Equilibrium of Forces

Any system of forces acting on a body is said to be in equilibrium when the resultant of all forces is equal to zero and algebraic sum of moments of all the forces is equal to zero

Condiⁿs of equilibrium: the system of forces is said to be in equilibrium when $\Sigma H = 0$ i.e; algebraic sum of all the horizontal component of forces is equal to zero

(ii) $\Sigma V = 0$ the algebraic sum of all vertical component of forces is equal to 0.

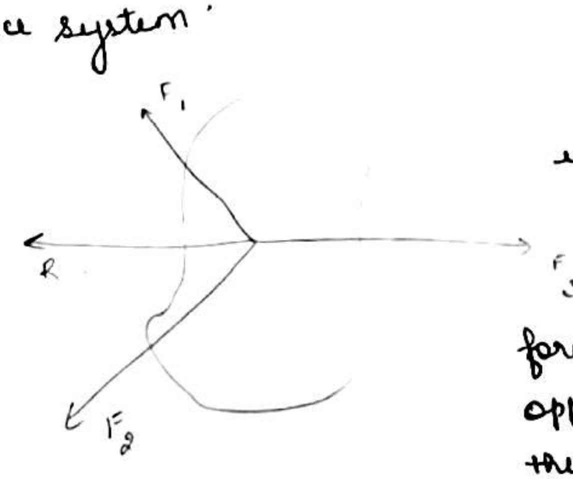
(iii) $\Sigma M = 0$: algebraic sum of all moment of forces about any refrence point is equal to 0.

Principle of Equilibrium of diff. forces systems:-

1) 2 force system:

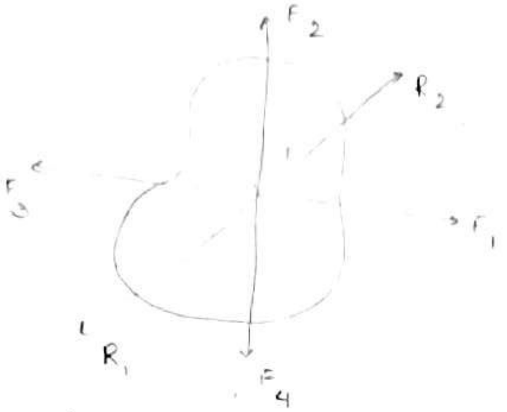
If a body is acted upon by 2 forces then for equilibrium they must be equal, opposite and collinear to each other

2) 3 force system:



If a body is acted upon by 3 forces then for equilibrium the resultant of any 2 forces must be equal, opp. and collinear with the 3rd force.

9) 4 force system:



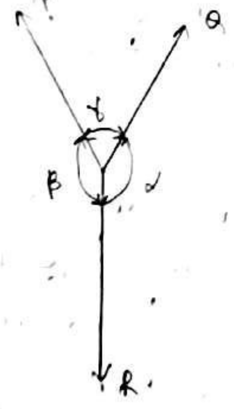
If a body is acted upon by four forces then for equilibrium the resultant of any 2 forces must be equal, opp and collinear to ~~each~~ other that of the other resultant of the forces

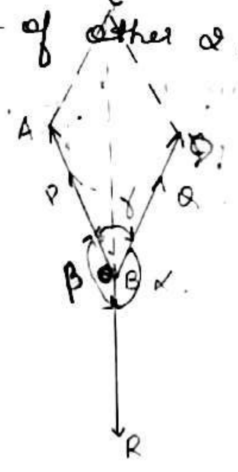
Equilibriant :- the force which is having same magnitude, opposite in direcn & collinear to the resultant of system of forces is called as equilibriant of forces

10 marks

Lami's Theorem

If 3 coplanar forces acting simultaneously at a point ~~will~~ be in equilibrium then each force is proportional to sine of angle of other 2 forces





consider P & Q as the two forces along OA & OB D

Project OA & OD in order to make a ||gm

$A\hat{O}C = 180 - \beta \rightarrow (1)$

$DOC = A\hat{C}O = 180 - \alpha \rightarrow (2)$

$CAO = 180 - A\hat{C}O - A\hat{O}C$

$= 180 - (180 - \alpha) - (180 - \beta)$

$= \alpha + \beta - 180 \rightarrow (3)$

$\alpha + \beta + \gamma = 360°$

Subtracting 180

$\alpha + \beta + \gamma - 180 = 180$

$\alpha + \beta - 180 = 180° - \gamma$

$\therefore CAO = 180 - \gamma$

$$\frac{OA}{\sin(ACO)} = \frac{OC}{\sin(CAO)} = \frac{AC}{\sin(AOC)}$$

$$\frac{P}{\sin(180-\alpha)} = \frac{R}{\sin(180-\gamma)} = \frac{Q}{\sin(180-\beta)}$$

