TRUSSES

(1) ENGINEERING STRUCTURES

Any system of connected member's built to support or transfer forces acting on them and to safely withstand forces.

Type

(a) Trusses

(b) Frames

(c) Machines.

TRUSS: It is a system of uniform bars or members (of circular section, angle section, channel section etc.) joined together at the ends by rivetting or welding and connected to support loads. The members of a truss are straight members and loads are applied ~~at~~ only at joints. Every ~~f~~member of a truss is a two force member Fig(1)

7 Joints (J)

11 members (m)

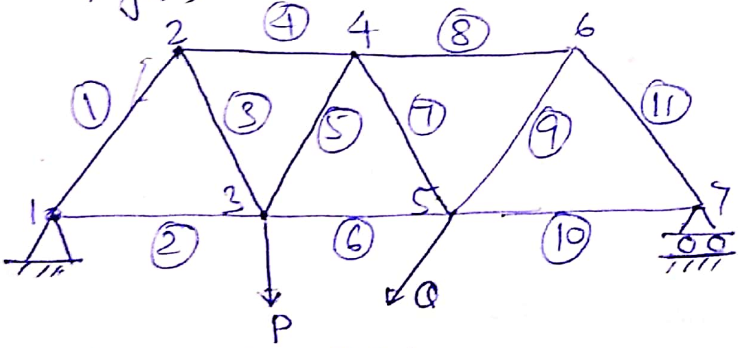
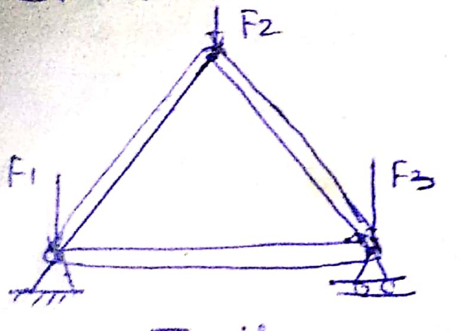


Fig 1.

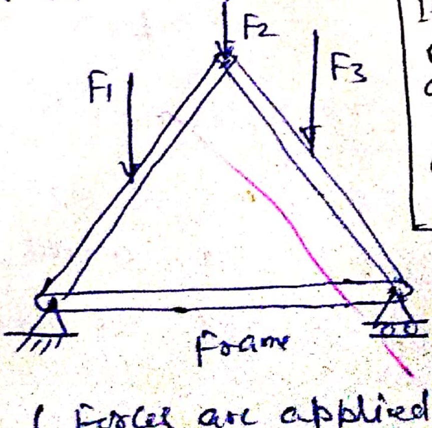
FRAME: It is a structure consisting several bars or members pinned together and in which one or more than one of its member is subjected to more than two forces. They are designed to support loads and are stationary structure.

MACHINE: Machines are structures to transmit forces and contain some moving members.

We shall discuss only plane structures, that is, structures whose members lie in one plane.



(Forces are applied at the joints)



(Forces are applied on the member)

Fig(2)

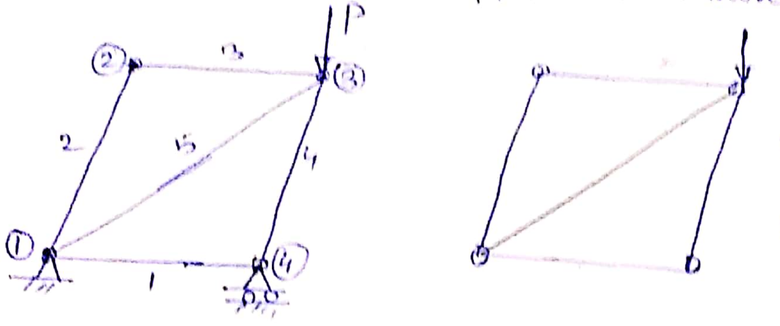
Types of Trusses:

I) plane Truss:
If all the members of a truss lie in a single plane, such a truss is called plane truss.
Example: Roof Truss
Bridge Truss.

