Truss and frame:

A framed structure is an assemblage of a no. of bars or rods joined together in such a way to form a rigid framework

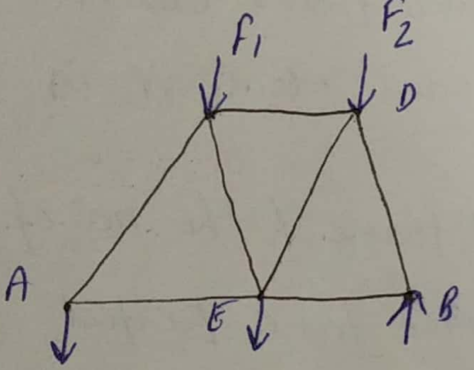
Structure is designed to resist geometrical distortion

The engineering structures may be broadly divided into

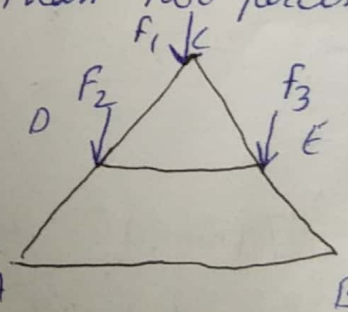
a) Trusses b) Frames c) Machines

Truss: The structure is called truss when the loads are applied only at joints. They are joined together at their ends by riveting or welding.

Every member of a truss is a two force system.



Frame - It is the structure consisting of several bars or members pinned together and in which one or more than one of its members is subjected to more than two forces.

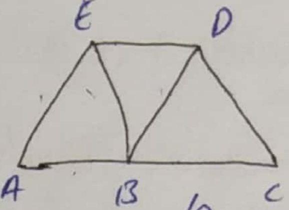


Machine: The machines are the structures that have some movable parts and are used to transmit power.

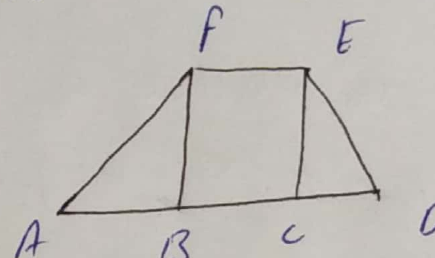
Perfect, deficient and redundant frames -

The structure is said to be perfect if the no. of members is just sufficient to prevent distortion of shape when subjected to external loads.

$$\boxed{m = 2j - 3}$$



$m = 7,\ j = 5$ (Perfect truss)



Here no. of joint = 6

$= 2 \times 6 - 3$

$= 9$

(Imperfect / deficient truss)

Since there are only eight members. Such a frame cannot prevent geometrical distortion when loaded. Hence it is called imperfect or deficient frame.

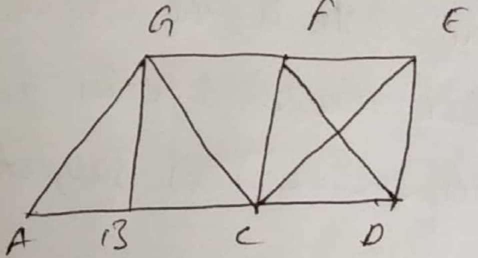
A structure is termed redundant frame if the no. of members in it is more than that required for a perfect frame.

$j = 7$

$m = 12$

$m = 2 \times 7 - 3$

$= 11$



Statically determinate and statically indeterminate frame

A truss is statically determinate if the equations of static equilibrium alone are sufficient to determine the axial forces in the members without the need of considering their deformation.

Equations of static equilibrium are not sufficient to determine the forces in statically inderminate frames, their is need of considering their deformation also.

Assumption for the perfect truss

1) The joints of a simple truss are assumed to be pin connections and frictionless. The joints, therefore, cannot resist moments.
2) The loads on the truss are applied at the joints only.
3) The members of a truss are straight two force members
4) The weight of the members are negligibly small.
5) The truss is statically determinate.
6) The members are slender and of uniform cross section.

Methods of Determination of axial forces in the members

1) Method of joints
2) Method of sections
3) Graphical method.