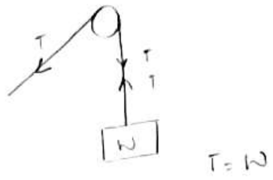
$$\therefore \frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$$

Points to remember while solving problems

* 1) If the member is subjected to pull (T force) then the body provides resistance & ... [illegible]

4) String, cables, ropes, wires, chains are always subjected to tension force only.

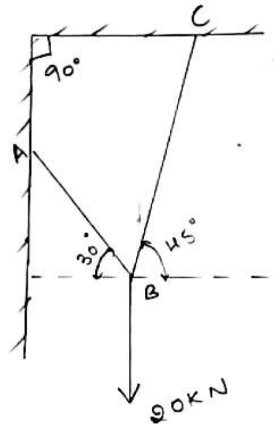
5) A string carrying a freely hanging load on one side will be in tension. If such string passes through frictionless pulley, then tension of either side of the pulley remains same.



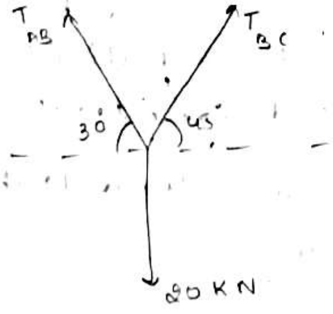
$T = W$

Probs:

1) 2 cables A & C are connected to the rigid surface as shown in figure. Determine the force in the cable BA BC



Free body digm:



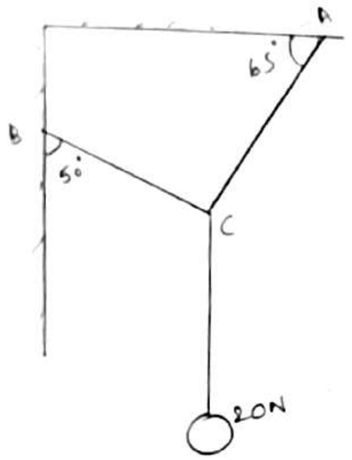
$$\frac{T_{AB}}{\sin(90+45^\circ)} = \frac{T_{BC}}{\sin(90+30^\circ)} = \frac{20}{\sin(180-30^\circ-45^\circ)}$$

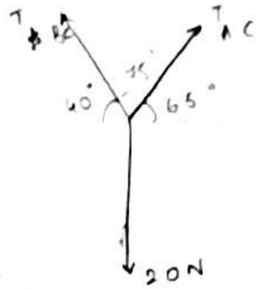
$$\frac{T_{AB}}{\cos 45} = \frac{T_{BC}}{\cos 30} = \frac{20}{0.9659}$$

$$T_{AB} = \frac{20 \times \cos 45}{0.9659} = \underline{14.64\ kN}$$

$$T_{BC} = \frac{20 \times \cos 30}{0.9659} = 17.93\ kN$$

2) An electric bulb hangs at a point C as shown. Determ the forces in the string AC & BC



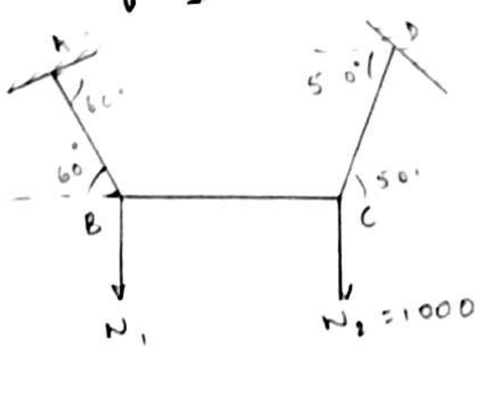


$$\frac{T_{AB}}{\sin(90^\circ+65^\circ)} = \frac{T_{AC}}{\sin(90^\circ+40^\circ)} = \frac{20}{\sin(75^\circ)}$$