II) Space Truss
If all the members of truss does not lie in a single plane then truss called space Truss

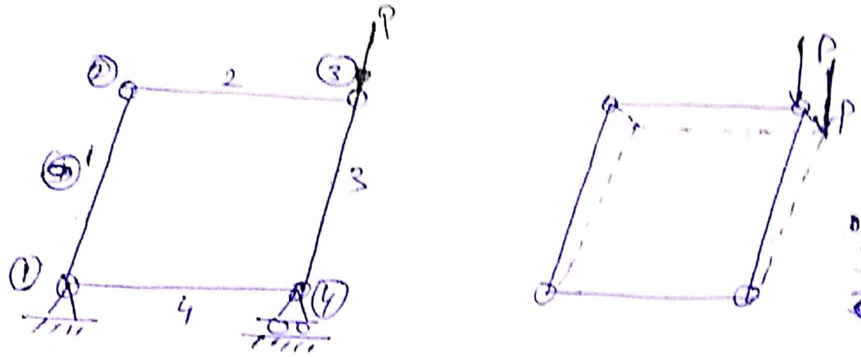
(2) RIGID OR PERFECT TRUSS

- The term rigid with reference to truss means noncollapsible truss when external supports are removed.



$m = 5$
$J = 4$
~~$m+J$~~ $m = 2J - 3$

Noncollapsible



$m = 4$
$J = 4$
$m < 2J - 3$

Collapsible

Fig. (3)

Mathematical Condition for Rigid or perfect Truss;

1). $m = 2J - 3$ (for rigid or perfect truss)

m = number of members in the truss
J = number of joints in the truss

Redundant truss

if $m > 2J - 3$ Truss contains more members than required to be just rigid and it is over rigid and statically indeterminate.

Deficient or imperfect truss

if $m < 2j - 3$ Truss contains less members than required to be just rigid and is collapsible or under rigid

Statically Determinate ! A truss is statically determinate if the equations of static equilibrium alone are sufficient to determine the axial force in the members without the need of considering their deformations.

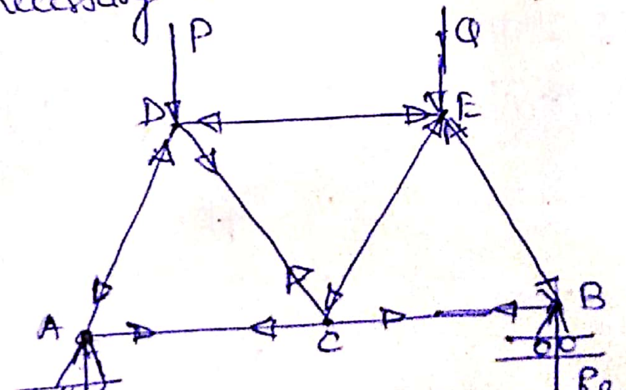
Basic Assumptions for the perfect Truss.

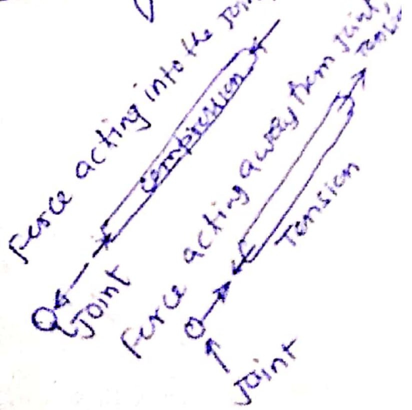
1. The joints of a simple truss are assume to be pin connections and frictionless. The joints therefore can't resist moments.
2. The loads on the truss are applied at the joints only.
3. The members of a truss are straight two force force member's with forces members with the forces acting colliner with the centre line of the members.
4. The weight of members are negligibly small otherwise mentioned.
5. The ~~stru~~ truss is statically determinate.

TRUSS: DETERMINATION OF AXIAL FORCES IN THE MEMBERS

Various Methods
(1) Method of Joint's
(2) Method of sections
(3) Graphical Method.

(1) Method of Joints. In this method the equilibrium of each joint is considered. Compute the support reactions using equations of equilibrium. Determination of support reactions may not be necessary in case of a cantilever type of truss.

