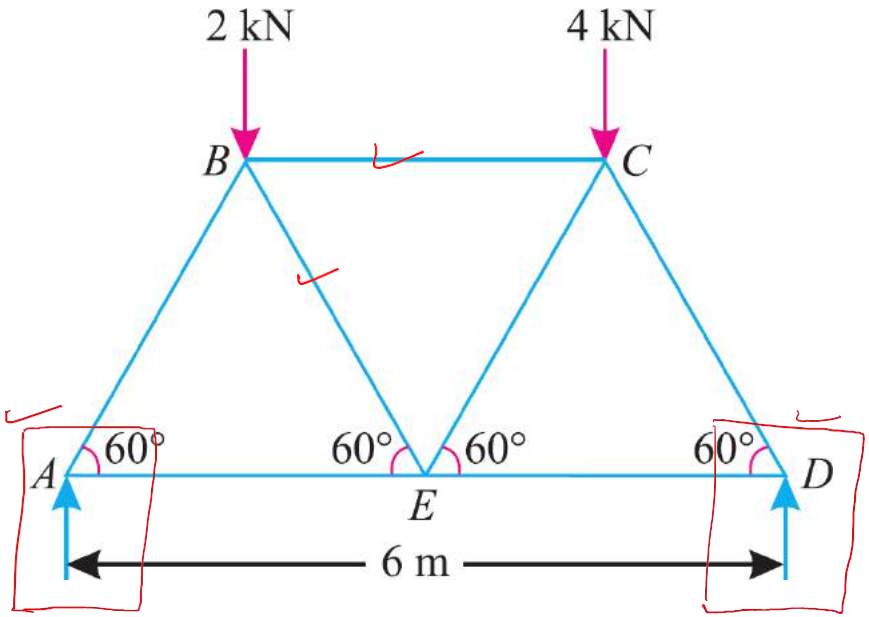
$$P_{BC} + P_{BE}\cos 60 = P_{AB}\cos 60$$

$$\boxed{P_{BC} = -1.732\ KN.}$$



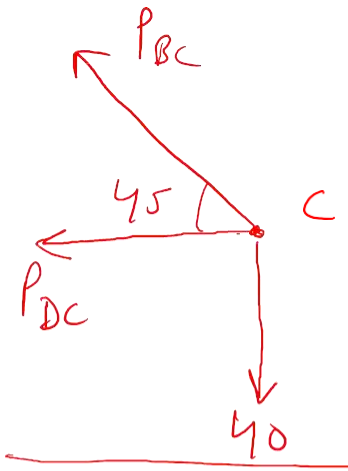
$$4 + P_{EC}\sin 60 + P_{CD}\sin 60 = 0$$

