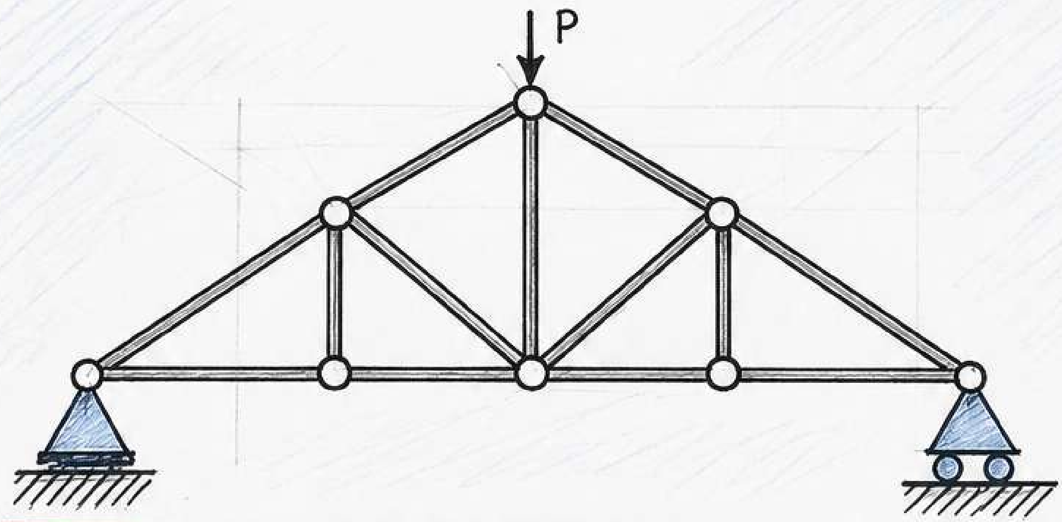
THEORY OF STRUCTURES

UNIT - 5

SIMPLE TRUSSES



Topics Covered :

- Types of Simple Trusses
- Analysis of Simple Trusses
- Method of Joints
- Method of Sections

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Department of Civil Engineering

Course Title- Theory of Structure **Course Code -**315313

Programme Name -Civil Engineering **Semester-**Fifth

Unit	Title	COs	Learning hours	R Level	U Level	A Level	Total Marks
V	Simple Truss	CO5	10	2	4	6	12

TOS- 315313

Unit -5
Simple Trusses

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*** 5.1 Introduction To Truss :-** A truss is a frame structure consisting of straight members connected through together at their ends by pin joints

The members are generally arranged in the form of triangles and are subjected mainly to axial forces, either tension or compression.

Examples: Roof Truss, bridge Trusses, industrial sheds, Transmission towers etc

*** characteristic of Truss :-**

1. Members are straight.
2. members are connected to at their ends
3. joints are assumed to be pin-jointed
4. loads are assumed to be act at joints only.
5. self weight of members is neglected or converted into joint loads.
6. Each members carries only axial force.
7. Member force is either - Tension, • compression

*** Assumptions for Analysis of Trusses :-**

1. All joints are assumed to be perfectly pin-joited
2. members are straight and uniform
3. Loads acts only at the joints.
4. self weight of member is neglected or considered as joint load.
5. Each member is a two force member
6. members carry only axial force.
7. Deformation of the truss is small.
8. The truss lies is one plane for plane-truss analysis.

Important :-

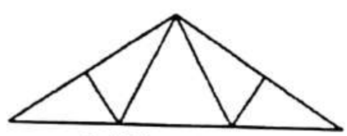
Tension → members tends to elongate

compression → members tends to shorten.

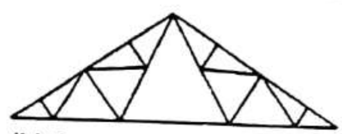
* 5.2 Types of Trusses :-

1. Simple Truss
2. Fink Truss
3. Compound fink Truss
4. French truss
5. Pratt truss
6. Howe Truss
7. North Light Truss
8. King post truss
9. Queen post truss.

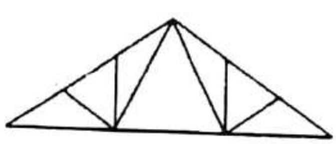
5.2 TYPES OF TRUSSES



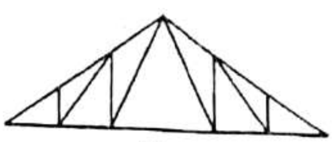
(a) Simple fink
(span 6 - 9 m)



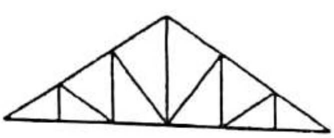
(b) Compound fink or french
(span 12 - 18 m)



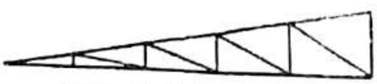
(c) Simple fan
(span 7.5 - 12 m)



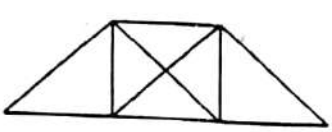
(d) Pratt
(upto 30 m)



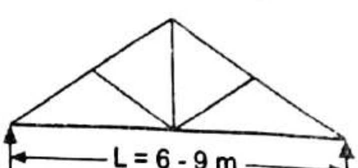
(e) Howe
(span 6 - 24 m)



(f) North light root truss
(span 8 - 10 m)



(g) Queen-post truss
(spans upto 10 m)



(h) King-post truss

* 5.3: Statically Determinate Frame/ Trusses

A frame, the members of which can be analysed by applying three static conditions of equilibrium

viz $\Sigma F_x = 0$

$\Sigma F_y = 0$ and

$\Sigma M = 0$ is called a statically determinate frame.

