As1 unit 1 - aircraft structures -1 unit -1 (2021 regulation)

Aircraft structures -1 (Anna University)

23-12-11

Unit - I

Statically determinate structure.

Truss : A truss is a system of straight bars (or) members joined togeather at their ends by frictionless hingers to form a rigid frame work.

Assumptions : All the members are pin-jointed.

* All external forces are applied at joints.

* members are connected concentrically by frictionless hingers.

* Each members is subjected to axial force only. and the same is constant along the length.

Static Determinancy :

$$m = 2j + f - r$$

A plane truss is statically determinant if $m = 2j + f - r$.

where, $m \rightarrow$ No. of members

$j \rightarrow$ No. of joints

$f \rightarrow$ No. of special conditions

$r \rightarrow$ No. of reactions.

If $m = 2j-3$ then the frame is called Perfect frame.

If $m < 2j-3$, then the frame is called Deficient frame.

If $m > 2j-3$, Then the frame is called redundant frame.

Reactions at Supports: Frames are provid with following two supports:-

(i) Roller or force support:

~~Frames are provided with~~ The line of actio of reaction will be at right angles to the roller base.

(ii) Hinged support or fixed support:

The direction and the line of action of reaction will depend upon the load system on the Structure.

To determine the reactions:

Reactions at the Support of a Structure can be determined by the Conditions of equilibrium.

1) $\Sigma F_V = 0$

2) $\Sigma F_H = 0$

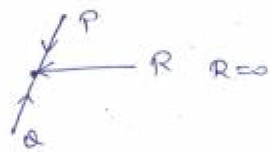
3) $\Sigma M_{any\ point} = 0$

To determine which members of a truss donot carry forces :-

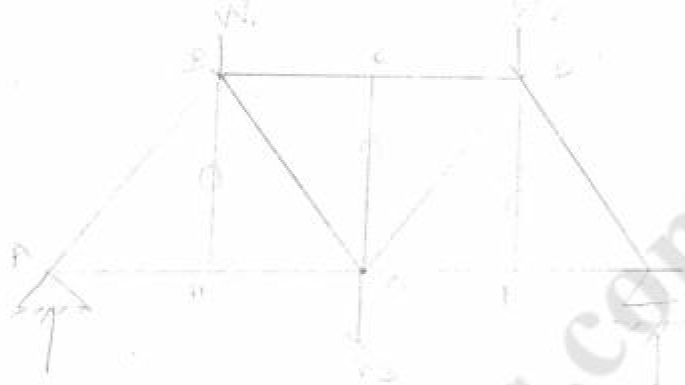
(i) If there is only one force acting at a joint then for the equilibrium condition of the joint, this force equals zero.

(ii) If the only two forces acting at a joint are not along the same straight line then for the equilibrium of the joint each force will be zero.

(iii) If three forces act at a joint and two of them are along the same st. line then for the equilibrium of the joint the third force should be equal to zero.



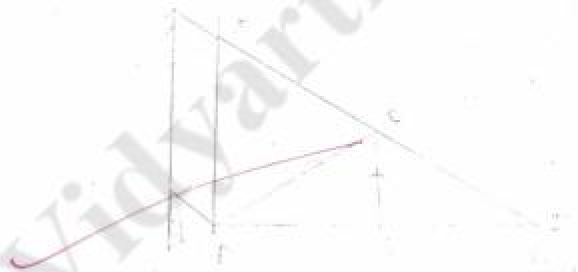
Find the members which donot carry forces?



Force, BH = 0

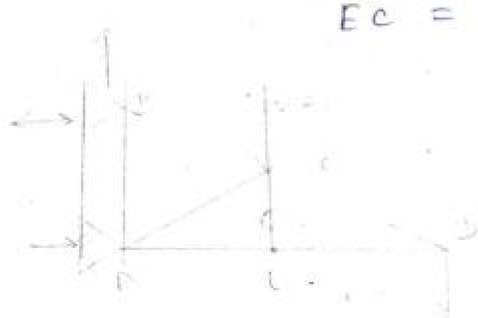
CG = 0

DF = 0



AC = 0

EC = 0



force at CE = 0.