$$\boxed{P_{EC} = -0.577\ KN}$$



Simply supported frame

Sol: $\theta = 45°$

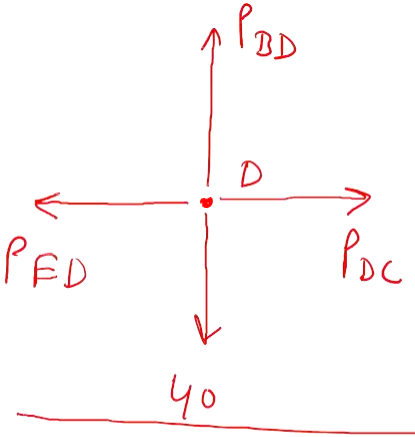


$P_{BC} \sin 45 = 40$

$$P_{BC} = 56.56 \text{ KN.}$$

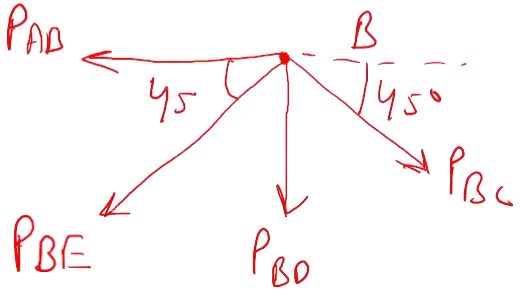
$P_{DC} + P_{BC} \cos 45 = 0$

$$P_{DC} = -40 \text{ KN.}$$



$$P_{ED} = P_{DC} = -40 \text{ KN.}$$

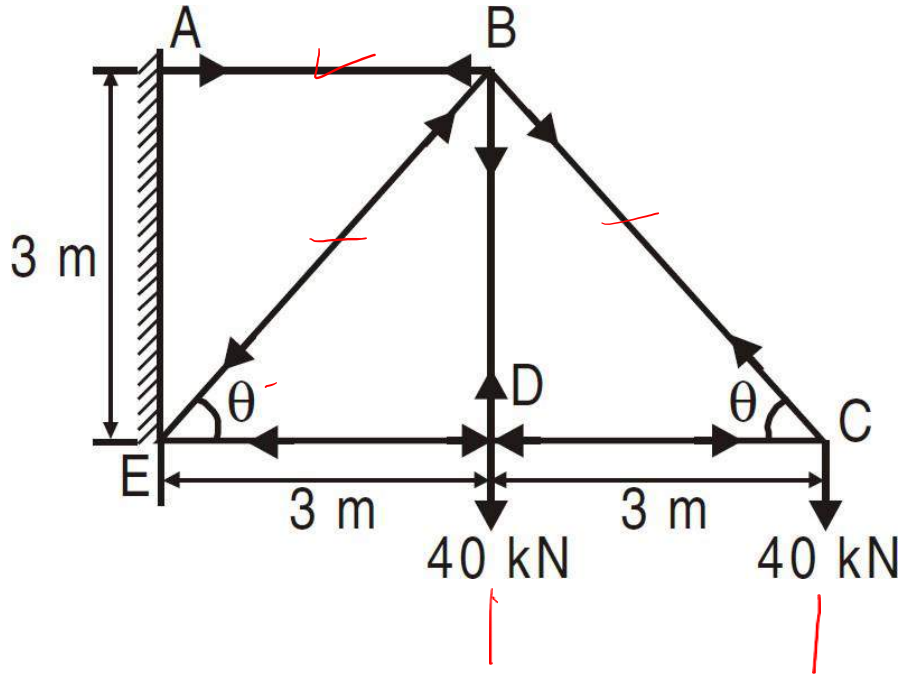
$$P_{BD} = 40 \text{ KN.}$$



$P_{BE} \sin 45 + P_{BD} + P_{BC} \sin 45 = 0$

$$P_{BE} = -113.13 \text{ KN.}$$

fixed support

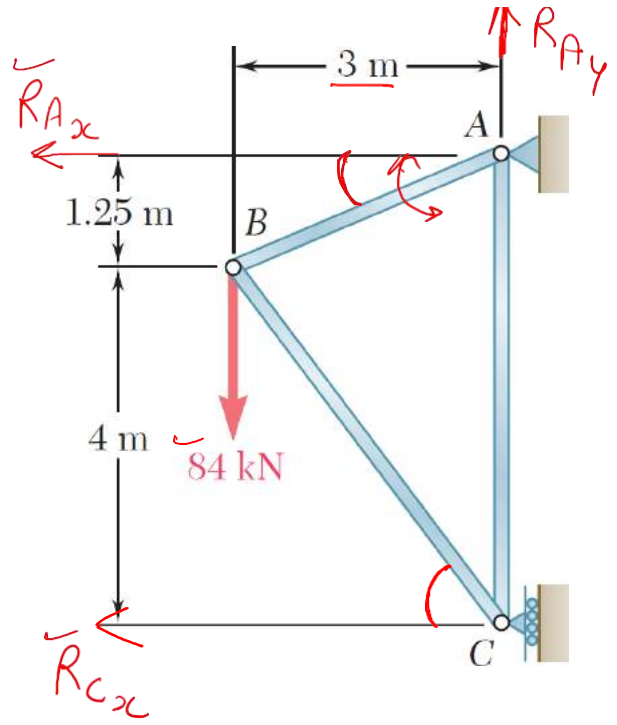


$P_{AB} + P_{BE} \cos 45 = P_{BC} \cos 45$

$$P_{AB} = 120 \text{ KN}$$

Sol: $R_{A_y} = 84\,KN$; $R_{A_x} + R_{C_x} = 0$ —

at A Hinged support
at C Roller support

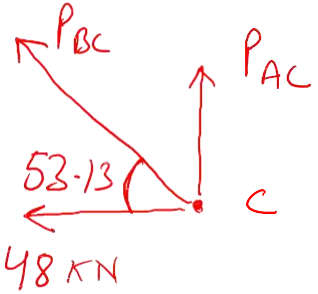


Taking moments about A

CW = ACW.

$R_{C_x} \times 5.25 = 84 \times 3$

$R_{C_x} = 48\,KN$; $R_{A_x} = -48\,KN$

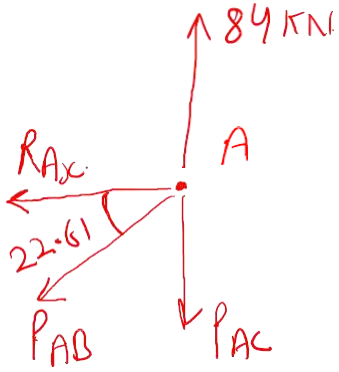


$48 + P_{BC} \cos 53.13 = 0$

$\boxed{P_{BC} = -80\,KN}$

$P_{AC} + P_{BC} \sin 53.13 = 0$

$\boxed{P_{AC} = 64\,KN}$



$P_{AB} \cos 22.61 + R_{A_x} = 0$

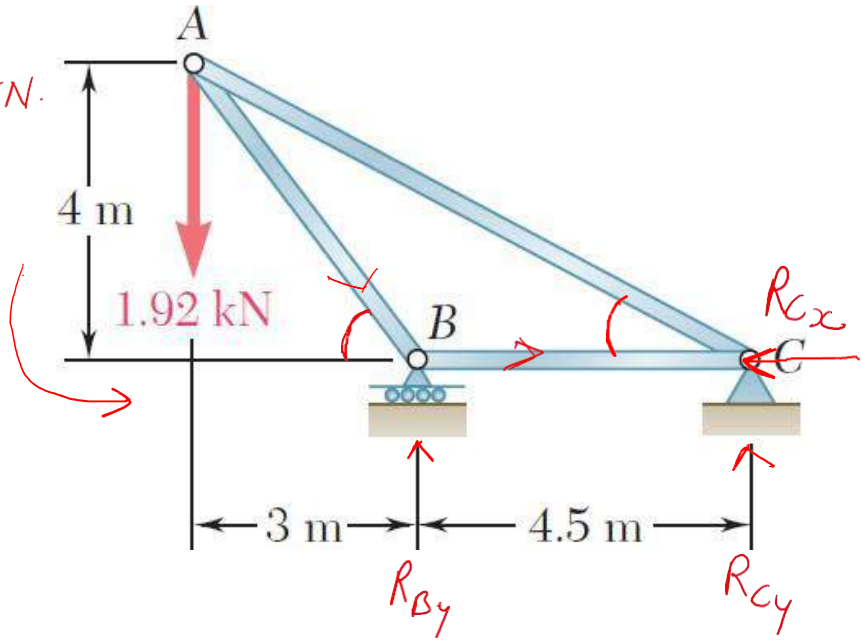
$P_{AB} = 52\,KN$

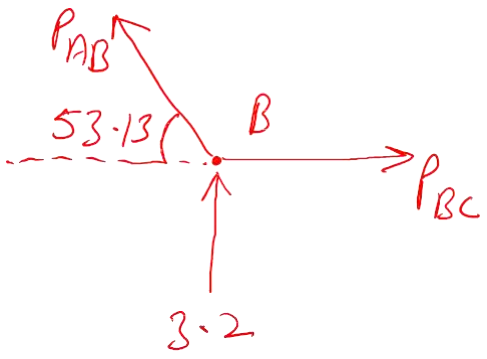
Sol: $R_{Cx} = 0$; $R_{By} + R_{Cy} = 1.92\,kN$