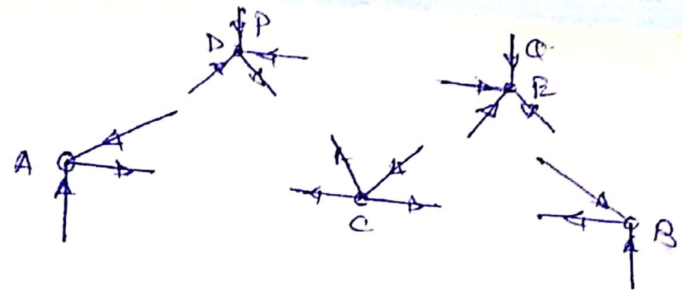




Representation of tension in the member AC. Arrow points away from the joints A and C (pull at the joint)

Representation of compression in the member EB. Arrow point towards the joints E and B (push at the joint).

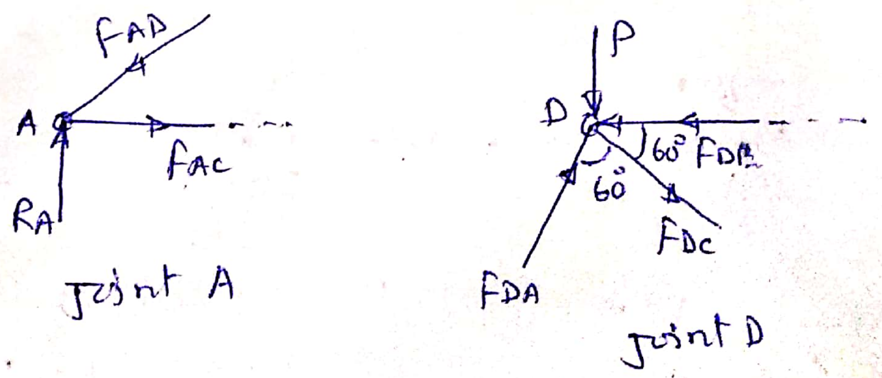
Fig 4



Fig(b)

Assume and mark the directions of the axial forces in the members on the diagram as shown in fig(a). ~~If the solution~~ If in the solution the magnitude of a force comes out to be negative the assumed direction of the force in the member is simply reversed.

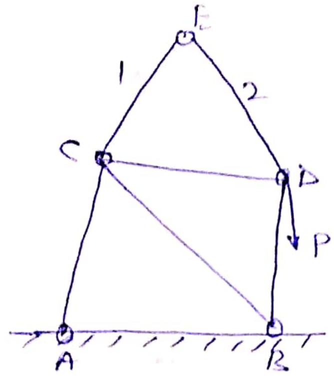
Choose a joint (fig b) and consider its free body diagram. The forces acting on the joint represent a system of concurrent forces in equilibrium. Therefore only two equations of equilibrium can be written for the each joint and can be solved to determine only two unknown forces. Therefore start from a joint where not more than two unknown forces appeared. For example, we should start from point A and not from joint D (fig c)

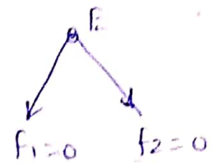


Consider the equilibrium for the remaining joints.

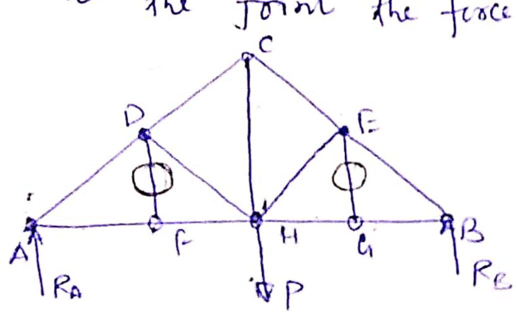
...conditions.

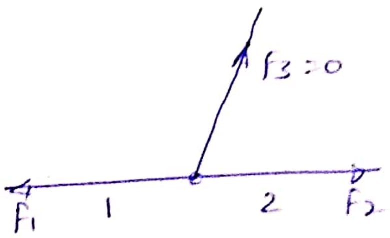
1. When two members meeting at a point are not collinear and there is no external force acting at the joint, then the forces in both the members are zero.