Force at AH = 0 , DE = 0

Analysis of Truss :

~~The analysis of~~

A Structure can be analysed by the following methods :

* Analytical method.
  (i) * Method of joints
  (ii) * Method of Section

* Graphical method
  (i) Maxwell's method.
  (ii) culmann's method

Method of Joints.

The analysis of a truss consist of th

following steps :

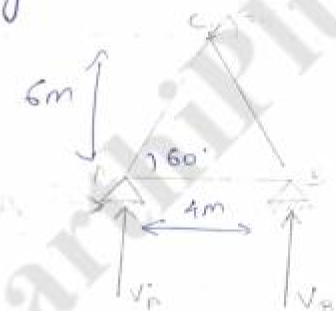
(i) Determination of reactions at the suppor

(ii) Determination of forces in the members o

the Truss.

1) Determine the forces in the members of

the following truss :



To find reaction :

$$\Sigma F_v = 0$$

$$V_A + V_B - 4000 \sin 30^\circ = 0$$

$$V_A + V_B = 4000 \sin 30^\circ$$

$$V_A + V_B = 2000 \text{ N}$$

$$\Sigma F_H = 0$$

$$H_A = 4000 \cos 30^\circ$$

$$H_A = 3464.10 \text{N}$$

moment at A = 0

$AD = 3.46m$

$$M_A = V_B \times 4 + 4000 \sin 30^\circ \times 3.46$$

$$+ 4000 \cos 30^\circ \times 6$$

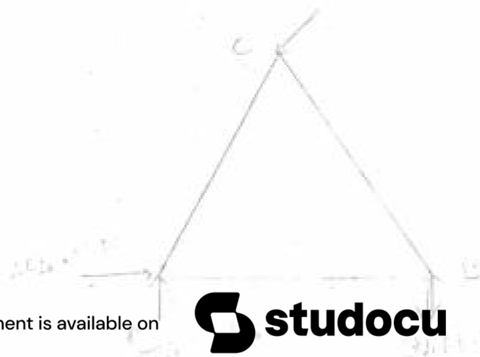
$$= -V_B \times 4 + 6920 + 20784.609$$

$$V_B = ~~6926.15~~ \; 3466.15 \text{ N}$$

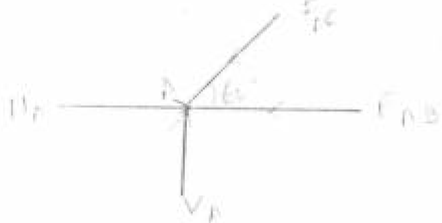
$$V_A + V_B = 2000$$

$$V_A = 2000 + 3466.15$$

$$V_A = 5466.15 \text{ N}$$



Consider joint A



$\Sigma F_V = 0 \quad 5466.15 = F_{AC} \sin 60°$

$F_{AC} = 6311.78 \text{ N}$

$\Sigma F_H = 0$

$3464.10 = F_{AC} \cos 60°$

$F_{AC} = 6928.2 \text{ N}$

$F_{AB} = \sout{F_{AC} \cot 60°}$

$= - H_A - F_{AC} \cos 60°$

Sign Convention :

$-ve$ tension

$+ve$ Compression

Consider joint B :

$- F_{CB} \sin 60° + V_B = 0$

$F \quad = - V_B$

$$= \frac{-3466.15}{\sin 60°}$$

$$= -39798.08 \text{ N}$$

25.12.12

2) Determine the forces in the each member of the truss as shown in the figure.