* 5.4. Classification of Frames / Trusses

The frames are classified into two main groups

1. Perfect frame 2. Imperfect frame

1. Perfect frame :- A frame which has members just sufficient to keep it in stable equilibrium when loaded at its joints is called a perfect frame. Its shape remain unchanged after loading.

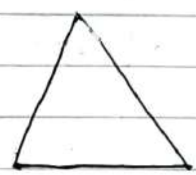


fig. Basic perfect frame

A triangle is a basic perfect frame which has three members pin jointed to each other and three joints. If this frame is loaded at its joints, its shape remains unchanged.

mathematically, a perfect frame is that which satisfies the relation $n = 2j-3$,

where n = No. of members

j = No. of joints

For triangle, $n = 3$, $j = 3$

Now $n = 2j-3 = 2\times3-3 = 3$

$n = 6-3$

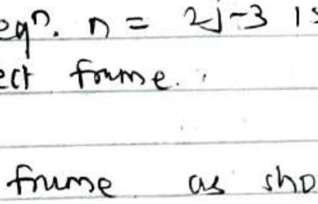
$n = 3$

2) Imperfect frame :- A frame in which the Number of members are more or less than $2j-3$ is called an imperfect frame.
Imperfect are classified into two types
i) Deficient frame and ii) Redundant Frame

i) Deficient frame :- A deficient frame is an imperfect frame in which the number of members are less than $2j-3$
mathematically, for deficient frame, $n < 2j-3$
$(2j-3)-n$ is called degree of deficiency.

ii) Redundant frame :- A Redundant frame is an Imperfect frame in which the Number of members are more than $2j-3$
mathematically, for a redundant frame, $n > 2j-3$
$n-(2j-3)$ is called degree of redundancy.

* consider a frame as shown in fig

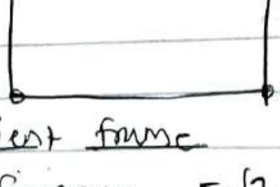


Here $n=5$, $j=4$
$2j-3 = 2\times4-3 = 5$
$= n$

fig- Perfect frame

since the g' eqn. $n = 2j-3$ is satisfied, the frame shown is a perfect frame.

* conside a frame as shown in fig.

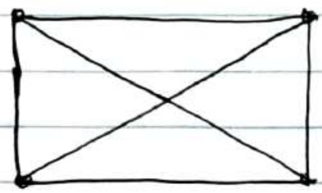


Here $n=4$, $j=4$
$2j-3 = 2\times4-3 = 5$
since $n < 2j-3$, the frame is deficient frame

fig. Deficient frame

* Degree of Deficiency $= (2j-3)-n$
$= 5-4 = \underline{\underline{1}}$

consider a frame as shown



Here $n = 6$, $j = 4$

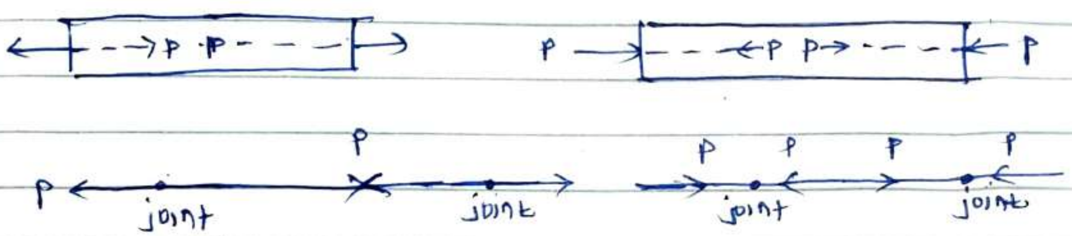
$2j-3 = 2 \times 4 - 3 = 5$

since $n > 2j-3$, the frame is redundant frame.

fig. Redundant frame

Degree of Redundancy $= n - (2j-3) = 6-5 = 1$

* Nature of Forces in members.



i) Tensile stress/ force

ii) compressive stress/ force

* Methods of Analytical / Analysis of frames

1) Analytical method → i) method of joint
ii) method of sections

2) Graphical method

* Calculate forces in Different members by using method of joints *

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Ex:-01) Determine the forces in the members AB, AD and DE of the cantilever frame shown in fig.