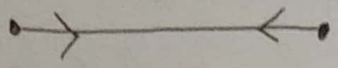
1) Method of joint

Every joint is treated seperately as a FBD

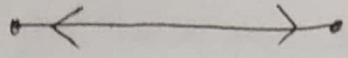
$$\sum F_x = 0 \; ; \; \sum F_y = 0$$

- Certain direction of forces acting on the joints is assumed. If the magnitude of a particular force comes out positive, the assumption in respect to its direction is correct.
- Start from a joint where not more than two unknown force appear.
- The force in the member will be tensile if the member pulls the joint (force is directed away from the pin.)

- For compression, force is towards the pin.



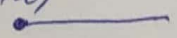
Tension : Pulling at each end



Compression : Pushing at each end.

Special condition

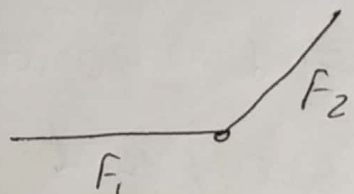
i) A single force cannot form a system in equilibrium.
It implies, if there is only one force acting at a joint,



then for equilibrium it should be equal to zero. $F_1 = 0$

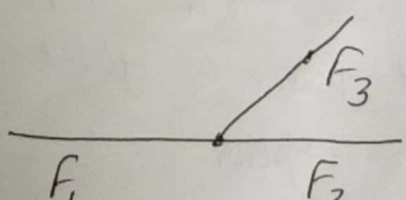
ii) when two members meeting at a joint are not collinear and there is no external force acting at the joint, then the force in both the members are zero.

$F_1 = F_2 = 0$

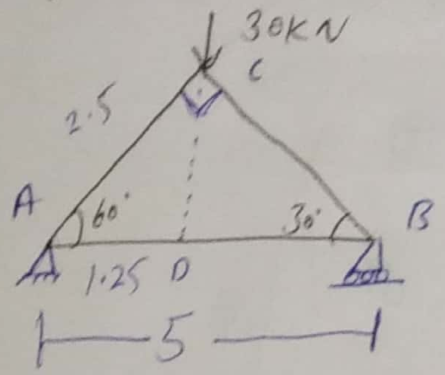


iii) When three members are meeting at an unloaded joint and out of them two are collinear, then the force in the third member will be zero.

$F_3 = 0$



Q Determine the forces in all the members of a truss with the loading and support system as shown in fig



$\frac{p}{h} = \sin 30$

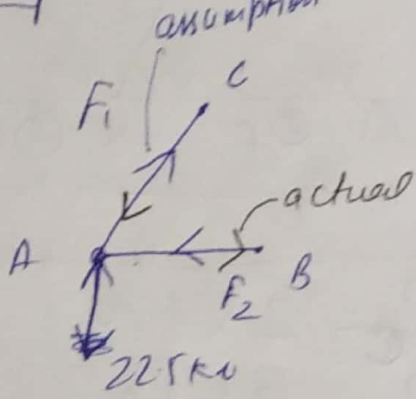
Sol

AC = 2.5 m

AD = 1.25 m

$R_a = 22.5$ kN

$R_b = 7.5$ kN



Joint A

$\sum f_x = \quad F_2 = F_1 \cos 60°$

$\sum f_y = \quad \cancel{F_1 \cos} \; F_1 \sin 60 = -R_a$

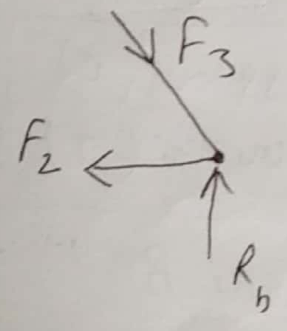
$\boxed{F_1 = -25.97 \text{ kN}}$ (C)

Our assumption is wrong. It is compressive in nature

$\boxed{F_2 = -12.99 \text{ kN}}$ (T)

This assumption is also wrong. It is tensile in nature.