Let V_A and V_B be the vertical reaction force acts in the supports A & B respectively.

$$\Sigma F_V = 0$$

$$V_A + V_B = 10$$

$$\Sigma F_H =$$

Moment at A = 0

$$M_A = V_B \times AB \circlearrowleft + 10 \times \frac{CD}{AD}$$

$$= V_B \times 6 \circlearrowleft + 10 \times \frac{CD}{\tan 60^\circ} \circlearrowright$$

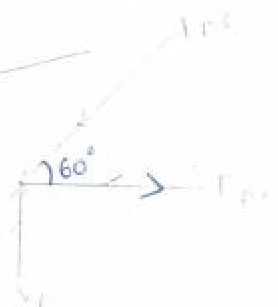
~~$M_A = 3.46$~~

$$M_A \Rightarrow -V_B \times 6 + 30 = 0$$

$$\boxed{V_B = 5\ kN}$$

$$\boxed{V_A = 5\ kN}$$

Consider Joint A :



$$\Sigma F_{V_A} = 0$$

$$V_A - F_{AC} \sin 60^\circ = 0$$

$$5 = F_{AC} \sin 60^\circ$$

$\Sigma F_{HA} = 0$

$F_{AB} + F_{AC} \cos 60^\circ = 0$

$= -5.7735 \cos 60^\circ$

$F_{AB} = +2.8867 \text{ kN}$ (tension)

Consider joint B

$\Sigma F_V = 0$

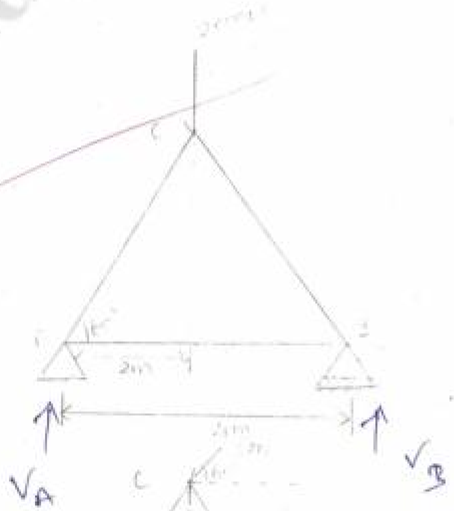
$V_B - F_{BC} \sin 60^\circ = 0$

$5 = F_{BC} \sin 60^\circ$

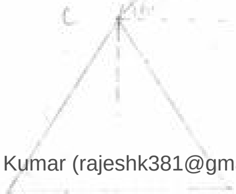
$F_{BC} = 5.7735 \text{ kN}$ (comp)

Members	Forces (kN) Compression	Tension
AB		2.8867 kN
BC	5.7735	
CA	5.7735	

3)



$\tan 60° = \frac{CD}{AD}$



3) Determine the forces in the each member of the given truss.

To find reaction force : $\tan 60^\circ = \frac{CF}{DF}$

$\Sigma V = 0$

$V_A + V_D = 60\,kN$

Moment about Pt A = 0

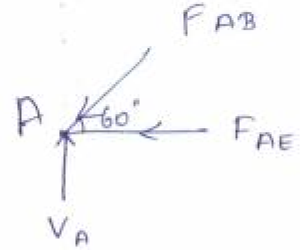
$0 = V_D \times 6 + 40 \times 4.5 + 20 \times 1.5$