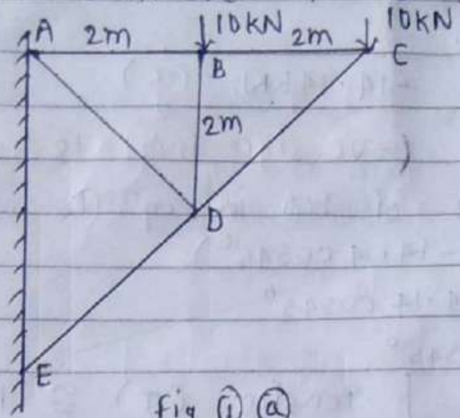

fig ① ⓐ

soln:- ⇒ simplify the given fig. as shown below for better understanding.

$$\tan \angle BCD = \frac{BD}{BC} = \frac{2}{2} = 1m \quad \therefore \angle BCD = 45^\circ$$

similarly $\angle BAD = 45^\circ$

since $\angle BCD = 45^\circ$, $\angle BAD = 45^\circ$, $\angle ABD = \angle CBD = 90^\circ$

$\angle BDC = \angle ADB = 45^\circ$

$\angle ADE = [180^\circ - (\angle BDC + \angle ADB)]$

$\therefore \angle ADE = [180^\circ - (45^\circ + 45^\circ)] = 90^\circ$

from the geometry of figure $\angle AED = \angle DAE = 45^\circ$

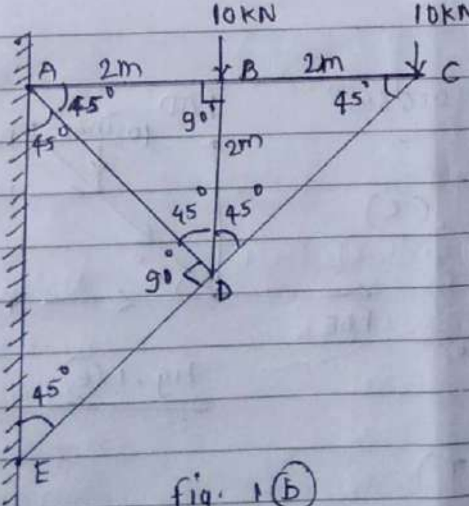

fig. 1 ⓑ

* Note → consider tension as +ve and compression as -ve

* consider the joint 'C'

→ + ← −

considering the equilibrium of joint B we get.

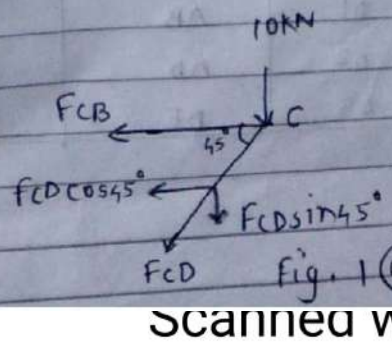

Fig. 1 ©

$\Sigma Fx = -F_{CB} - F_{CD} \cos 45^\circ$

$0 = -F_{CB} - F_{CD} \cos 45^\circ$ — i)

* $\sin 45^\circ \Rightarrow 0.70$ *
* $\cos 45^\circ \Rightarrow 0.70$ *
* $\tan 45^\circ \Rightarrow 1$ *

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$\overset{+}{\uparrow}\overset{-}{\downarrow}$, $\Sigma f_y = -10 - F_{CD}\sin 45^\circ$

$0 = -10 - F_{CD}\sin 45^\circ$

$\therefore F_{CD}\sin 45^\circ = -10$

$\therefore F_{CD} = \dfrac{-10}{\sin 45^\circ} = -14.14\,kN$ (C)

(-ve sign indicate compression)

Substituting the value of FCD in eq^n. ① we get

① $\rightarrow$ $0 = -F_{CB} - (-14.14\cos 45^\circ)$

$0 = -F_{CB} + 14.14\cos 45^\circ$

$\therefore F_{CB} = 14.14\cos 45^\circ$

$\therefore \boxed{F_{CB} = 9.99\,kN}$ Tensile (T) $\cong$ 10kN (T)

* Consider joint 'B'

$\overset{+}{\rightarrow}\overset{-}{\leftarrow}$, $\Sigma f_x = 9.99 - F_{BA}$

$0 = 9.99 - F_{BA}$

$\therefore F_{BA} = 9.99 \cong 10\,KN$ (T)

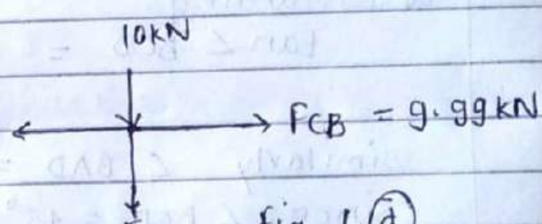

fig 1.(d)

$\overset{+}{\uparrow}\overset{-}{\downarrow}$, $\Sigma f_y = -10 - F_{BD}$

$0 = -10 - F_{BD}$

$\boxed{F_{BD} = -10\,KN}$ (C)

* Consider joint 'D'

$\overset{+}{\rightarrow}\overset{-}{\leftarrow}$, $\Sigma F_x = -F_{DE} - 14.14 - 10\cos 45^\circ$

$0 = -F_{DE} - 21.21$

$\boxed{F_{DE} = -21.21\,KN}$ (C)