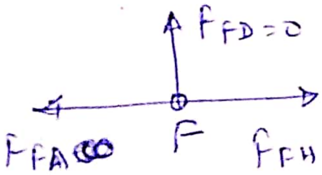


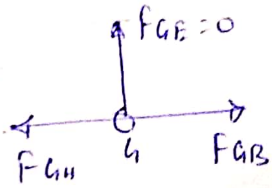


2. When there are three members meeting at a ~~point~~ joint, of which two are collinear and the third be at angle and if there is no load at the joint the force in the third member is zero

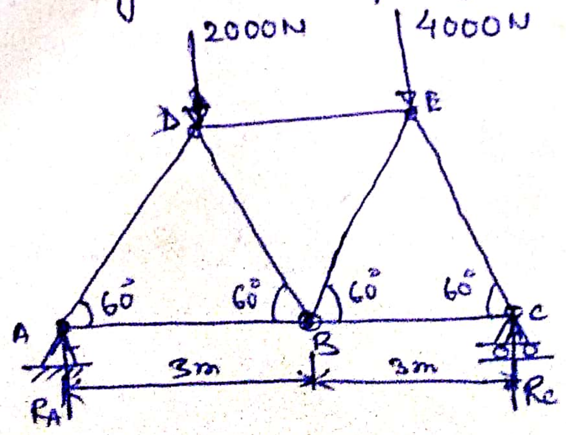








Ex(1) using the method of joints, find axial forces in all the members of a truss with the loading shown in Fig.



Sol^n : To determine the support reactions consider the equilibrium of entire truss.

In general, the reaction at a hinge can have two components acting in the horizontal and the ~~horizontal~~ vertical directions

As there is no horizontal external force acting on truss, so the horizontal component of reaction at A is zero

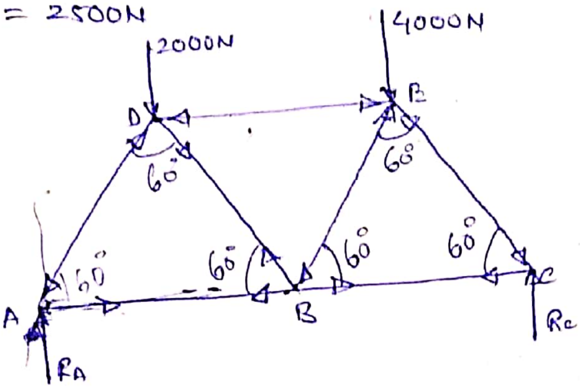
$\Sigma M_A = 0$

$\Rightarrow \quad 2000 \times 1.5 + 4000 \times 4.5 - R_C \times 6 = 0$

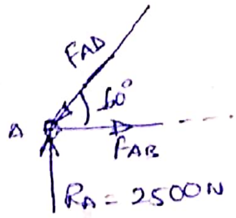
$\Rightarrow \quad R_C = 3500N$

$\Sigma F_y = 0 \qquad R_A + R_C - 2000 - 4000 = 0$

$R_A = 2500N$



Joint A: Let us begin with the joint A at which there are only two unknown forces. We cannot begin with the joint D, because, there are three unknown forces acting at the joint D.



Joint A

Consider the free body diagram of the joint A.
For equilibrium

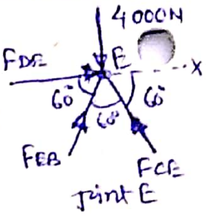
$\Sigma F_x = 0: \quad F_{AB} - F_{AD} \cos 60° = 0 \quad ------ (I)$

$\Sigma F_y = 0: \quad R_A - F_{AD} \sin 60° = 0 \quad ------ (II)$

$F_{AD} = \frac{R_A}{\sin 60°} = \frac{2500}{0.866} = 2887N (C)$ Ans

$F_{AB} = F_{AD} \cos 60° = 2887 \times 0.5 = 1443\ N (T)$ Ans.