$6 V_D = 180 + 30$

$V_D = 35\,kN$

$V_A = 60 - V_D$

Consider Joint A



$$\Sigma V_A = 0$$

$$V_A = F_{AB} \sin 60^\circ$$

$$\boxed{F_{AB} = 28.86 \text{ kN}}$$

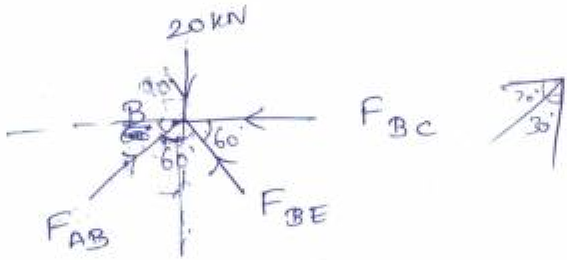
$$\Sigma H_A = 0$$

$$F_{AE} + F_{AB} \cos 60^\circ = 0$$

$$F_{AE} = -28.86 \cos 60^\circ$$

$$\boxed{F_{AE} = -14.43 \text{ kN}}$$

Consider Joint B



$$\Sigma V_B = 0$$

$$20 = F_{AB} \cos 30^\circ + F_{BE} \cos 3$$

$F_{BE} = -5.76$ kN

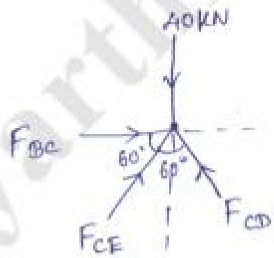
$\Sigma V_B = 0$

$F_{AB} \sin 30^\circ = F_{BC} + F_{BE} \cos 60^\circ$

$28.86 \times \sin 30^\circ + 5.76 \cos 60^\circ = F_{BC}$

$F_{BC} = 17.31$ kN

Consider Joint C



$\Sigma V_c = 0$

$40 = F_{CD} \cos 30^\circ + F_{CE} \cos 3$

$\Sigma H_c = 0$

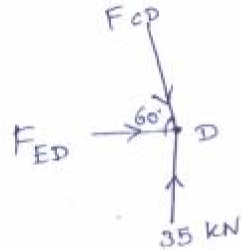
$F_{BC} + F_{CE} \cos 60^\circ = F_{CD} \cos 60^\circ$

$F_{CD} \cos 60^\circ - F_{CE} \cos 60^\circ = 17.31$

$F_{CE} \cos 60^\circ = F_{CD} \cos 60^\circ - 17.3$

5.79

Consider Joint D



$\Sigma V_D = 0$

$$F_{CD} \sin 60^\circ = 35$$

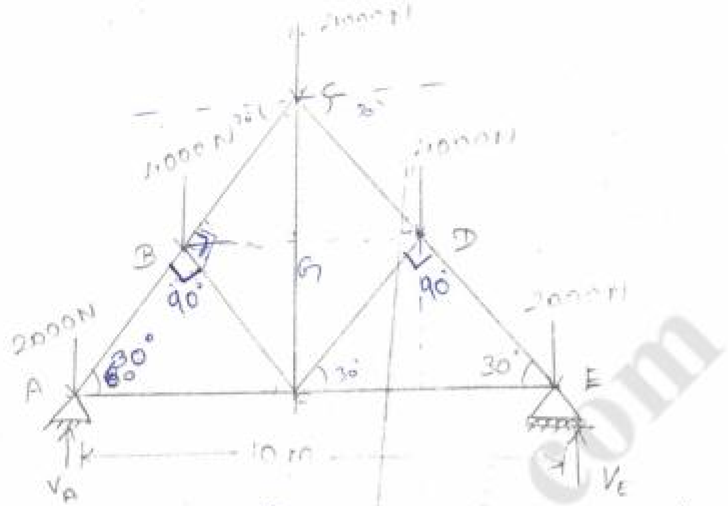
$$\boxed{F_{CD} = 40.41 \text{ kN}}$$

$\Sigma H_D = 0$

$$F_{DE} + F_{CD} \cos 60^\circ = 0$$

$$\boxed{F_{DE} = -20.205 \text{ kN}}$$

Member	Force (kN) Compression	Force (kN) Tension
AB	28.86	
AE		−14.43
BE		−5.76
BC	17.31	
CE	5.79	
ED		−20.20
CD	40.41	



Determine the forces in the members AB, FD, CD of the given figure.