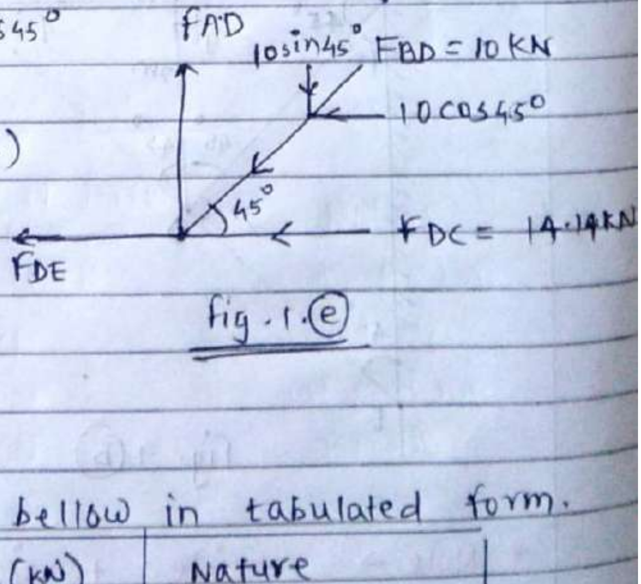

fig. 1.(e)

$\overset{+}{\uparrow}\overset{-}{\downarrow}$, $\Sigma F_y = f_{AD} - 10\sin 45^\circ$

$0 = f_{AD} - 10\sin 45^\circ$

$\therefore f_{AD} = 10\sin 45^\circ$

$\therefore \boxed{f_{AD} = 7.07\,KN}$ (T)

* Result is mentioned as bellow in tabulated form.

Sr. No	member	magnitude (KN)	Nature
01	AB	10	Tensile
02	AD	7.07	Tensile
03	DE	21.21	Compressive.

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Ex:-02 Determine the forces along with nature in the members AB, AE, EB and EF For frame subjected to a load as shown in fig 2a using method of joints.

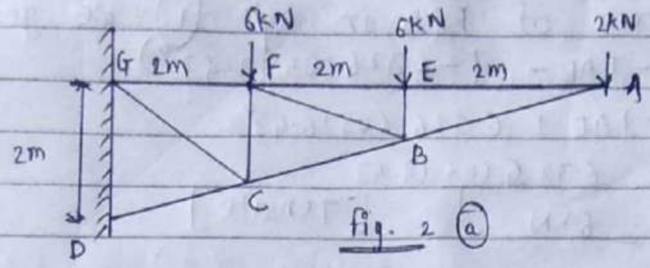


fig. 2 (a)

$\Rightarrow$ Draw the fig. fig. 2 (b) for futher calculation.

$$\tan\theta = \frac{2}{6} = \frac{1}{3}$$

$$\therefore \theta = \tan^{-1}\left(\frac{1}{3}\right) = 18.43^\circ$$

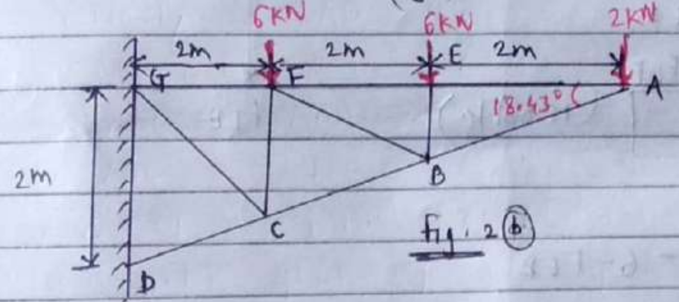


fig. 2 (b)

* consider joint 'A'

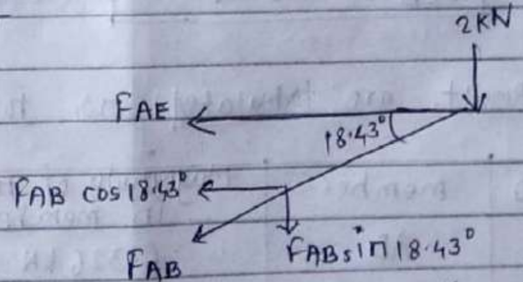


fig. 2 (c)

Assume FAE and FAB to be tensile. Take tension positive and compression negative

$\rightarrow +$

$\leftarrow -$; $\Sigma F_x = -F_{AE} - F_{AB}\cos 18.43^\circ$

$0 = -F_{AE} - F_{AB}\cos 18.43^\circ$ --- i)

$\uparrow + \quad \downarrow -$; $\Sigma F_y = -2 - F_{AB}\sin 18.43^\circ$

$0 = -2 - F_{AB}\sin 18.43^\circ$

$F_{AB} \sin 18.43^\circ = -2$

$\therefore F_{AB} = \dfrac{-2}{\sin 18.43^\circ}$

$\boxed{F_{AB} = -6.326\,KN}$ [comp.]

put the value of FAB in eqn. (1) we get.

i) $\Rightarrow \quad 0 = -F_{AE} - (-6.326 \cos 18.43^\circ)$

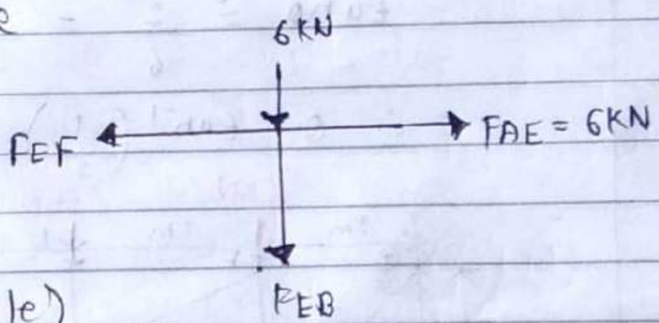
$0 = -F_{AE} + 6.326 \cos 18.43^\circ$

$\therefore \quad F_{AE} = 6.326 \cos 18.43^\circ$

$\boxed{F_{AE} = 6\,KN}$ [Tensile]