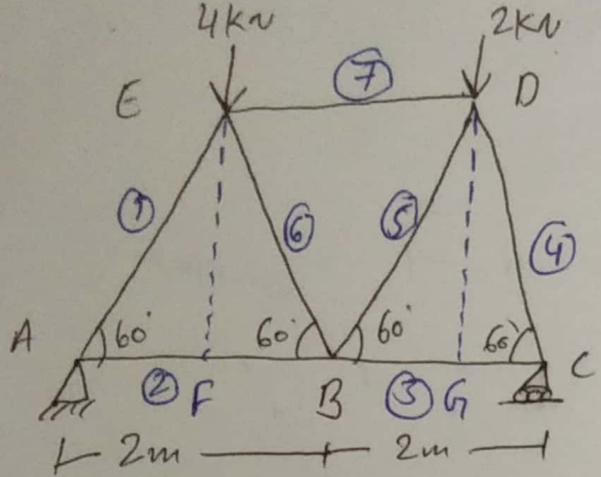
Consider joint B.



$\sum F_x = \quad F_3 \cos 30 - F_2 = 0$

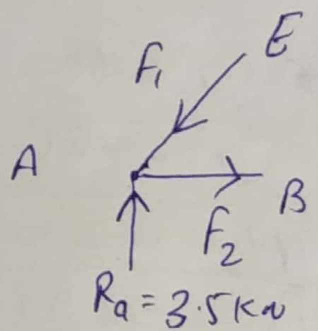
$\boxed{F_3 = 15 \text{ kN (compressive)}}$

Q Determine the reactions and the forces in each member of a truss as shown in fig. (2016)



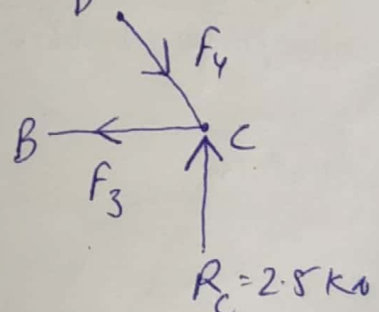
$$\boxed{\begin{gathered} R_C = 2.5\ kN \\ R_a = 3.5\ kN \end{gathered}}$$

Consider joint A



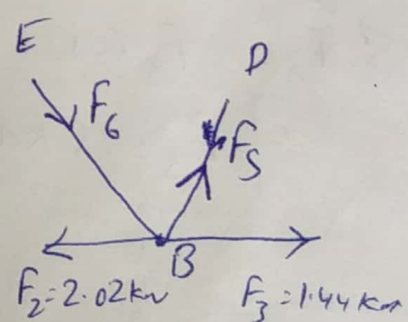
$$\boxed{\begin{gathered} F_1 = 4.04\ kN\ (C) \\ F_2 = 2.02\ (T) \end{gathered}}$$

Consider joint C



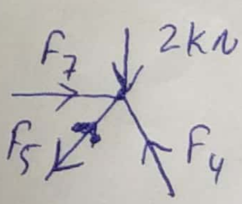
$$\boxed{\begin{gathered} F_4 = 2.88\ kN\ (C) \\ F_3 = 1.44\ kN\ (T) \end{gathered}}$$

Consider joint B



$$\boxed{\underset{(T)}{F_5} = \underset{(C)}{F_6} = \frac{1.16}{2} = 0.58\ kN}$$

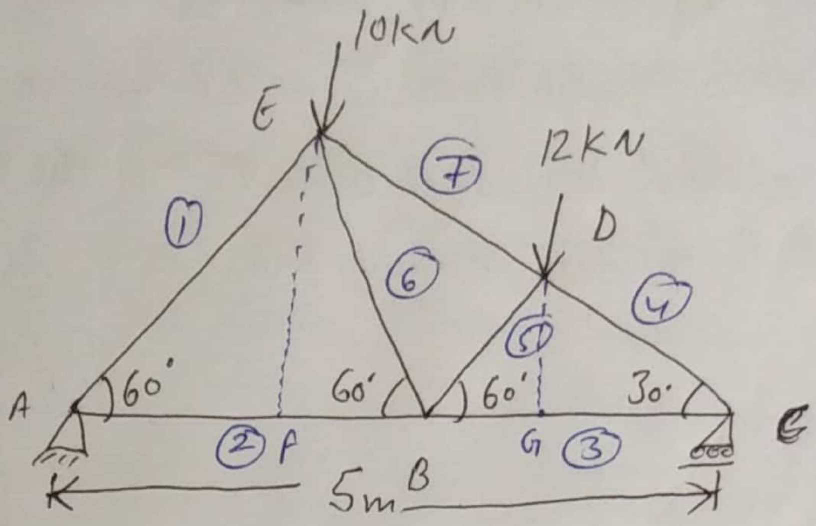
Joint D



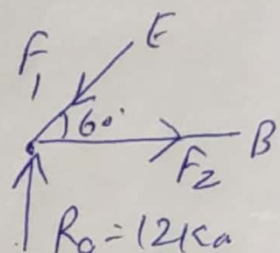
$$\boxed{F_7 = 1.73\ kN\ (C)}$$

Q. Determine the forces in all the members of truss loaded ④
(2016) and supported as shown in fig. (2014)

Sol.