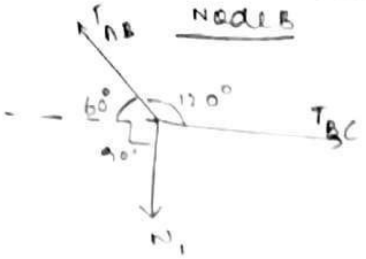
$$T_{AB} = \frac{20 \times \cos 65}{\sin 75^\circ} = \underline{8.75\ N}$$

$$T_{AC} = \underline{15.86\ N}$$

3. Find the force in all the wires AB, BC & CD & also load W_1 if $W_2 = 1000N$



NODE B

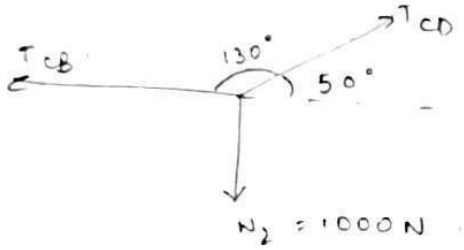


$$\frac{T_{AB}}{\sin(120+90)} = \frac{T_{BC}}{\sin(90°+60°)} = \frac{W_1}{\sin(120°)}$$

$T_{AB} = W_1(-0.577)$

$T_{BC} = W_1(-0.577)$

Node C.



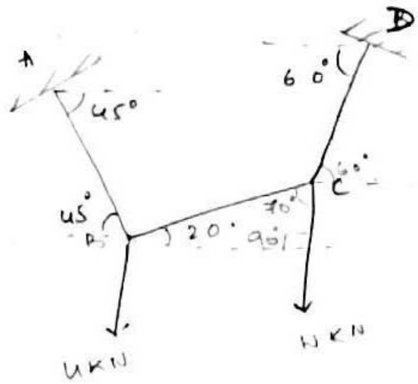
$$\frac{T_{CB}}{\sin(90+50)} = \frac{T_{CD}}{\sin(90°)} = \frac{1000}{\sin(130°)}$$

$T_{CB} = 889.099\ N$

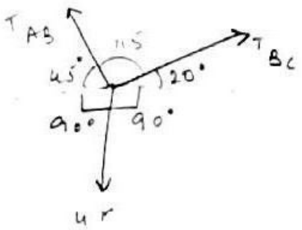
$T_{CD} = 1305.4\ N$

$$\therefore W_1 = \frac{839.099}{0.577}$$

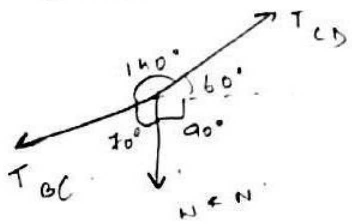
A string subjected to a force 4KN & WKN as shown ... mag of W & also tension in CD, AB, BC



at Node B.



at Node C



Node B

$$\frac{T_{AB}}{\sin(110)} = \frac{T_{BC}}{\sin(90+45)} = \frac{4}{\sin(115)}$$

$T_{AB} = \underline{4.14KN}$ $T_{BC} = 3.12$ KN.

Node C

$$\frac{T_{CD}}{\sin 70^\circ} = \frac{T_{BC}}{\sin(90^\circ+60^\circ)} = \frac{W}{\sin(140)}$$

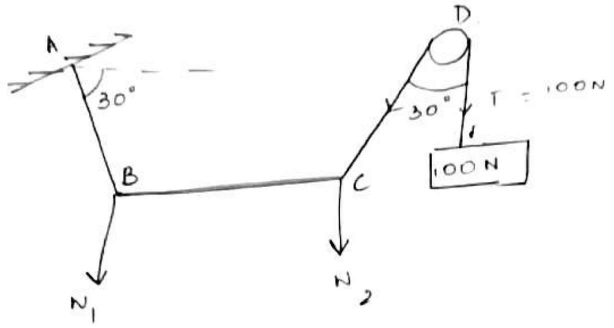
$T_{CD} = W(1.461) = \underline{5.86}$ KN.