* consider joint 'E' :-

Assume FEF and FEB to be Tensile



$\rightarrow +$

$\leftarrow -$; $\Sigma F_x = 6 - F_{EF}$

$0 = 6 - F_{EF}$

$\therefore \boxed{F_{EF} = 6\,KN}$ (Tensile)

$+\uparrow$

$-\downarrow$; $\Sigma F_y = -6 - F_{EB}$

$0 = -6 - F_{EB}$

$\therefore \boxed{F_{EB} = -6\,KN}$ (comp.)

* Result are tabulated as follows :-

Sr. NO	member	Magnitude of force in member	Nature
01	AB	6.326 KN	compressive
02	AE	6KN	Tensile
03	EB	6KN	compressive
04	EF	6KN	Tensile.

* Simple Trusses *

Solved Examples on Methods of section

Ex:-1) Using method of sections determine the forces in member AB and DE for the truss shown in Fig.

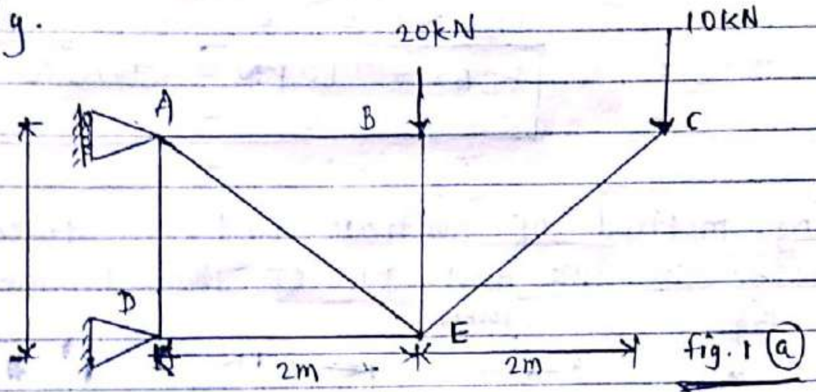


fig. 1 (a)

* Take Tension as positive and Negative as compressive

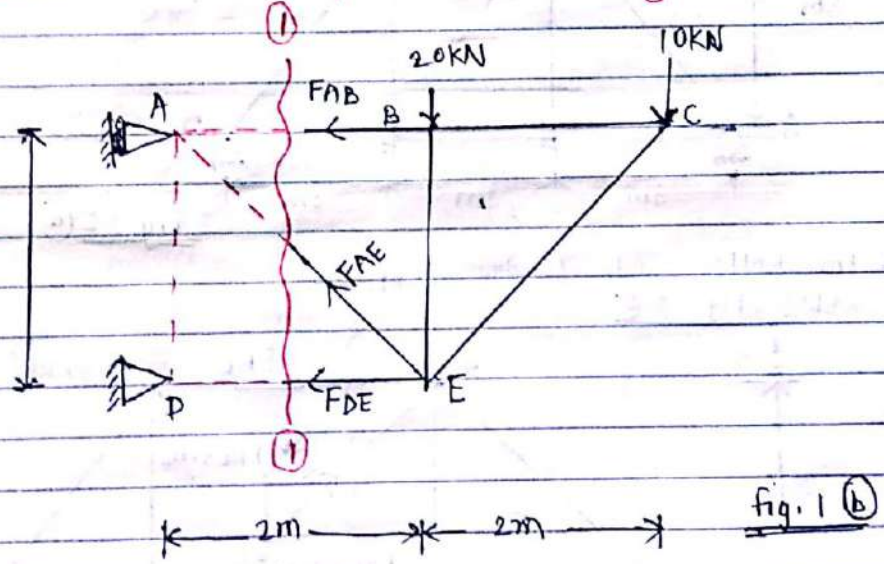


fig. 1 (b)

Let us consider equilibrium of right part of section 1-1

Assume FAB, FAE and FDE to be Tensile

Taking moment about joint 'A' we get

$$\Sigma M_A = 10 \times 4 + 20 \times 2 + FDE \times 2$$

$$0 = 40 + 40 + 2FDE$$

$$0 = 80 + 2FDE$$

$$2FDE = -80$$

$$\therefore FDE = \frac{-80}{2}$$

$$\therefore \boxed{FDE = -40\ kN}$$ Ans. [comp.]

∴ [Negative sign indicate compressive]

Now, Taking moment on joint 'E'

[↻ +, ↺ −] ; $\Sigma M_E = 10\times2 + 20\times0 - F_{BA}\times2 + F_{AE}\times0$

$0 = 20 - 2F_{BA}$

$F_{BA}\times2 = 20$

$\boxed{F_{BA} = 10\,KN \quad \text{Tensile}}$ Ans

Ex:- 2> Using method of section Find the forces in the member BC, BE and FE of the frame as shown in Fig.