Taking moments about B

CW = ACW

$0 = (1.92 \times 3) + (R_{Cy} \times 4.5) \longmapsto R_{Cy} = -1.28\,kN$, $R_{By} = 3.2\,kN$

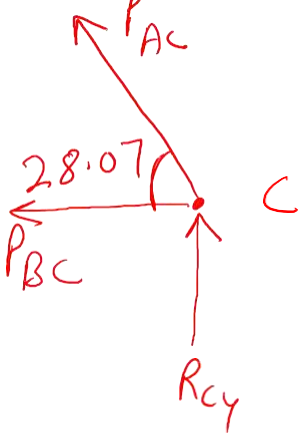




$3.2 + P_{AB} \sin 53.13 = 0$

$\boxed{P_{AB} = -4\,kN}$

$P_{BC} = P_{AB} \cos 53.13 = -2.4\,kN$



$P_{AC} \sin 28.07 = 1.28\,kN$

$\boxed{P_{AC} = 2.72\,kN}$

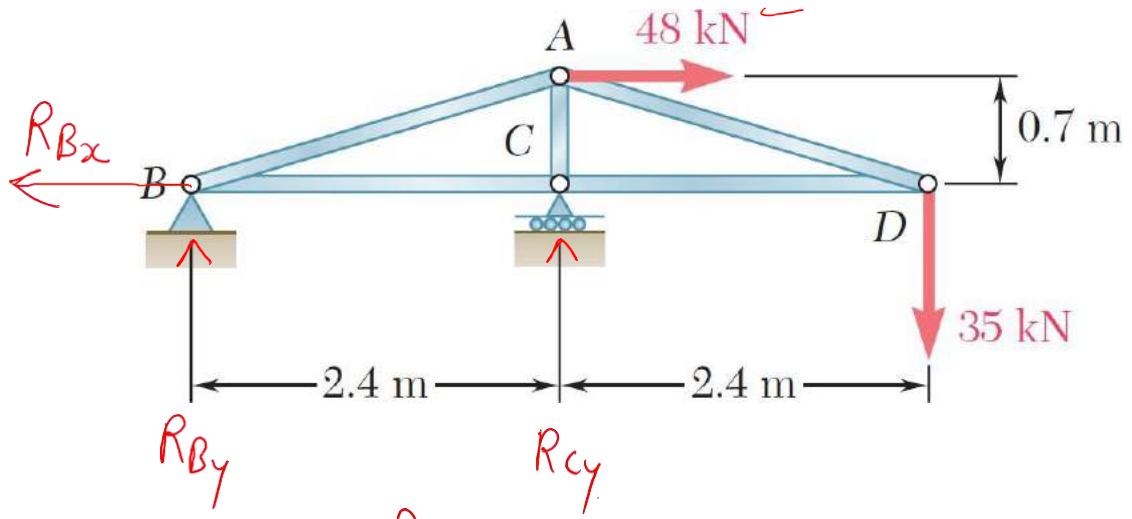
Sol: $R_{Bx} = 48\,kN$; $R_{By} + R_{Cy} = 35\,kN$.

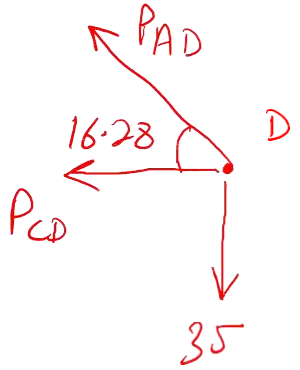
Taking moments about B

CW = ACW

$(48 \times 0.7) + (35 \times 4.8) = R_{Cy} \times 2.4$.

$R_{Cy} = 84\,kN$; $R_{By} = -49\,kN$.



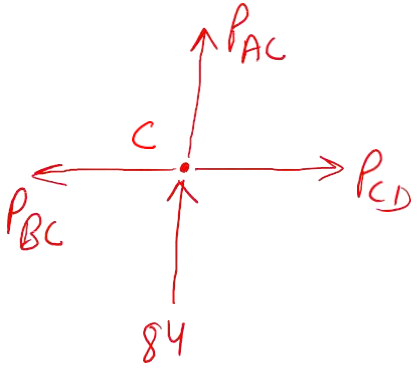


$P_{AD} \sin 16.28 = 35$

$\boxed{P_{AD} = 125\,kN}$

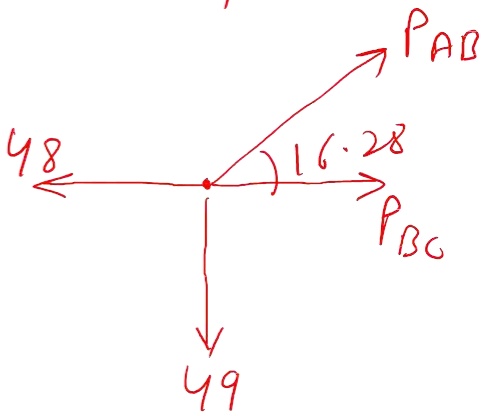
$P_{CD} + P_{AD} \cos 16.28 = 0$

$\boxed{P_{CD} = -120\,kN}$



$\boxed{P_{AC} = -84\,kN}$

$\boxed{P_{BC} = P_{CD} = -120\,kN}$

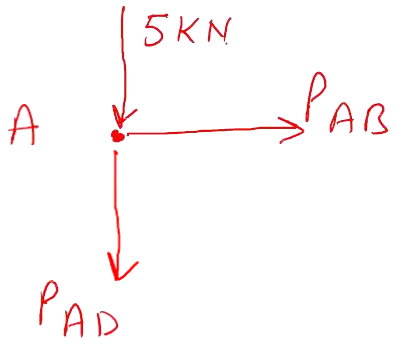


$P_{AB} \sin 16.28 = 49$.