To find reaction force:

$$\Sigma V = 0$$

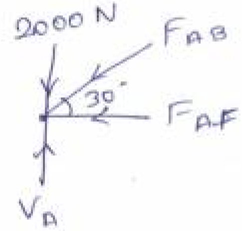
$$4000 + 4000 + 4000 + 2000 + 2000 = + V_A + V_E$$

$$16000 = V_A + V_E \quad \text{--- (1)}$$

moment at point A

$$V_E \times 10 + 2000 \times 10 + 4000 \times 7.5 + 4000 \times 2.5 + 4000 \times 5$$

Consider Joint A



$\Sigma V_A = 0$

$2000 + F_{AD} \sin 30^\circ = 8000$

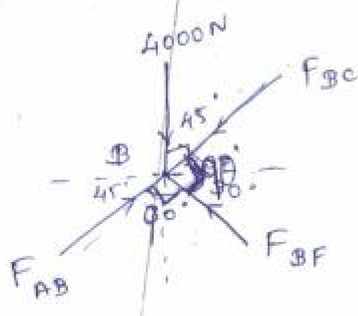
$F_{AB} = 12000 \text{ N}$

$\Sigma H_A = 0$

$F_{AF} + F_{AB} \cos 30^\circ = 0$

$F_{AF} = -10392.30 \text{ N}$

Consider Joint B



$\Sigma V_B = 0$

$4000 + F_{BC} \sin 45^\circ =$

$F_{AB} \cos 45^\circ + F_{BF} \cos 45$

 ~~11591.10 +~~

~~4000 + F_{BC} sin 45 =~~

$$4485.28 = F_{BC} \sin 45^\circ - F_{BF} \cos 45^\circ$$

$$\Sigma H_B = 0$$

$$F_{AB} \sin 45^\circ = F_{BC} \cos 45^\circ + F_{BF} \cos 45^\circ$$

$$12000 \sin 45^\circ = F_{BC} \cos 45^\circ + F_{BF} \cos 45^\circ$$

$$4485.28 = F_{BC} \sin 45^\circ - F_{BF} \cos 45^\circ$$

$$12970.56 = F_{BC}\ 1.4142$$

$$\boxed{F_{BC} = 9171.65\ N}$$

$$F_{BF} \cos 45^\circ = F_{BC} \sin 45^\circ - 4485.28$$

$$F_{BF} \cos 45^\circ = 6485.33 - 4485.28$$

$$\boxed{F_{BF} = 2828.49}$$

Consider Joint E

$$\Sigma V_E = 0$$

$$2000 + F_{ED} \sin 30^\circ = 8000$$

$$F_{ED} = \frac{6000}{\sin 30^\circ}$$

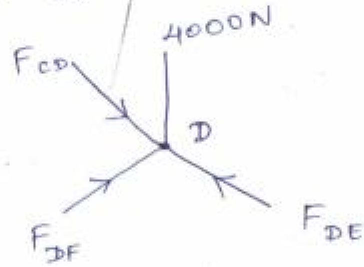
$$\boxed{F_{ED} = 12000 \text{ N}}$$

$$\Sigma H_E = 0$$

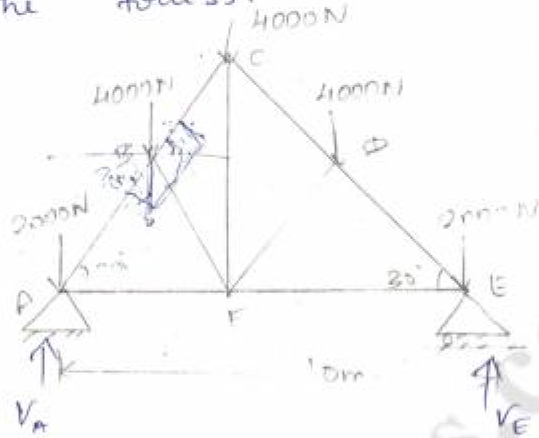
$$F_{EF} + F_{ED} \cos 30^\circ = 0$$

$$\boxed{F_{EF} = -10392.30 \text{N}}$$

Consider Joint D



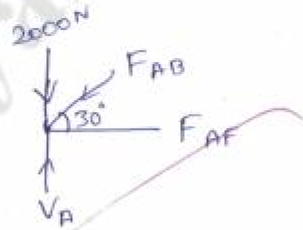
4) Determine the forces in the each member of the truss.