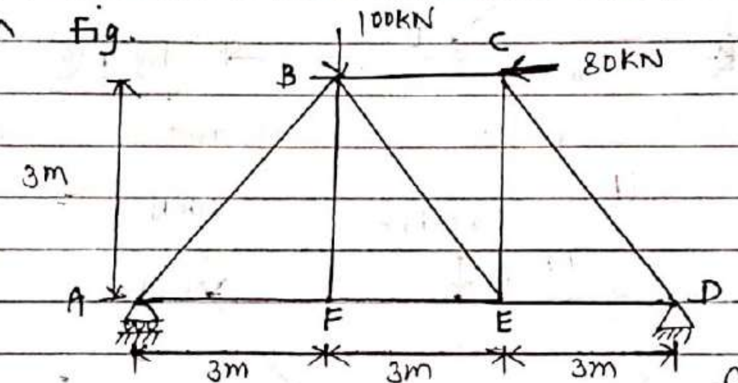


fig. 2(a)

* For better understanding refer Fig. 2(b)

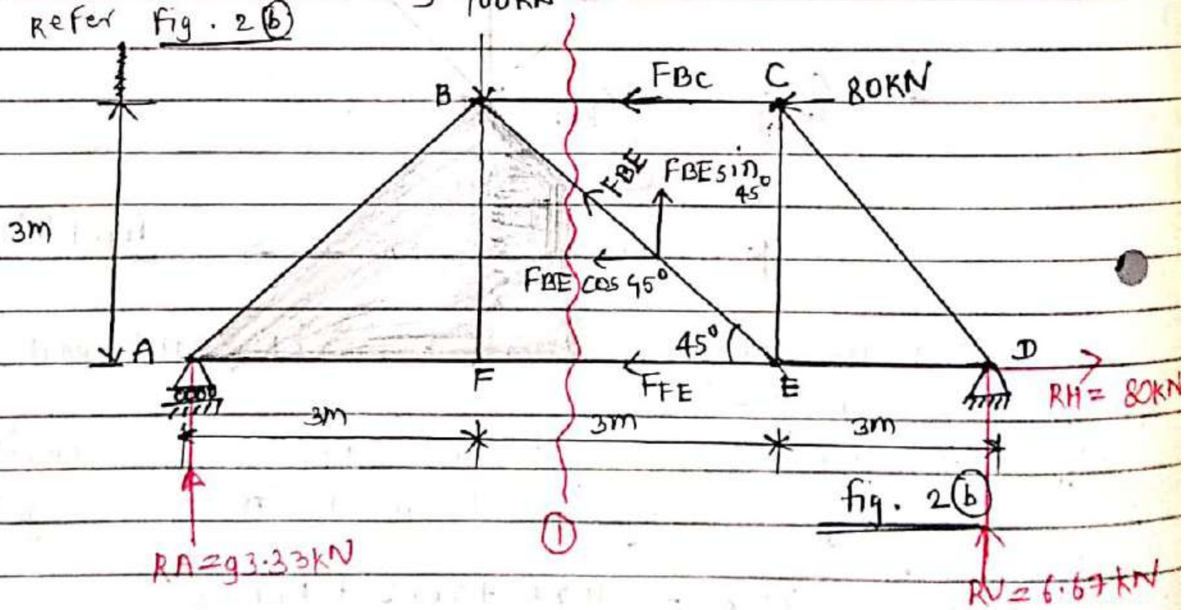


fig. 2(b)

* To find reactions at support A and D at Hinge support, consider the direction of the reaction RH and RV as shown in Fig 2(b)

[→ +, ← −]

$\Sigma F_x = R_H - 80$

$0 = R_H - 80$

$\therefore \boxed{R_H = 80\,KN} \rightarrow$

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$\begin{bmatrix} + \uparrow \\ - \downarrow \end{bmatrix}$; $\Sigma F_y = RV - 100 + RA$

$0 = RV - 100 + RA$

$\therefore RV + RA = 100$ ---- i)

Taking moment @ A

$[\circlearrowleft + \quad \circlearrowright -]$ $\Sigma M_A = 100 \times 3 - 80 \times 3 - RV \times 9$

$0 = 300 - 240 - 9RV$

$0 = 60 - 9RV$

$\therefore 9RV = 60$

$\therefore RV = \dfrac{60}{9}$ $\therefore$ $\boxed{RV = 6.67 \text{ kN}}$

substituting $RV = 6.67$ kN in eqn. (i) we get

$RV + RA = 100$

$RA = 100 - 6.67$

$\boxed{RA = 93.33 \text{ kN}}$ Ans.

* To find the forces in the members BC, BE and FE by method of section.

Consider a section ①-① which cuts the members BC, BE and FE as shown in fig. let us consider the right part of section ①-①. Assume FBC, FBE and FFE to be tensile take tensile as positive and compressive as Negative.

* Taking moment at 'E'

$[\circlearrowleft + \quad \circlearrowright -]$; $\Sigma M_E = -F_{BC} \times 3 - 80 \times 3 - 6.67 \times 3$

$0 = -3F_{BC} - 240 - 20.01$

$0 = -3F_{BC} - 260.01$

$3F_{BC} = -260.01$

$\boxed{F_{BC} = -86.67 \text{ kN}}$ [Comp.]