Joint E



Joint E

$F_{DE} = 1732N$

$F_{CE} = 4041N$

$\Sigma F_x = 0$

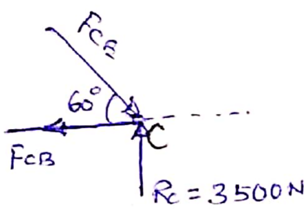
$F_{DE} + F_{EB} \cos 60° - F_{CE} \cos 60° = 0$

$F_{EB} \cos 60° = F_{CE} \cos 60° - F_{DE}$

$F_{EB} = 577 (C)$

The magnitudes of the forces F_{AB} and F_{AD} are both coming out be positive. therefore, the assumed direction of the forces are correct.

Joint C



Joint C

$\Sigma F_x = 0 \quad F_{CE} \cos 60° - F_{CB} = 0 \quad --- (III)$

$\Sigma F_y = 0 \quad R_C - F_{CE} \sin 60° = 0 \quad --- (IV)$

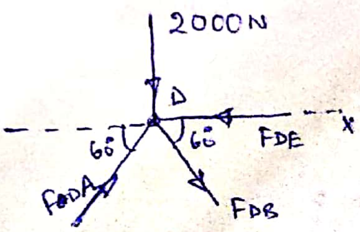
$F_{CE} = \frac{R_C}{\sin 60°} = \frac{3500}{0.866}$

$F_{CE} = 4041\ N (C)$ Ans

from eqn (III) $\quad F_{CB} = R_{CE} \cos 60°$

$= 4041 \times \frac{1}{2} = 2020.5\ N (T)$ Ans.

Joint D.



Joint D

$\Sigma F_x = 0: \quad F_{DB} \cos 60° + F_{AD} \cos 60° - F_{DE} = 0 \quad (V)$

$\Sigma F_y = 0; \quad F_{AD} \sin 60° - F_{DB} \sin 60° - 2000 = 0 \quad (VI)$

$F_{DB} = 577\ N (T)$ Ans

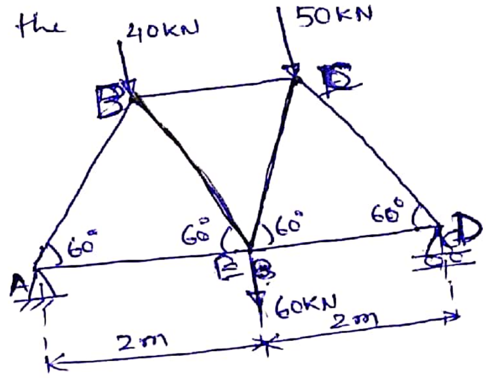
from (V) $\quad F_{DE} = 1732\ N (C)$

Note: There is no need ~~of~~ to consider the equilibrium of the joint B as all the forces have been determined.

Now all the forces are found so draw a table.

Sl.No	Member	Force (Newton)	Nature
~~AB~~ 1	AB	1443	Tensile
2	AD	2887	Compressive
3	BD	577	Tensile
4	DE	1732	Compressive
5	BE	577	Compressive
6	BC	2020.5	Tensile
7	CE	4041	Compressive

Q(2) Determine the forces in all members of the truss shown in the figure.



Ans.

Sl.No	Member	Force	Nature
1	AB	83.71	C
2	BC	60.61	T
3	CD	89.48	C
4	ED	44.74	T
5	EC	31.75	T
6	BE	37.52	T
7	AE	41.85	T

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THE METHOD OF SECTIONS

In this method, the equilibrium of a portion of the truss is considered which is obtained by cutting the truss by some imaginary section

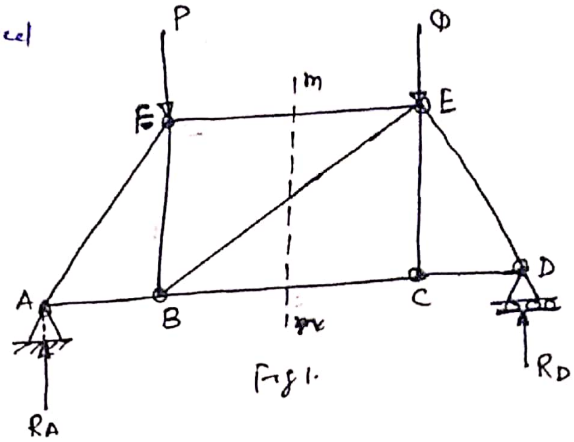


Fig 1.

consider a truss as shown in fig. 1. cut the truss into two separate portions by passing an imaginary section through those members in which forces to be determined.