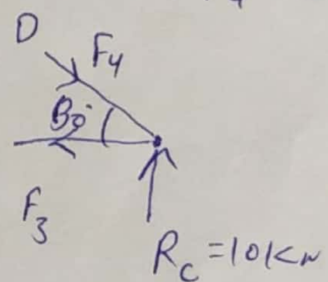


$R_c = 10$ kN
$R_a = 12$ kN



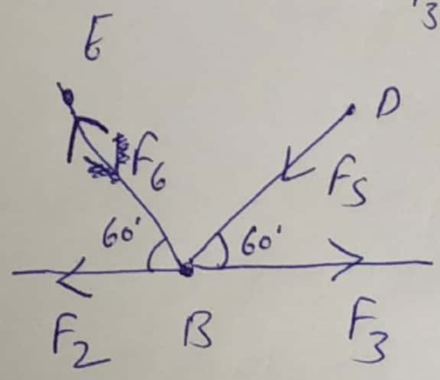
Consider joint A

$F_1 = 13.85$ kN (C)
$F_2 = 6.92$ kN (T)



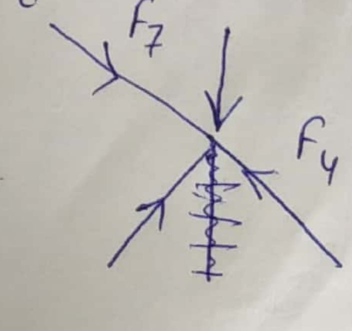
joint C

$F_4 = 20$ kN (C)
$F_3 = 17.32$ kN (T)



Joint B

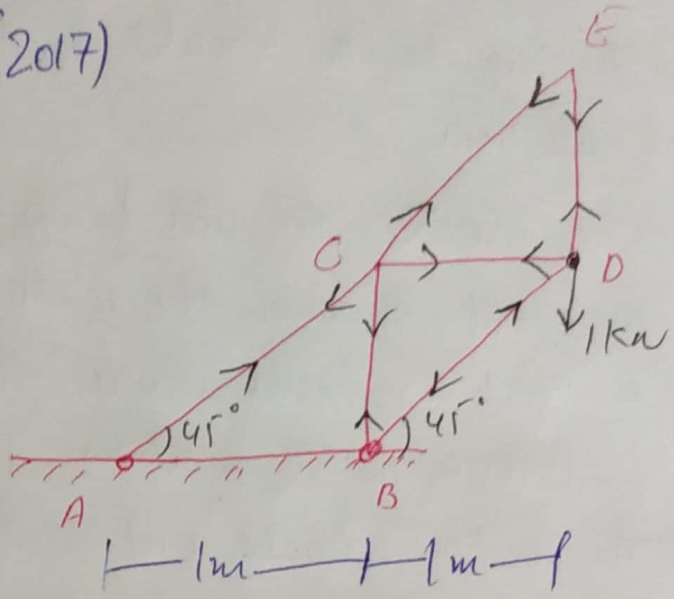
$F_5 = F_6 = 10.4$ kN
(C) (T)



joint D

$F_7 = 13.99$ kN (C)

Q Determine the axial forces in the bars of a plane truss loaded as shown in fig (2017)



Sol.