$\boxed{P_{AB} = 175\,kN}$

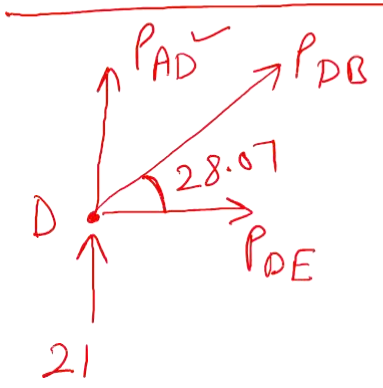
Sol: $R_D = R_F = 21\,KN$.

Symmetric frame.



$P_{BC} = P_{AB} = 0$ [zero force member]

$P_{AD} = -5\,KN$.

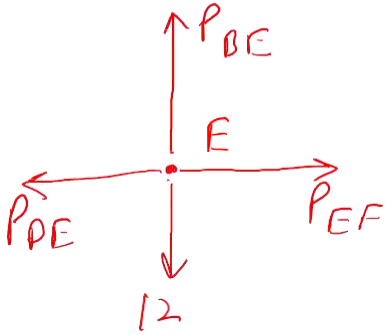


$21 + P_{AD} + P_{DB} \sin 28.07 = 0$

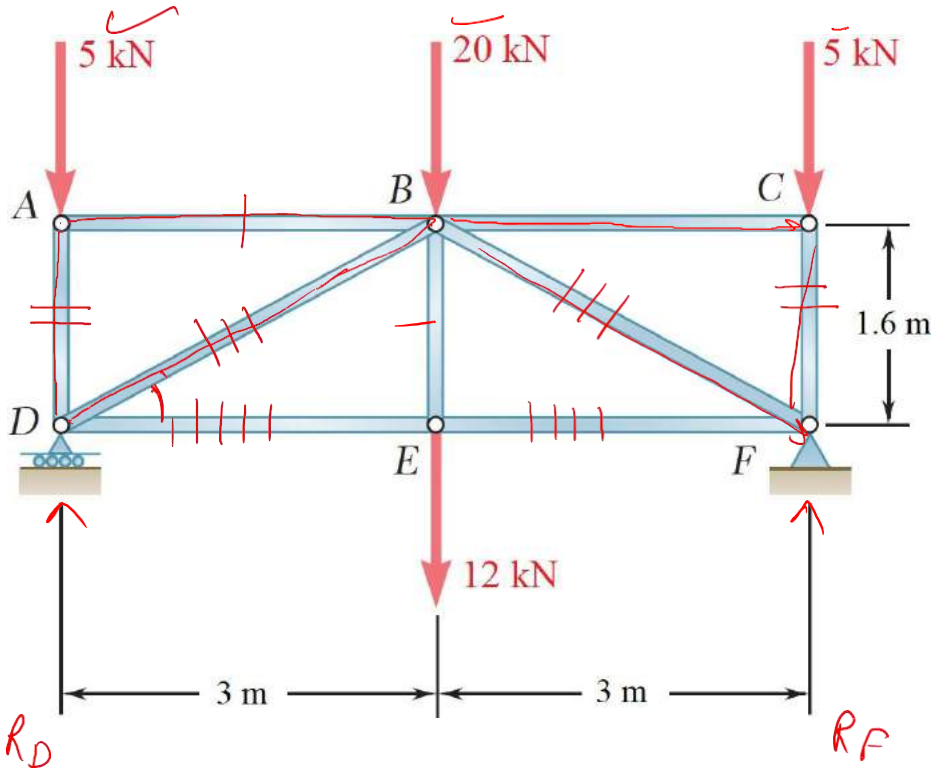
$P_{DB} = -34\,KN = P_{BF}$

$P_{DE} + P_{DB} \cos 28.07 = 0$

$P_{DE} = 30\,KN = P_{EF}$

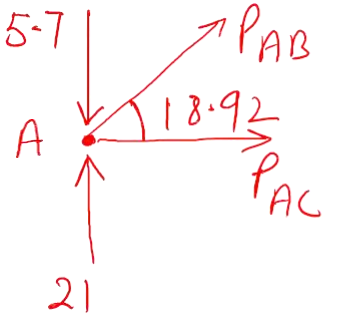


$P_{BE} = 12\,KN$.



Sol: Frame is symmetric.