The section mn cuts the members FE, BE & BC and the internal forces in these members become external forces as shown in fig. 2

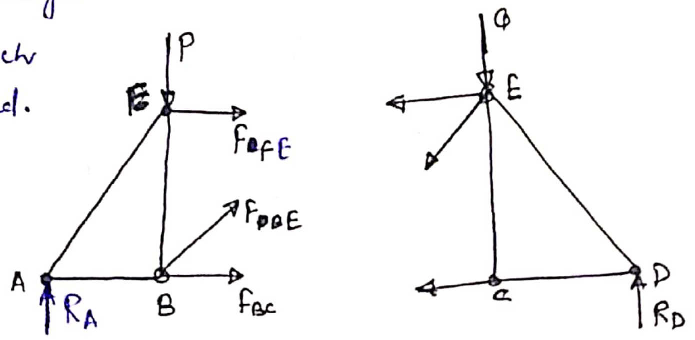


Fig 2

The equilibrium of the entire truss implies that every part of the truss would also be in equilibrium.

So $\Sigma F_x = 0$

$\Sigma F_y = 0$

& $\Sigma M = 0$

can be written for any one portion of the truss and can be solved to determine the ~~two~~ three unknowns.

Following points should be noted while using the method of Sections.

1. The section should be passed through the members and not through the joints.
2. A section should divide the truss into two clearly separate and unconnected portions.
3. A section should cut only three members since only three members since only three unknown can be determined from the three equations of equilibrium. However in special cases more than three members may be cut by a section.
4. When using a moment equation, the moment can be taken about any convenient point which may or may not lies on the section under consideration.

I: Find axial force in the member DE of the truss using the method of sections.

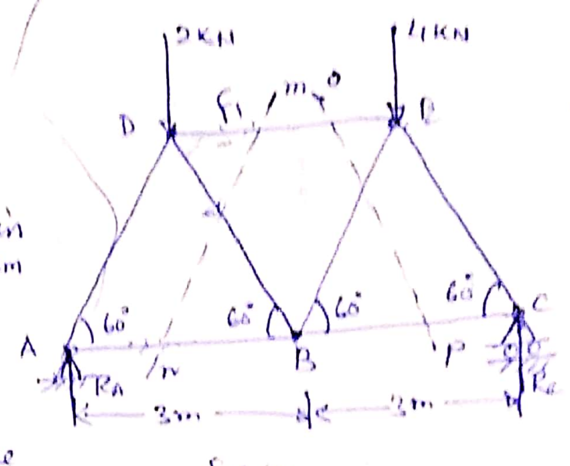


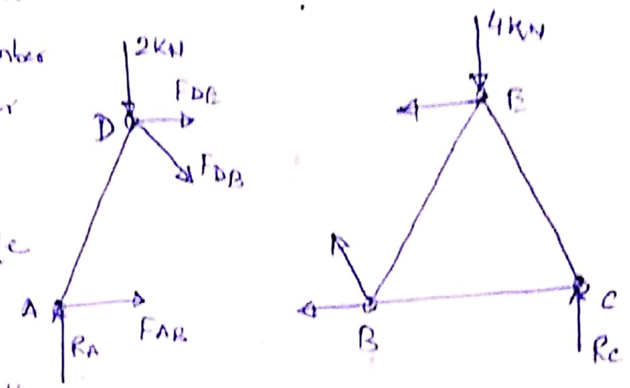
Fig (a)

Solution: For entire truss in equilibrium

$R_A = 2.5$ KN

$R_C = 3.5$ KN

To determine the force in member DE pass a section cutting the member DE and any two other members of the truss so as to divide the truss into two separate portions. The total numbers of members cut should not exceed three.