$T_{BC} = W(0.7778$

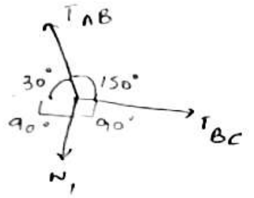
$\therefore W = \dfrac{3.12}{0.7786}$

$= \underline{4.011}$ KN.

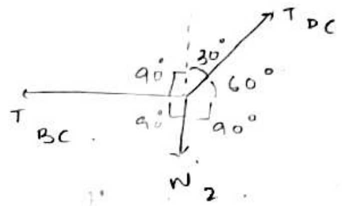
5) A light weight string ABCDE fixed to weights W_1 & W_2 @ B & C & a weight of 100N is ~~acting~~ passing through (over) a frictionless pulley @ E. Determine tension in all the strings and also the weights W_1 & W_2



at Node B



at Node C



at Node C

$$\frac{T_{DC}}{\sin 90} = \frac{T_{BC}}{\sin(150)} = \frac{W_2}{\sin(120°)} = 100 \Rightarrow T_{BC} = W_2 \frac{\sin(150)}{\sin(120)}$$

~~T_{BC}~~

$$\therefore T_{BC} = 100 \times \sin(150)$$

$$= \underline{\underline{50}} \text{ N}$$

at Node B

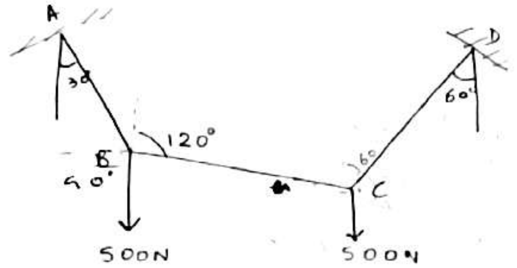
$$\frac{T_{AB}}{\sin 90°} = \frac{T_{BC}}{\sin 120} = \frac{W_1}{\sin 150}$$

$$\Rightarrow T_{BC} = W_1 \frac{\sin 120}{\sin 150°}$$

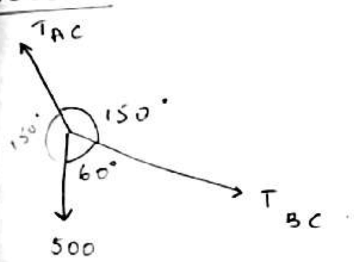
$$W_1 = \frac{50 \times \sin 30}{\sin 60°} = \underline{28.86 \text{ N}}$$

$$\therefore W_2 = \frac{50 \times \sin 60}{\sin 30}$$

$$= \underline{86.60} \text{ N}$$



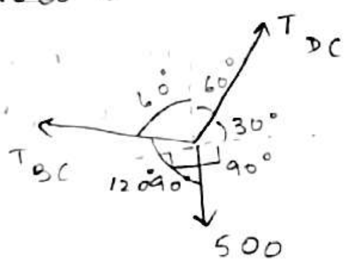
Node B



$$\frac{T_{AC}}{\sin 60} = \frac{T_{BC}}{\sin 150} = \frac{500}{\sin 150}$$

$T_{AC} = 866.025\,N$ $\quad$ $T_{BC} = 500\,N$

Node C



$$\frac{T_{DC}}{\sin(120°)} = \frac{T_{BC}}{\sin(120°)} = \frac{500}{\sin(120°)}$$

$T_{DC} = T_{BC} = 500\,N$

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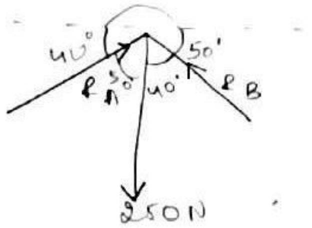
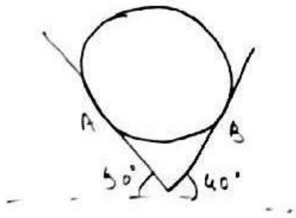
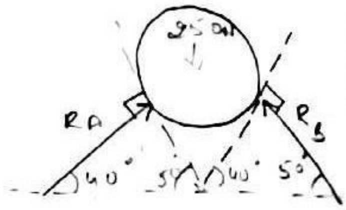
Problems on Sphere :

1) A sphere weighing 250N is fitted in a right angle lounge as shown in the fig. If all the contact faces are smooth, the determine the reac^{ns} at A & B





$$\frac{R_A}{\sin \cancel{50} 40°} = \frac{R_B}{\sin 50°} = \frac{250}{\sin 270°}$$



$R_A = 160.69$ (compressed force)

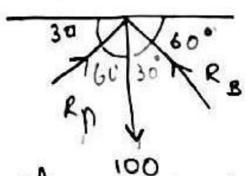
$R_B = 191.51$ (compressed force)

2) A sphere weighing 100N is fitted in the right angle lounge as shown in the fig. Determine the reac^n at A & B.