* Taking moment at B

$[\circlearrowleft + \quad \circlearrowright -]$; $\Sigma M_B = F_{FE} \times 3 - 6.67 \times 6 - 80 \times 3$

$0 = 3F_{FE} - 280.02$

$3F_{FE} = 280.02$

$\therefore F_{FE} = \dfrac{280.02}{3} = 93.34$ kN (Tensile)

$\boxed{F_{FE} = 93.34 \text{ kN}}$ [Tensile]

Now Resolving the forces Horizontally, we get

$\rightarrow +$

$\leftarrow -$

$$\Sigma F_x = -F_{BC} - 80 - F_{BE}\cos 45^\circ - F_{FE} + 80$$

$$0 = -(-86.67) - 80 - F_{BE}\cos 45^\circ - 93.34 + 80$$

$$0 = 86.67 - 80 - F_{BE}\cos 45^\circ - 93.34 + 80$$

$$0 = -6.67 - F_{BE}\cos 45^\circ$$

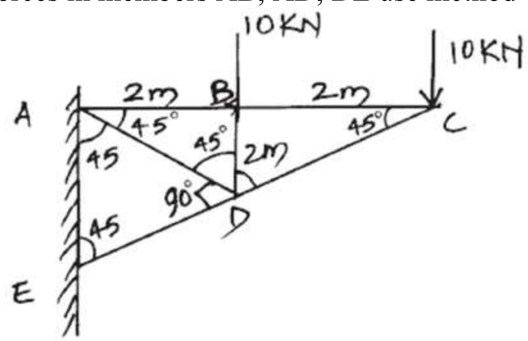
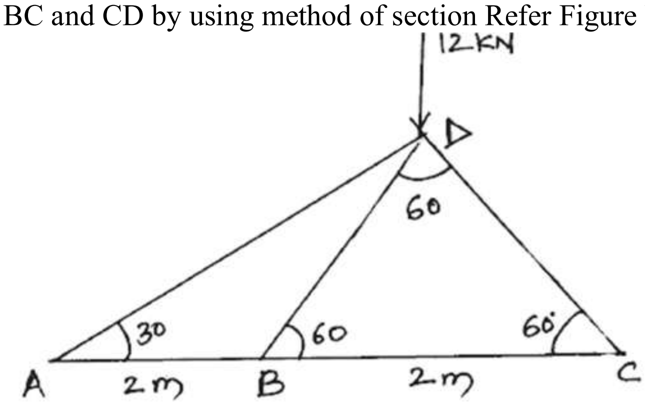
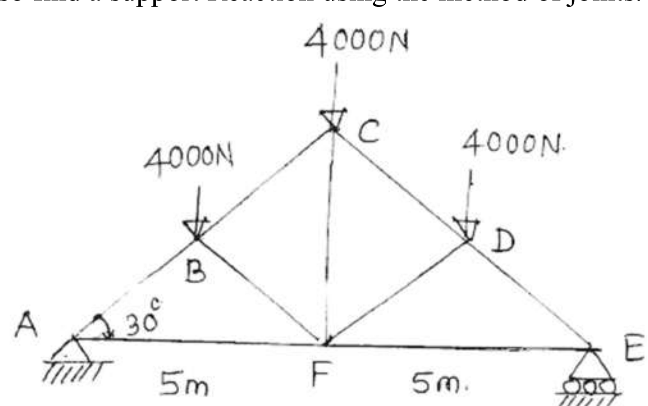
$$F_{BE} = \frac{-6.67}{\cos 45^\circ}$$

$$\boxed{F_{BE} = -9.43\,kN}$$ [comp.]

* Force Table *

Sr No	member	magnitude	Nature
01	BC	86.67 kN	compressive
02	BE	9.43 kN	compressive
03	FE	93.34 kN	Tensile.

Unit-5 Simple Trusses (Question Bank)

Que.No.	2 marks Questions
1	Enlist any four types of Trusses.
2	Define perfect frame with neat sketch.
3	Define perfect frame by giving equation.
4	State the condition for redundant and non-redundant frames.
	4 or 6 marks Questions
5	State the four assumptions made in analysis of simple frame.
6	Draw sketches of any four types of trusses.
7	Determine forces in members AB, AD, DE use method of joints. Refer Figure No. 4.  **Fig. No. 4**
8	Determine forces in AB, BC and CD by using method of section Refer Figure No. 5.  **Fig. No. 5**
9	State the method of Analysis of the frame and explain any one in details.
10	Determine the nature and magnitude of forces in the members (AB, BC, FD and CF) of the frame as shown in Figure No. 7. Also find a support Reaction using the method of joints.  **Fig. No. 7**
11	Using the method of sections calculate the magnitude of forces and its nature of members BC, BE and

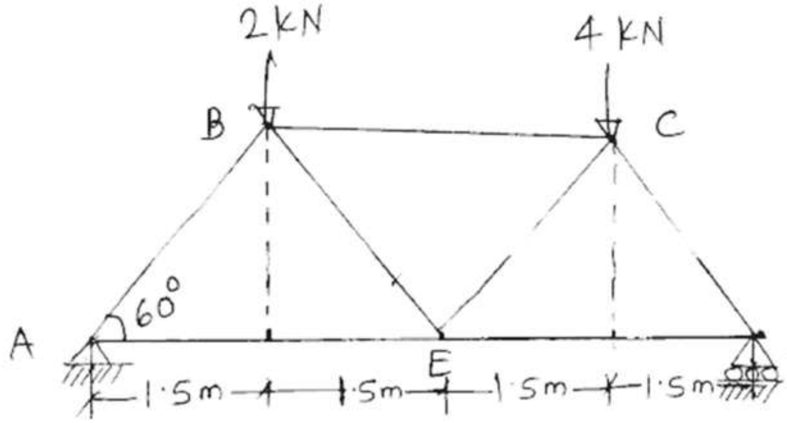
<table>
<tr><td></td><td>AE. For frame as shown in Figure No. 8.