$R_A = R_H = 21\,KN$

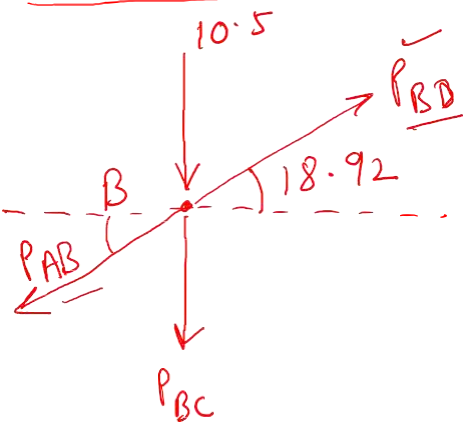


$21 + P_{AB}\sin 18.92 = 5.7$

$P_{AB} = -47.18\,KN$

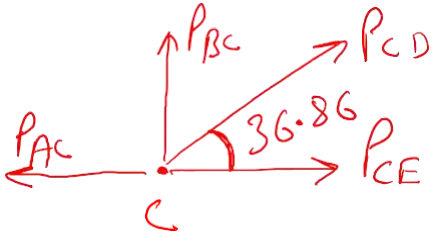
$P_{AC} + P_{AB}\cos 18.92 = 0$

$P_{AC} = 44.63\,KN$



$P_{BD} = P_{AB} = -47.18\,KN$

$P_{BC} = -10.5\,KN$

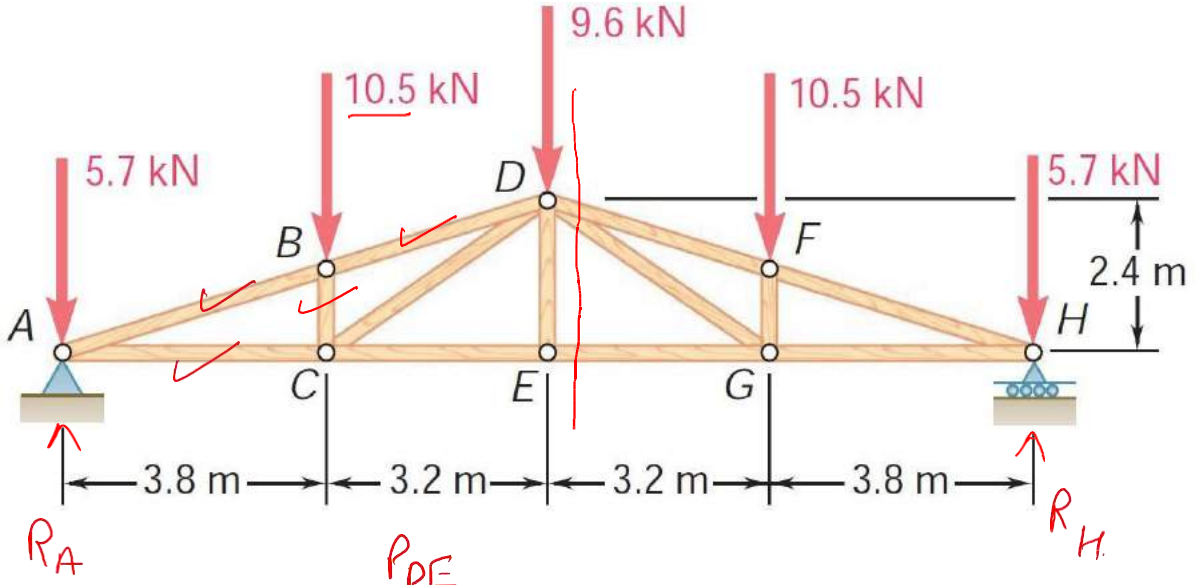


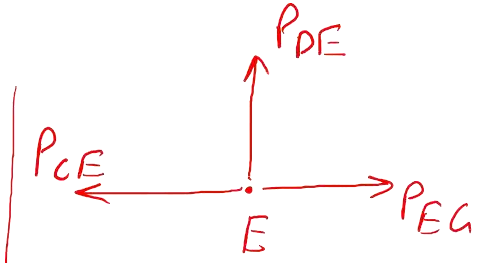
$P_{BC} + P_{CD}\sin 36.86 = 0$

$P_{CD} = 17.5\,KN$

$P_{CE} + P_{CD}\cos 36.86 = P_{AC}$

$P_{CE} = 30.62\,KN$





$P_{DE} = 0$

zero force member

Method of Sections

- Find Forces in Members 1, 2 and 3

$\theta = 36.86$; $LM = 1.5a$

$\Sigma M = 0$, $\Sigma P_y = 0$; $\Sigma P_x = 0$

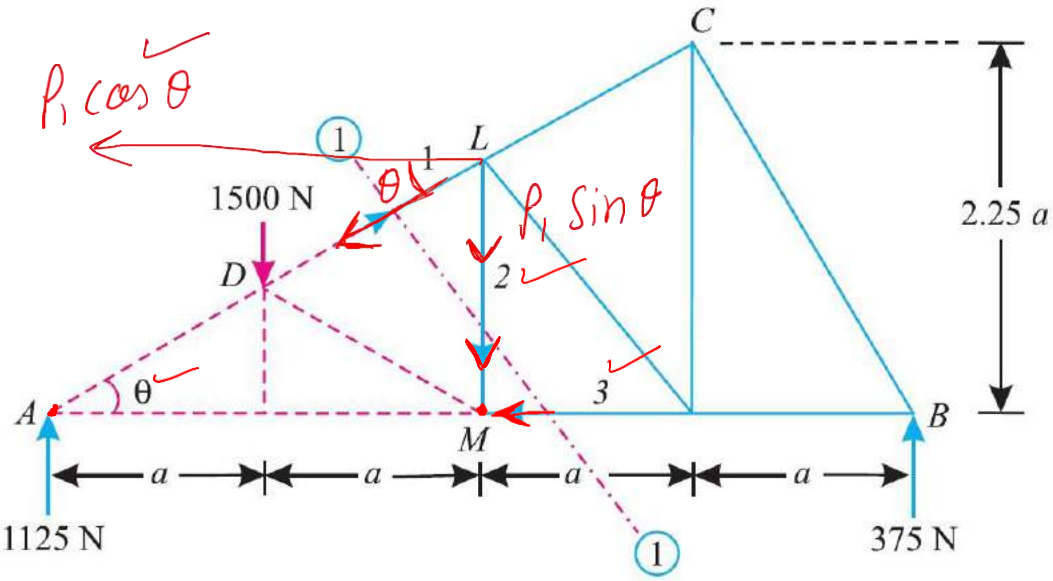
Soln $R_A + R_B = 1500\ N$

Taking moments about A

$CW = ACW$

$(1500 \times a) = R_B \times 4a$

$R_B = 375\ N$; $R_A = 1125\ N$



$P_1 \cos\theta$

$P_1 \sin\theta$

$\Sigma M_m = 0$

$(P_1 \cos 36.86 \times 1.5a) + (375 \times 2a) = 0$