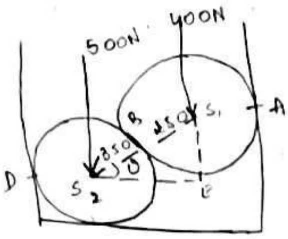
$$\frac{R_A}{\sin 30°} = \frac{R_B}{\sin 60°} = \frac{100}{\sin (270°)}$$

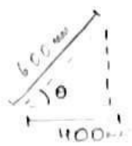
$R_A = 50$ (compressed)

$R_B = 86.60$ (compressed)



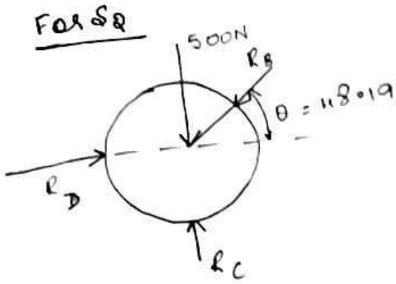
3) A horizontal channel ~~o~~ has an inner clearance of 1000mm carries 2 spheres of radius 350mm & 250mm whose weights are 500N & 400N resp. find the reac^n at all the contact surface.



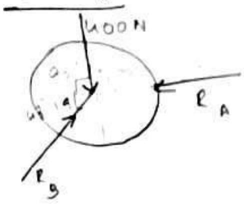


$\theta = 48.19°$

For S_2



For S_1



$$\frac{R_A}{\sin(138.19)} = \frac{R_B}{\sin 90°} = \frac{400}{\sin(131.81)}$$

$R_A = 357.766N$ $\quad R_B = 536.65\ N$

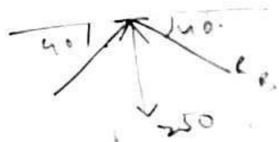
For S_2

$\Sigma H = -R\cos\theta + R_B.$

$\Sigma V = -R_C + 500 - R_B \sin 48.91$

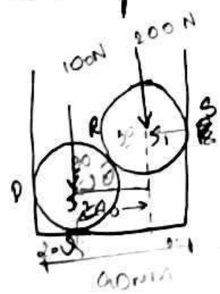
$\Sigma H = 0.$

$R_D = 357.7N$



$R_C = 899.9N$

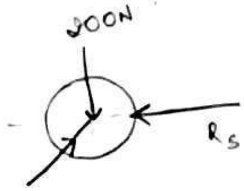
4) Determine the reactions at contact points P Q R S. If the radii of the spheres are equal to 20 and 30mm