$$V_A + V_E = 16000\,N$$

$$V_A = V_E = 8000\,N$$

Joint A :



$\Sigma V_A = 0$

$$2000 + F_{AB} \sin 30^\circ = V_A$$

$$F_{AB} \sin 30^\circ = 6000$$

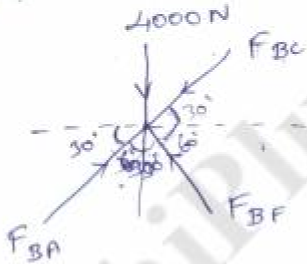
$$\boxed{F_{AB} = 12000\,N}$$

$\Sigma H_A = 0$

$F_{AF} + F_{AB} \cos 30° = 0$

$\boxed{F_{AF} = -10392.30 \text{ N}}$

Joint B :



$\Sigma V_B = 0$

$4000 + F_{BC} \sin 30° = F_{AB} \cos 60° + F_{BF} \cos 30°$

$= 6000 + F_{BF} \cos 30°$

$F_{BC} \sin 30° - F_{BF} \cos 30° = 2000 \text{ N}$

$\Sigma H_B = 0$

$F_{BC} \cos 30° + F_{BF} \cos 60° = F_{AB} \cos 30°$

$F_{BC} \cos 30° + F_{BF} \cos 60° = 10392.30$

$F_{BC} \sin 30° - F_{BF} \sin 30° = 2000$

~~$F_{BC}(1.366)$~~

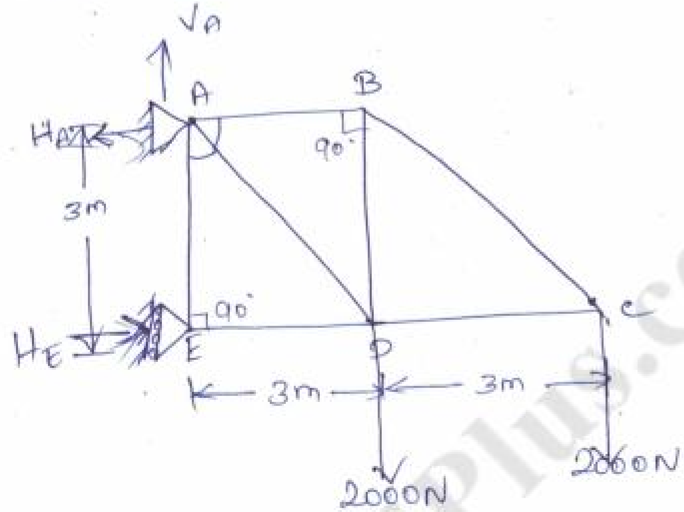
$F_{BC} \sin 30° - F_{BF} \sin 30° = 2000$

$F_{BC} \sin 30° = +9071.96 \sin 30° + 2000$

~~F_{BC}~~

~~$F_{BF} = 5071.96$~~

5) Determine the forces in the each member of the truss as shown in fig:-



$$\Sigma V = 0$$

$$\boxed{V_A = 4000 N}$$

$$\Sigma H = 0$$

$$H_E + H_A = 0$$

moment about A

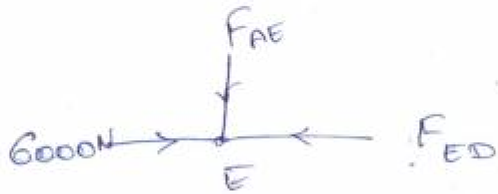
$$2000 \times 6 + 2000 \times 3 + H_E \times 3 =$$