$F_{EC} = F_{ED} = 0$

$F_{DB} = \sqrt{2}$ kN (C)

$F_{DC} = 1$ kN (T)

$F_{CA} = \sqrt{2}$ kN (T)

$F_{CB} = 1$ kN (C)

Method of section:

Following points should be noted while using the method of sections

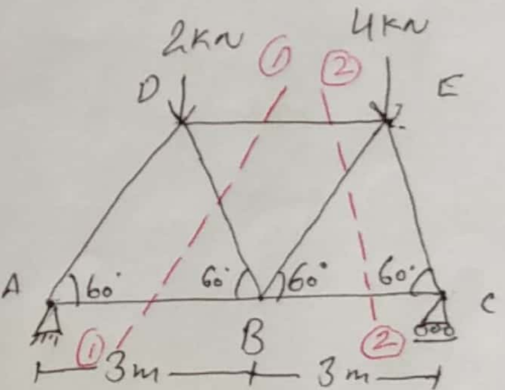
i) The section should be passed through the members and not through the joints.

ii) A section should divide the truss into two clearly seperate and unconnected portions.

iii) A section should cut only three members since only three unknown can be determined from the three equations of equilibrium.

iv) When using the moment equation, the moment can be taken about any convenient point which may or may not lie on the section under consideration.

Q Find the axial force in the member DE of the truss using method of section.



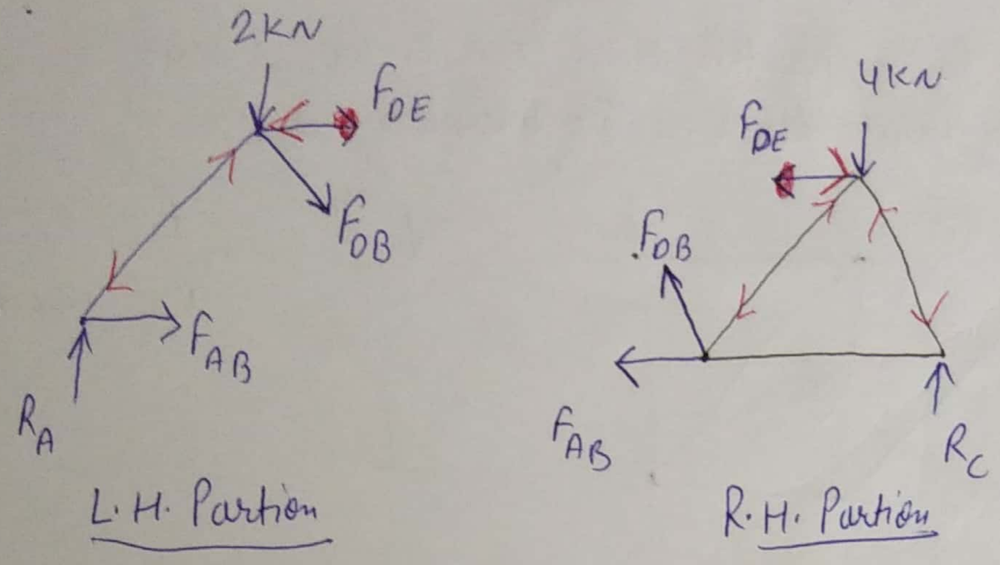
Sol.

$R_A = 2.5\,kN$

$R_C = 3.5\,kN$

Now either we section the given truss by 1-1 or 2-2 plane.

Let us consider the truss is cut by section 1-1.



Consider the equilibrium condition of L.H partion

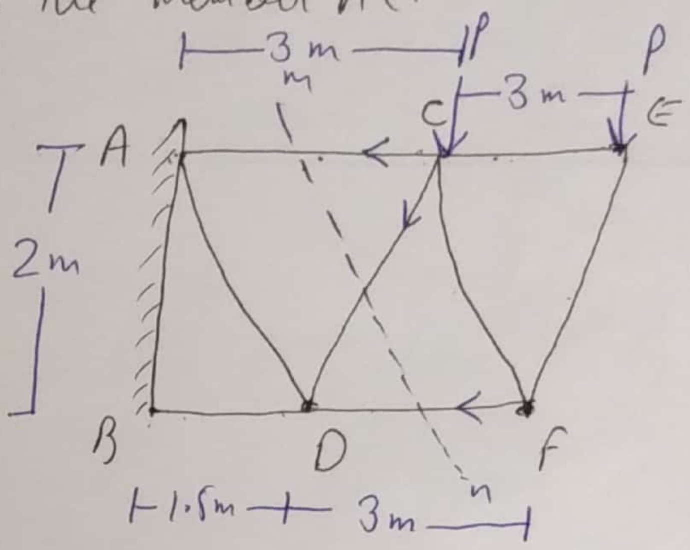
Take moment about B.