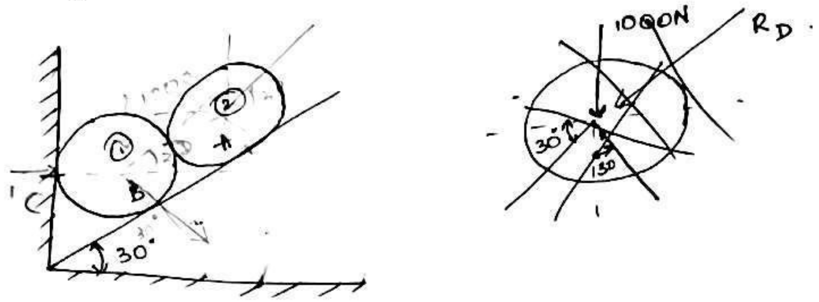
$$\cos\theta = \frac{40}{50} =$$

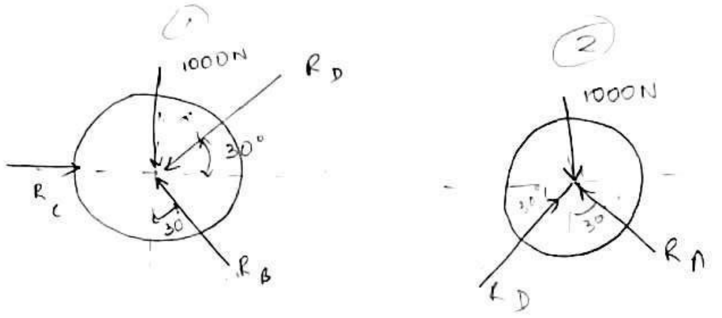
$\theta = 36.86$

for S_1



5) Find the reacⁿ at 2 contact surfaces of 2 identical cylinders weighing 1000 N each





2 :-

$$\frac{R_A}{\sin 120} = \frac{R_D}{\sin 150} = \frac{1000}{\sin 90^\circ}$$

$R_A = 866.025$ N

$R_D = 500$ N

1 $\Sigma H = 0 = R_B \sin 30^\circ + R_D \cos 30^\circ - R_C$

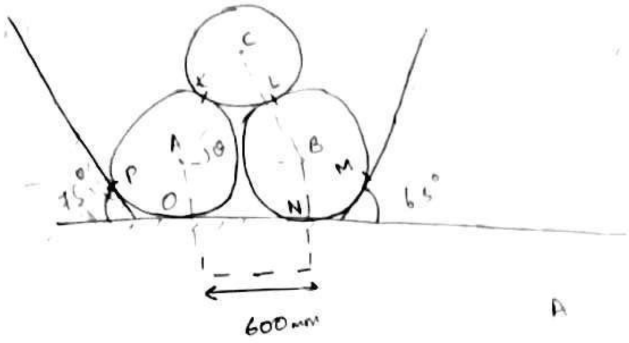
$\Sigma V = 0 = -R_B \cos 30^\circ + R_D \sin 30 + 1000$

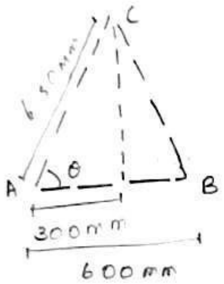
$$0 = \frac{R_B}{2} + 749.99 - R_C$$

$$0 = -R_B(0.866) + 433.0125 + 1000$$

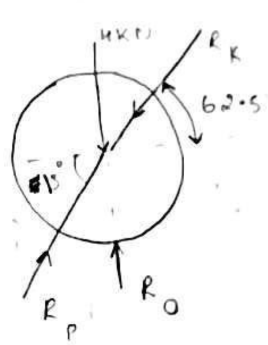
$R_B =$

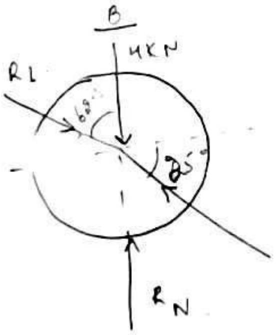
6) Determine the reac^ns at contact points for spheres A, B, C as shown in the fig. Self weight of A & B is equal to 4KN, C = 6KN diameter of A & B is equal to 500mm & diameter of C is equal to 800mm.

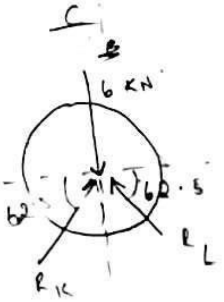




$\theta = 62.5^\circ$







A

$$\Sigma H = 0 = R_K \cos 62.5' - R_p \cos 75^\circ$$

$$\Sigma V = 0 = 4000 + R_K \cancel{\cos} \sin 62.5 - R_O - R_p \sin 75$$

C

$$\frac{6000}{\sin 55} = \frac{R_L}{\sin(152.5)} = \frac{R_K}{\sin(152.6)}.$$

$$R_L = R_K = 8882.145$$

$R_O =$

$$R_p = 6033.94.$$

Support and Support Reactions.