Left Hand portion

Right Hand portion

Fig (b)

There can be more than one way to pass a section (mn or op)

Consider the truss as cut by the section mn. The two portions of truss are as shown in fig.

Assume and mark the directions of the forces in the cut members. The forces in the cut members can be assumed to act away from the joints. But the directions of axial forces assumed in a member in the two portions of the truss must be consistent with the principle of action and reaction. For example, if the force in the member DE at the joint D is shown to act from left to right then at joint E ~~from~~ it must be shown to act from right to left.

Consider now the equilibrium of the left hand portion of the truss. The three unknown forces acting on the portion of the truss are F_{DE}, F_{DB} & F_{AB}.

Write the equation of equilibrium

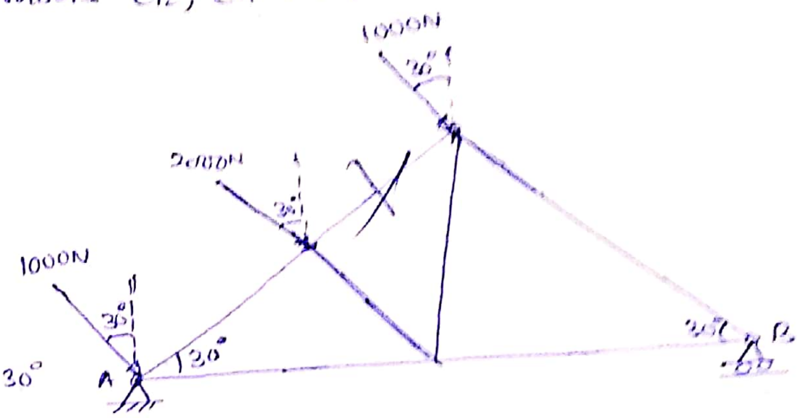
Taking moments about B.

$\Sigma M_B = 0 \quad -2000(3\sin 30^\circ) + R_A \times 3 - F_{DE}(3\cos 30^\circ) = 0$

$\Rightarrow F_{DE} = \frac{1500}{0.866} = 1732\ N\ (T)$ Ans

Note: Moment centre B chosen above, does not lie on the action of the forces under consideration.

Q. A truss is loaded and supported as shown. Determine axial forces in the members CB, CG and FG.



Sol^n Support reactions

$\circlearrowleft + \Sigma M_A = 0$

$- R_B 3 + 2000 \times AD + 1000 \times AC = 0$

$3 R_B = 2000 \times AF \cos 30° + 1000 \times AG \cos 30°$

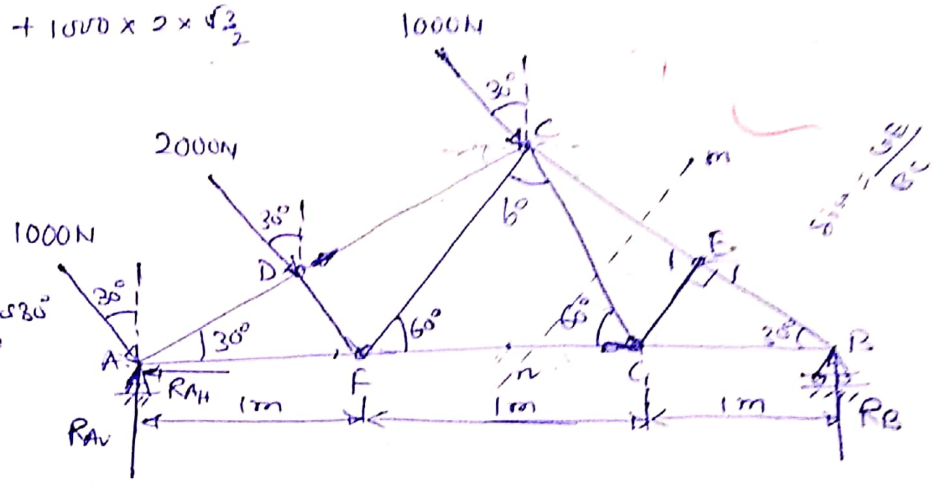
$= 2000 \times 1 \times \frac{\sqrt{3}}{2} + 1000 \times 2 \times \frac{\sqrt{3}}{2}$