$\sum M_B = 0$; $2000 \cdot (3 \cos 60°) - R_A \cdot 3 + F_{DE} = 0$

$F_{DE} = 1732\ N$ ($\cancel{T}$) Compressive

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

Sol:



Consider the equilibrium of the right hand portion of the truss

Take moment about point D.

$$F_{AC} \cdot 2 - P(1.5) - P(4.5) = 0$$

$$F_{AC} = 3P$$

$$3 = 3P$$

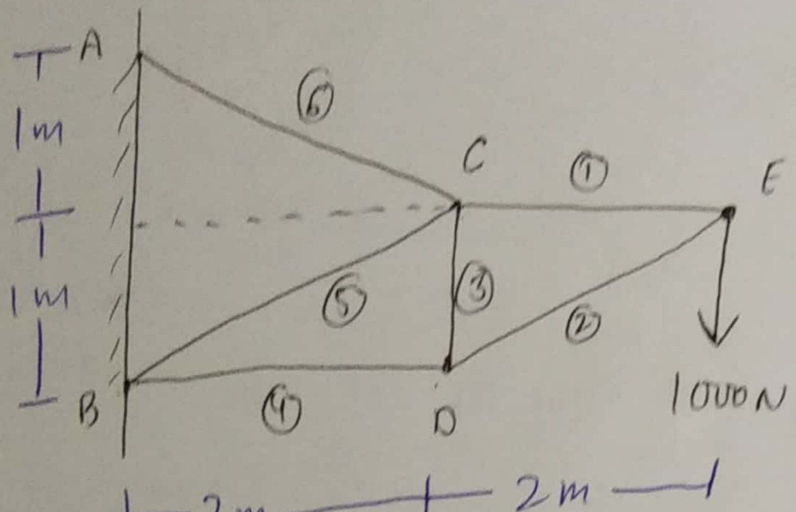
$$\boxed{P = 1\,kN}$$

Q. A Cantilever truss is loaded as shown in fig. Find the axial forces in all the members

$F_1 = 2000 (T)$ $F_4 = 2000 N (C)$

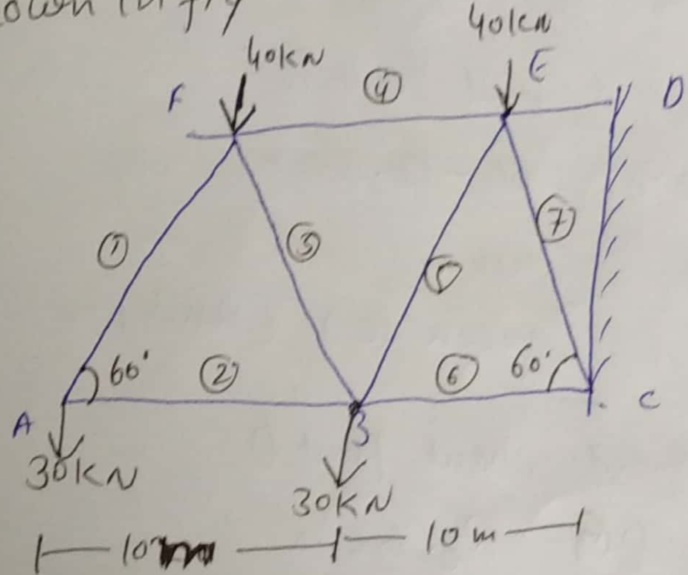
$F_2 = 2240 (C)$ $F_5 = 0$

$F_3 = 1000 (T)$ $F_6 = 2240 (T)$



Q. Determine the forces in each member of the cantilever truss loaded as shown in fig

Sol



$F_1 = 34.64 kN (T)$

$F_2 = 17.32 kN (C)$

$F_3 = 80.81 kN (C)$

$F_4 = 57.72 KN (T)$

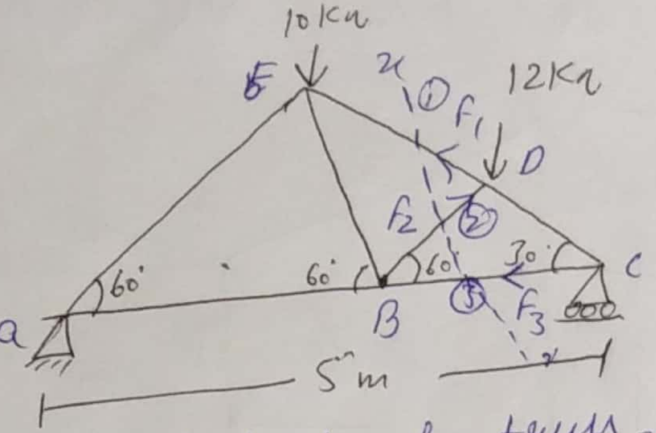
$F_5 = 115.45 KN (T)$

$F_6 = 115.44 kN (C)$

$F_7 = 161.62 kN (C)$

$F_8 = 196.25 kN (T)$