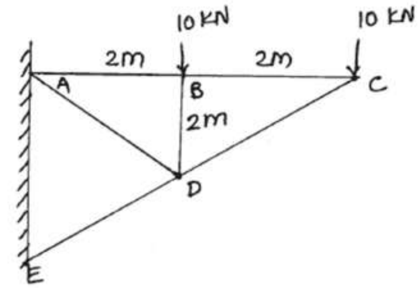
Fig. No. 8</td></tr>
<tr><td>12</td><td>Determine the forces in the members AB, AD and DE of the cantilever frame as shown in Figure No. 6 by method of section.


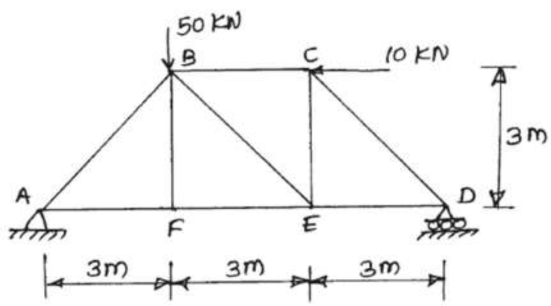
Fig. No. 6</td></tr>
<tr><td>13</td><td>Find forces in the members of BC, BE and FE of the frame as shown in Figure No. 07.


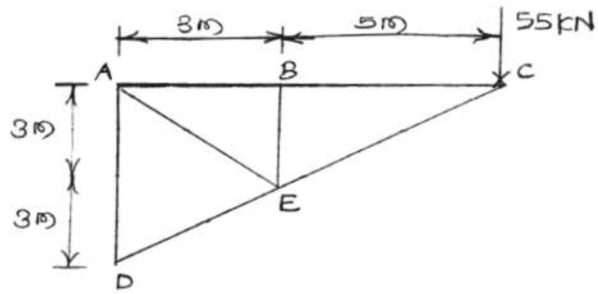
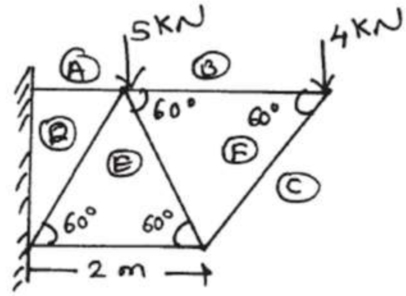
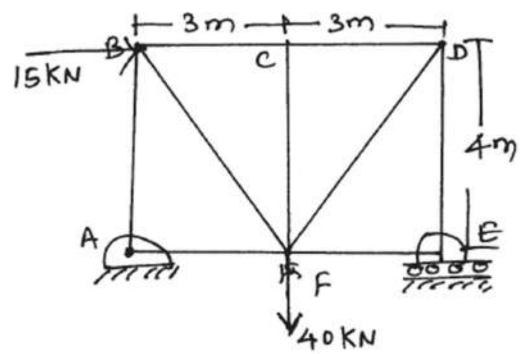
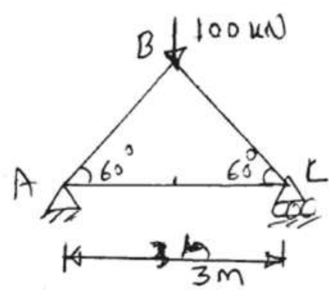
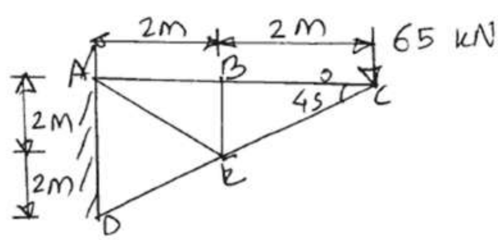
Fig. No. 7</td></tr>
<tr><td>14</td><td>Calculate magnitude and state nature of forces in members AB and AE and DE only by using method of section for a truss as shown in Figure No. 9.


Fig. No. 9</td></tr>
</table>

15	cantilever truss as shown in Fig. No. 6. Find the forces in the member BF, EC, EF and FC method of Joint.  **Fig. No. 6**
16	Determine the forces in any six members of the truss as shown in Fig. No. 7. Tabulate the results using method of section.  **Fig. No. 7**
17	Using method of joints calculate magnitude and state nature of forces in all members of the truss as shown in Fig. No. 8.  **Fig. No. 8**
18	Calculate magnitude and state nature of forces in members ABand AE and DE only by using method of sections for a truss as shown in Fig. No. 9.  **Fig. No. 9**