$$= \frac{+18000}{3}$$

$$H_E = +6000 \text{ N}$$

$$H_A = -6000 \text{ N}$$

Consider joint E

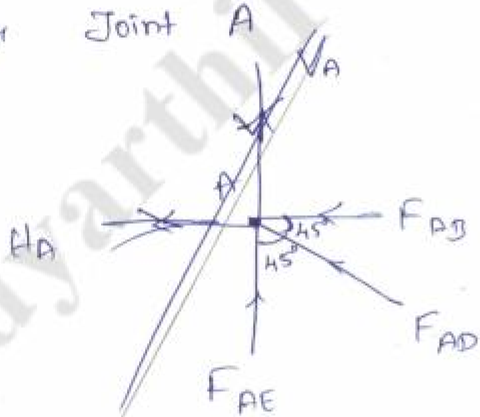


$\Sigma H = 0$

$$F_{ED} = 6000\,N$$

$\Sigma V = 0$ $$F_{AE} = 0$$

Consider Joint A

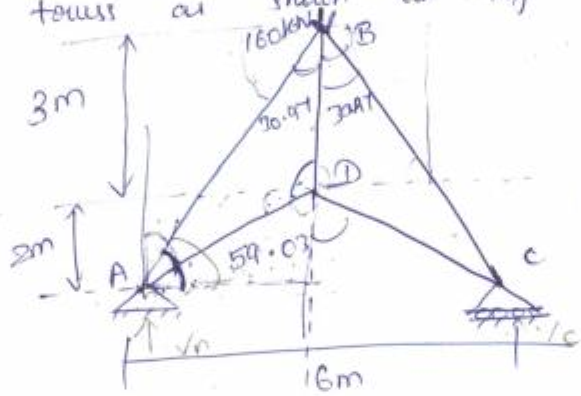


~~$\Sigma V_A = 0$~~

~~V_A~~

Joint C :

6. Determine the force in the each member of the truss as shown in fig:



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

0.66

$\theta = 33.42$

$\tan\theta = \frac{3}{3\cos 33.4}$

$\theta = 50.14$

$\sin\theta = \frac{x}{2}$

Reactions :

$\Sigma V_A = 0$

$V_A + V_c = 160$ kN

$\Sigma H = 0$

$\Sigma M_A = 0$

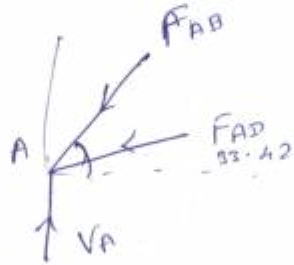
$160 \times 3 + V_c \times 6 = 0$

$6 V_c = 480$

$V_c = 80$ kN

$V_A = 80$ kN

Consider Joint A



$\Sigma H = 0$

$F_{AD} \cos 33.42 + F_{AB} \cos 59.03 = 0$

$\Sigma V = 0$

$V_A = F_{AB} \sin 59.03 + F_{AD} \sin 33.42$

① × sin 33.6 / cos 33.6 $F_{AD} \cos 33.6 + F_{AB} \cos 59.03 = 0$ × sin 33.6   × sin 59.03

② × cos / sin 33.6 $F_{AD} \sin 33.6 + F_{AB} \sin 59.03 = +V_A$ × cos 33.6   × cos 59.03

(−)   (−)   (−)

$F_{AB} [\cos 33.06 \sin 59.03 - \sin 33.6 \cos 59.03]$

$= 80 \cos 33.6$

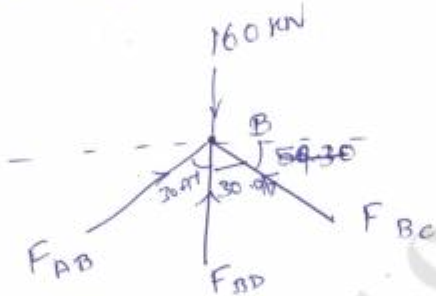
0.433

$F_{AB} = 153.88$ kN (C)

$$F_{AD} = 95.86 \text{ kN (T)}$$

consider Joint BD

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



$\Sigma H = 0$

$$F_{BC} \sin 30.97 = F_{AB} \sin 30.97$$

$$F_{BC} = 155.28 \text{ kN (C)}$$

$\Sigma V = 0$

$$160 = F_{AB} \cos 30.97 + F_{BD} + F_{BC} \cos 30.9$$

$$F_{BD} = 160 - 133.09 - 133.09$$

$$F_{BD} = 106.18 \text{ kN (T)}$$

Member	Tension	Compression
F_{AB}		
F_{BC}		
F_{BD}		

6-01-12 Composite Beam :

A Beam ~~carrying~~ having components of two or more than two materials rigidly ~~be~~ joined togeather is called a composite beams.