Q. Determine the forces in the members (1), (2) and (3) of the truss loaded and supported as shown in fig.



Sol

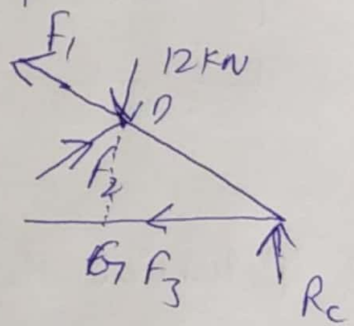
$R_a = 12\,kN$

$R_c = 10\,kN$

$BD = 1.25\,m$

$CD = 2.165\,m$

Considering equilibrium conditions of right part of the truss,



Take moment about C.

$$F_2 \cdot CD - 12\, DG = 0$$

$$F_2 = 10.39\,kN\ (C)$$

Take moment about point B.

$$F_1 \cdot BD + R_c \cdot BC - 12 \cdot BG = 0$$

$$F_1 = -14\,kN$$

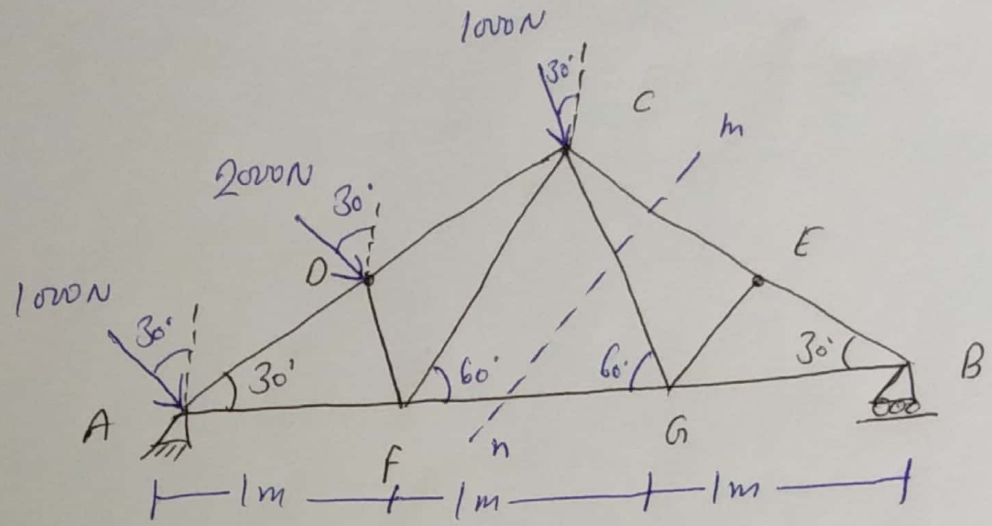
$$= 14\,kN\ (C)$$ [Assumption is wrong]

Take moment about point D.

$$F_3 \cdot DG - R_c \cdot GC = 0$$

$$F_3 = 17.32\,kN\ (T)$$

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



Taking moment about point A

$R_B \cdot 3 - 2000 \cdot AD - 1000\,AC = 0$

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

$R_{av} = \frac{4000}{\sqrt{3}}$ N

$R_{ah} = 2000$ N

Taking moment about C – $F_{FG} = 2000N\,(T)$

" " " G - $F_{CE} = 2309\,(C)$

" " " B $F_{CG} = 0$