$R_B = \frac{2000}{\sqrt{3}}$ N

$\Sigma F_y = 0$

$R_B + F_{AV} - 1000 \cos 30° - 2000 \cos 30° - 1000 \cos 30° = 0$

$F_{AV} = \frac{4000}{\sqrt{3}}$ N



$\Sigma F_x = 0$

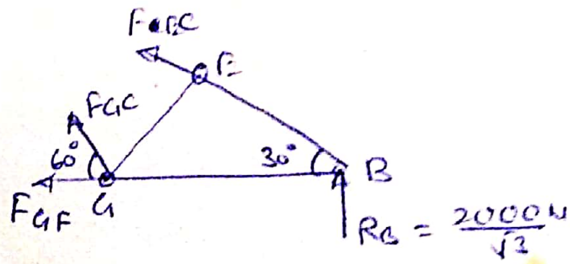
$- R_{AH} + 1000 \sin 30° + 2000 \sin 30° + 1000 \sin 30° = 0$

$R_{AH} = 2000$ N

Pass a section mn through the truss cutting the members CB, CG and FG. Consider the equilibrium of the right hand portion of the truss

Taking moments about point C

$\circlearrowleft + \Sigma M_C = 0$



$F_{FG} \times 0.5 \tan 60° - R_B \times 1.5 = 0$

$F_{FG} = 2000$ N (T) Ans.

Taking moments about point G.

$\circlearrowleft + \Sigma M_G = 0$

$- F_{BC} \times 1 \times \sin 30° + R_B \times 1 = 0$

$F_{EC} = - \frac{2000}{\sqrt{2}} \times \frac{1}{0.5} = -2309$ N

Reverse the sign of the force F_{EC}

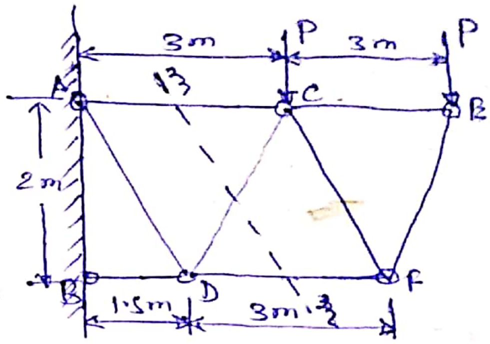
$F_{BC} = 2309$ N (C)

Taking moment about B

$\Sigma M_B = 0 \Rightarrow F_{GC} \times 1 \times \sin 60° = 0$

$F_{GC} = 0$

Q A cantilever truss is loaded as shown in fig. Find the value of loads P which produce an axial force of magnitude 3 KN in the member AC.



Solution: In this case we need not determine the support reactions

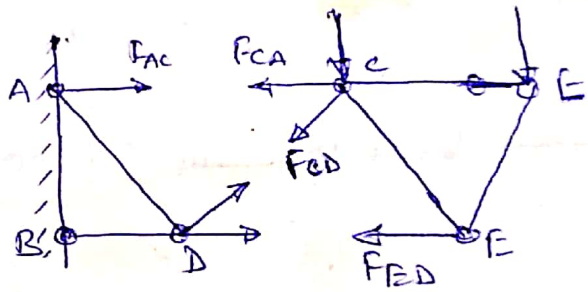
The force in member AC can be determined using method of ~~joints~~ sections.

pass a section mn cutting the members AC, DC and DF. consider the equilibrium of the right hand portion of truss as shown in fig.

$\Sigma M_D = 0$

$-F_{CA} \times 2 + P \times 1.5 + P \times 4.5 = 0$

$F_{CA} = \frac{6P}{2} = 3P$



Given $3 = 3P$

$P = 1 KN.$

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