A beam of two materials is most commen such as wooden beam reinforced by ~~material~~ metal strips and concrete beam reinforced with steel rods.

Consider a rectangular beam of ~~wood~~ wood with base B and height D which is rigidly fixed with a strip of material 2 with thickness t and same height as that of material 1 on both sides as shown in fig:-

Let the skin stress of material 1 is equal to f_1.

Skin stress of material 2 is equal to f_2.

modular ratio $m = \frac{E_2}{E_1}$

Young's Modulus of material 2

where $E_2 = E$

Since, the beam of material 1 and strip of material 2 are rigidly together, the strain induced in the both the material will be same.

Therefore, $\frac{f_1}{f_2} = \frac{E_1}{E_2} \Rightarrow \frac{f_1}{E_1} = \frac{f_2}{E_2}$

moment of resistance = resisting moment offered by beam of material 1 + Resisting moment by strip of material

$$M = M_1 + M_2 \quad \text{--- (1)}$$

From, simple bending theory

$$\frac{M}{I} = \frac{E}{R} = \frac{f}{y}$$

$$M = \frac{fI}{y}$$

$$M_1 = \frac{f_1 \, BD^3/12}{(D/2)}$$

$$= \frac{f_1 BD^3}{12} \times \frac{2}{D}$$

$$M_1 = \frac{f_1 BD^2}{6}$$

$$M_2 = f_2 \frac{tD^2}{6}$$

Substitute the value of m_1 & M_2 in eqn (1)

$$M = m_1 + m_2$$

$$M = f_1 \frac{BD^2}{6} + 2 f_2 \frac{tD^2}{6}$$

$$\frac{f_2}{f_1} = m = \frac{E_2}{E_1} \text{ (modular ratio)}$$

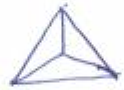
$$M = \frac{f_1 D^2}{6} \left[B + 2 \frac{f_2}{f_1} t \right]$$

$$M = \frac{f_1 D^2}{6} \left[B + 2mt \right]$$

3 - D Truss or Space truss

The Basic 3 - D Truss is tetrahedral.

$$m = 3j - 6$$



Space truss (or) 3 - D truss is a 3 - D assemble of members in that each member are connected to the foundation are to the members by frictionless hinges.

For Space truss, $m = 3j - 6$

If $m < 3j - 6$, than the Space truss is known as Space linkage.

If $m > 3j - 6$, than the Space truss is known as internally redundant.

The basic 3 - D truss is tetrahedran.

B

Let a member AB with Co-ordinates x_A, y_A, z_A & x_B, y_B, z_B as shown in

And $\theta_x, \theta_y, \theta_z$ are the angles b/w the member AB and with x, y, z axes respec

~~from fig:~~

~~Cos~~

Let L_{AB} be the length of the member AB

from fig:

$$\cos\theta_x = \frac{x_B - x_A}{L_{AB}}$$

forces ~~in the 3-D tower along~~ induced in the member AB along x-a

$$F_{ABx} = F_{AB}\cos\theta_x$$

$$= F_{AB}\left(\frac{x_B - x_A}{L_{AB}}\right)$$

Tension Co-efficient :

Tension Co-efficient is defined as the ratio of tensile force in ~~the member~~ to the length of the member.

$$t = \frac{F}{L}$$

$$F_{ABx} = t_{AB}(x_B - x_A)$$

Similarly y-axis

$$F_{ABy} = t_{AB}(y_B - y_A)$$

force component ... z-axis

$$F_{ABz} = t_{AB}(z_B - z_A)$$