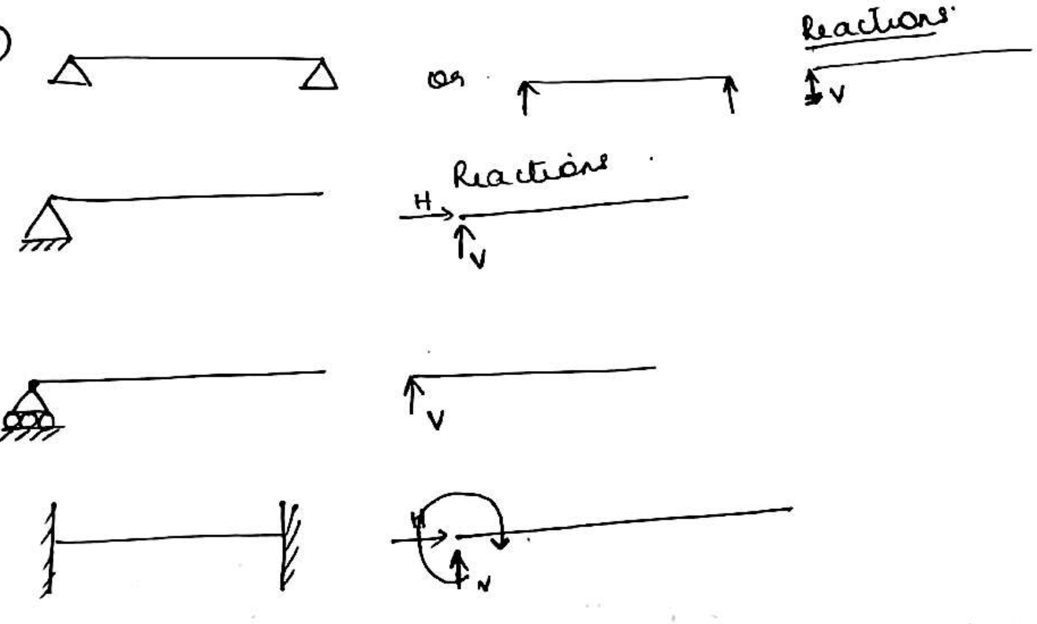
Support is a part of structure which helps to withstand the another structure against various internal & external forces.

The reacⁿ which occurs in the in a support due to the ~~resist~~ resistance of above mentioned forces is called as support reacⁿs.

Types of supports:

1) Simple support
2) hinged / Pinned.
3) ~~Root~~ Roller.
4) Fixed.

1)
2)
3)
4)

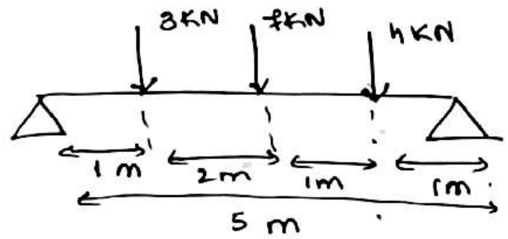


1) Simple support: the support which is defined as structure which rests freely on the support with one vertical reaction ⊥r to the horizontal structure

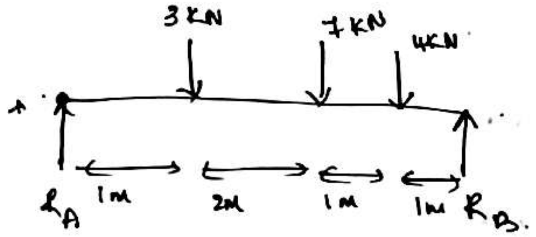
2) hinged / Pinned support: this support can withstand both horizontal & vertical forces but not a moment hence there are 2 reacⁿs existing in one support that is one horizontal & one vertical.

3) Roller support: are free to rotate & translate along the surface upon which the roller rests. no. of reac^ns for a roller support is one vertical which is ⊥r to the horizontal structure.

4) Fixed support: can resist vertical and horizontal forces as well as moment. Hence the no. of reac^ns are one vertical, one horizontal and a moment.

10) 

Determine the support reactions at A & B.

Ans. 