$P_1 = -625\ N$ Ans

$\Sigma P_y = 0$

$375 - P_1 \sin 36.86 - P_2 = 0$

$P_2 = 750\ N$ Ans

$\Sigma P_x = 0$

$-P_1 \cos 36.86 - P_3 = 0$

$P_3 = 500\ N$ Ans

Find forces in Members BC, GC and GF

Sol: $R_A + R_E = 26\,kN$

Taking moments about A

$A_{cw} = c_w$

$(R_E \times 6) = (8 \times 1.5) + (6 \times 2) + (12 \times 4)$

$R_E = 12\,kN$; $R_A = 14\,kN$

$\Sigma M_G = 0$

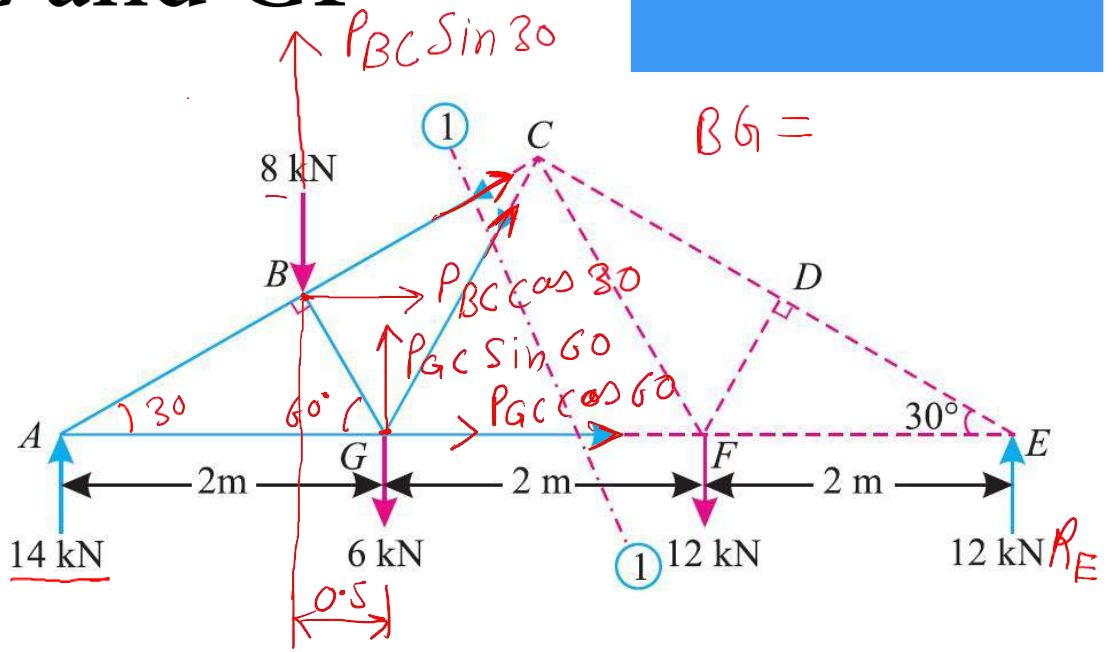
$(8 \times 0.5) - (14 \times 2) - (P_{BC} \times 2\cos 60) = 0$

$\boxed{P_{BC} = -24\,kN}$

$\Sigma P_y = 0$

$14 + P_{BC}\sin 30 + P_{GC}\sin 60 - 8 - 6 = 0$

$\boxed{P_{GC} = 13.85\,kN}$



BG =

$\Sigma P_x = 0$

$P_{BC}\cos 30 + P_{GC}\cos 60 + P_{GF} = 0$

$\boxed{P_{GF} = 13.85\,kN}$

Determine the forces in the members FH, HG and GI

Sol: $R_A = R_O = 35\ KN$

$\Sigma M_G = 0$

$(10\times2) + (10\times6) + (10\times10) - (35\times12) - (P_{FH}\times3.46) = 0$

$\boxed{P_{FH} = -69.36\ KN}$

$\Sigma P_y = 0$

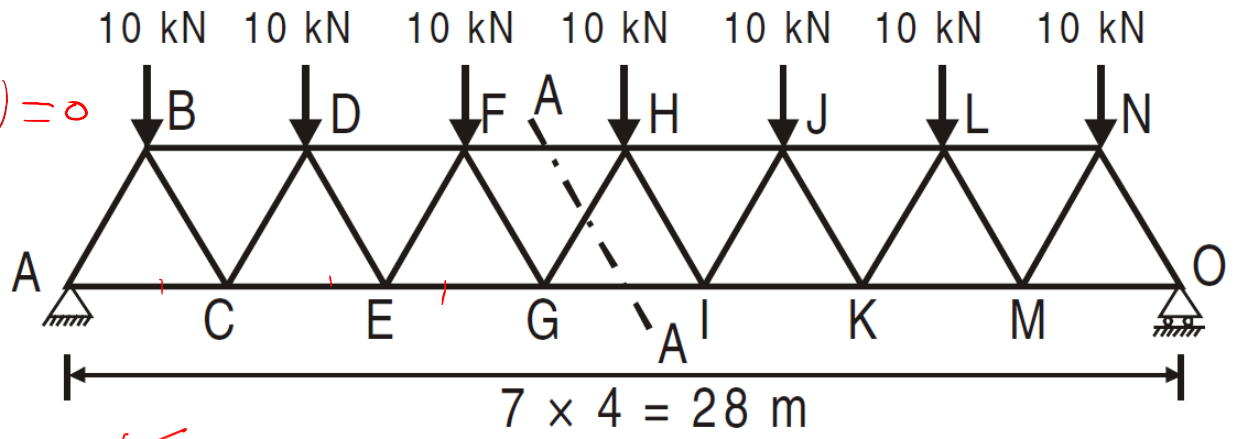
$35 + P_{GH}\sin 60 - 30 = 0$

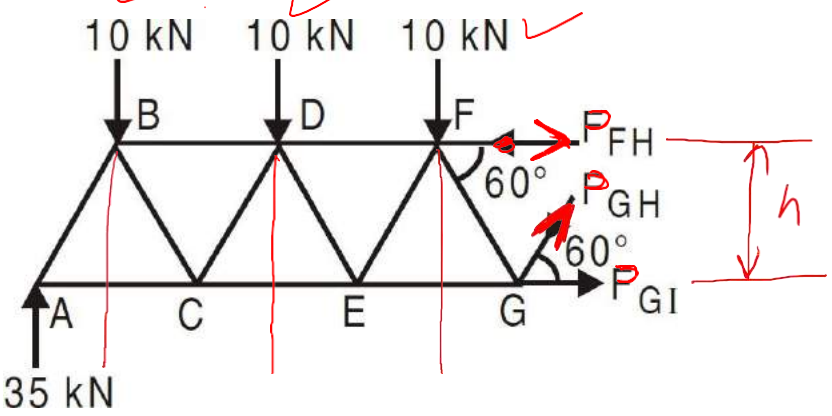
$\boxed{P_{GH} = -5.77\ KN}$

$\Sigma P_x = 0$

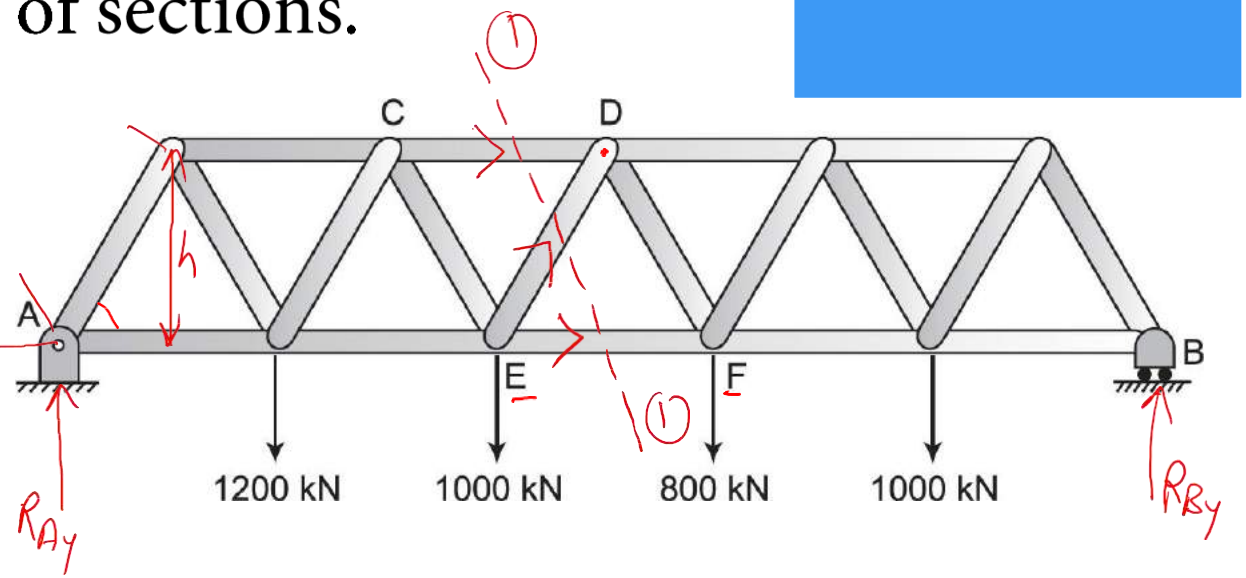
$P_{FH} + P_{GH}\cos 60 + P_{GI} = 0$

$\boxed{P_{GI} = 72.245\ KN}$





The length of each truss member in figure is 7 m. Find the forces in members CD, DE & EF using method of sections.



Sol: $R_{Ax} = 0$; $R_{Ay} + R_{By} = 4000\,KN$

Taking moments about A

$A(cw) = C(w)$

$R_{By} \times 35 = (1200 \times 7) + (1000 \times 14) + (800 \times 21) + (1000 \times 28)$

$R_{By} = 1920\ KN$; $R_{Ay} = 2080\ KN$

$\Sigma M_E = 0$

$(1200 \times 7) - (2080 \times 14) - (P_{CD} \times 7 \sin 60) = 0$

$P_{CD} = -3418\,KN$

$\Sigma F_y = 0$

$2080 + P_{DE} \sin 60 - 1200 - 1000 = 0$

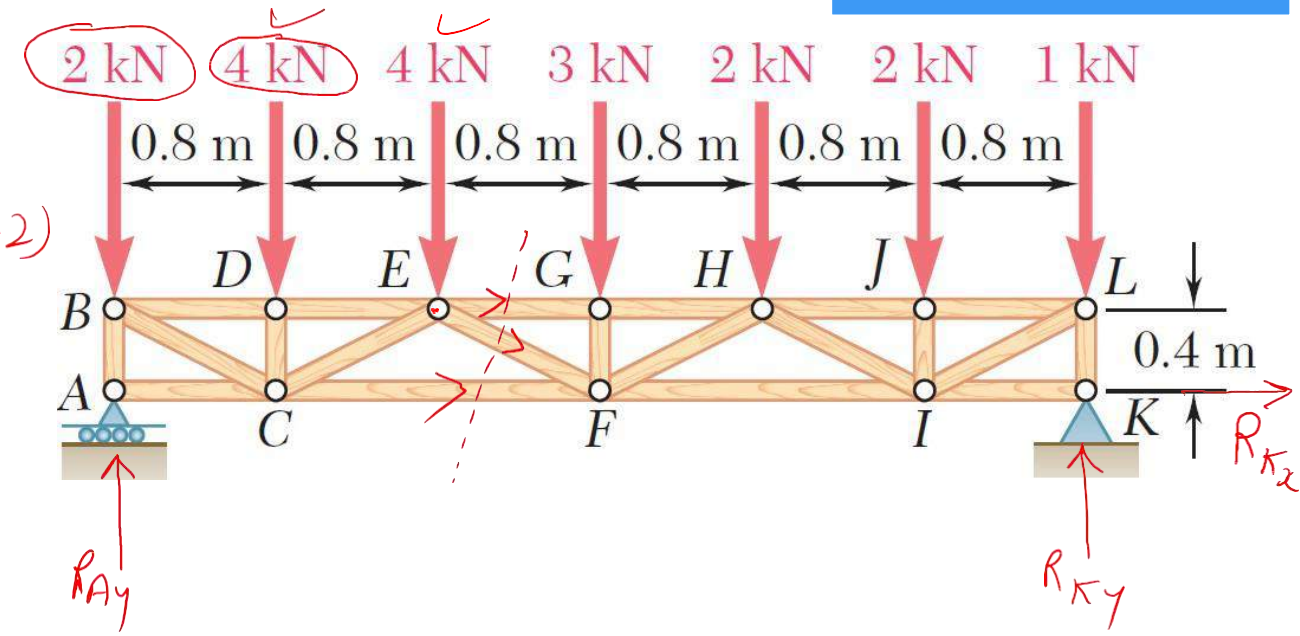
$P_{DE} = 138.56\,KN$

$\Sigma F_x = 0$

$P_{EF} + P_{DE} \cos 60 + P_{CD} = 0$

$P_{EF} = 3348.72\,KN$

Determine the force in members *CF*, *EF*, and *EG*.



Sol: $R_{Kx} = 0$; $R_{Ay} + R_{Ky} = 18$

Taking moments about A

ACW = CW

$R_{Ky} \times 4.8 = (4 \times 0.8) + (4 \times 1.6) + (3 \times 2.4) + (2 \times 3.2) + (2 \times 4) + (1 \times 4.8)$

$R_{Ky} = 7.5\ KN$; $R_{Ay} = 10.5\ KN$

$\Sigma M_E = 0$

$(4 \times 0.8) + (2 \times 1.6) + (P_{CF} \times 0.4) - (10.5 \times 1.6) = 0$

$P_{CF} = 26\ KN$

$\Sigma P_y = 0$

$10.5 - 2 - 4 - 4 - P_{EF} \sin 26.56 = 0$

$P_{EF} = 1.118\ KN$

$\Sigma P_x = 0$

$P_{EG} + P_{EF} \cos 26.56 + P_{CF} = 0$

$P_{EG} = -27.1\ KN$

Determine the force in members *BD* and *DE* of the truss shown

Sol:

$\Sigma M_E = 0$

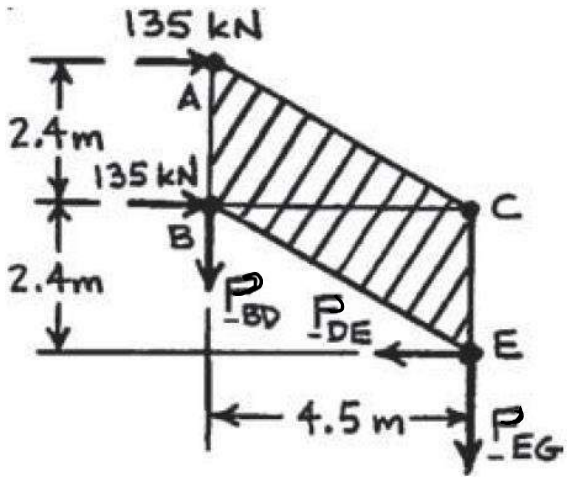
$(P_{BD} \times 4.5) - (135 \times 2.4) - (135 \times 4.8) = 0$

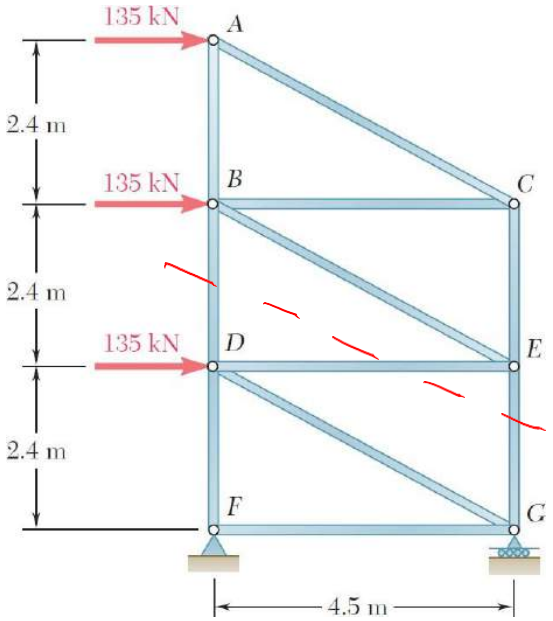
$P_{BD} = 216\ KN$

$\Sigma P_x = 0$

$(2 \times 135) - P_{DE} = 0$

$P_{DE} = 270\ KN$





Determine the force in members DG and EG of the truss shown

Sol.

$$\Sigma P_x = 0$$

$$(135 \times 3) + P_{DG} \cos 28.07 = 0$$

$$P_{DG} = -459\ \text{KN} \quad \text{Ans}$$

$$\Sigma M_D = 0$$

$$(-135 \times 2.4) - (135 \times 4.8) - (P_{EG} \times 4.5) = 0$$

$$P_{EG} = -216\ \text{KN} \quad \text{Ans}$$