$\Sigma H = 0$

$\Sigma V = 0$

$R_A + R_B - 3 - 7 - 4 = 0$

$R_A + R_B - 14 = 0$

$R_A + R_B = 14\ KN \longrightarrow (1)$

$\Sigma M_A = 0$

$-R_B(5) + 4(4) + 7(3) + 3(1) = 0$

$16 + 21 + 3 = 5R_B$

$R_B = \frac{40}{5} = 8$

$R_A = 14 - 8$

$= 6\ KN$

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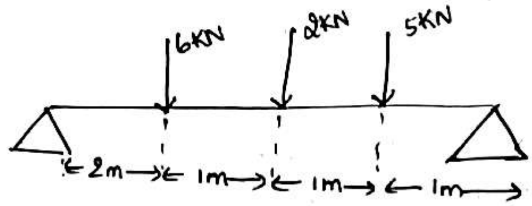
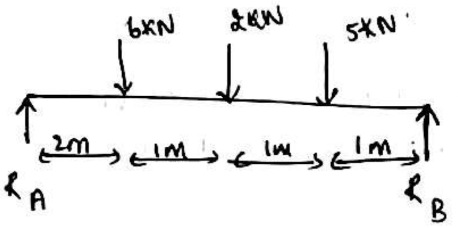
2) A simply supported beam of length 5m is loaded as shown. Determine support reactions.



Ans:-



$\Sigma H = 0$

$\Sigma V = 0$ $\qquad R_A + R_B - 6 - 2 - 5 = 0$

$R_A + R_B = 13\ KN$

$\Sigma M_A = 0 := -R_B(5) + 5(4) + 2(3) + 6(2)$

$5R_B = 20 + 6 + 12$

$= 38$

$R_B = 38/5 = 7.6\ KN$

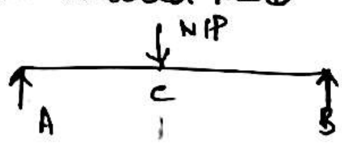
$R_A = 13 - 7.6$

$= 5.4\ KN$

types of loads : 8 types.

(i) Point load / concentrated load

~~concentrated~~



The load whose magnitude is concentrated in a single point of a beam is called as point load / concentrated load.

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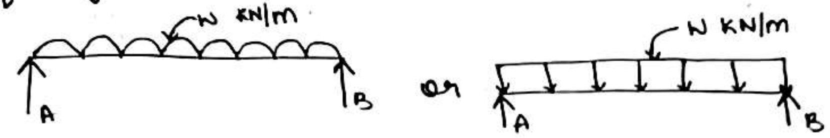
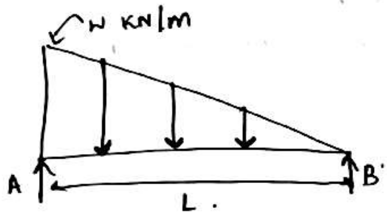
2) Uniformly distributed load (UDL) :



The load whose intensity is same throughout the entire span of the beam is called (UDL)

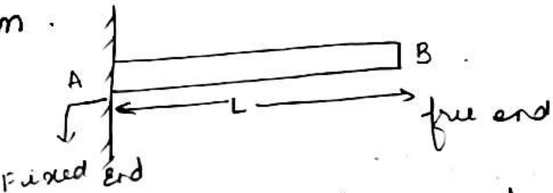
3) Uniformly varying load (UVL) :



The load whose intensity varies with length of beam is called as uniformly varying load

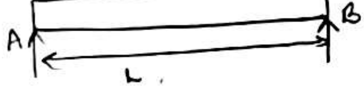
Types of beams:

1) Cantilever beam .

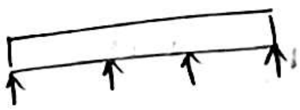


It is a type of beam in which one end of the beam is fixed and other end of the beam is free .

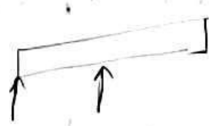
2) Simple Supported beam :- It is a type of beam where in the horizontal member (slab) rests simply on two supports



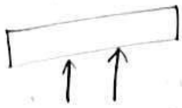
3) Continuous beam :- It is a type of beam which consists of more than 2 simple supports .



Overhanging beam:



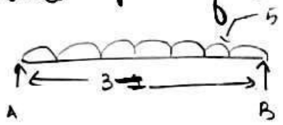
(One side overhanging)



(Two side overhanging)

It is a beam which extends beyond the support is called as overhanging beams.

37. A simply supported beam of length 3m is provided with uniformly distributed load of 5 KN/m throughout the entire span of the beam. Calculate reacns at A & B.



Ans:-

$\Sigma V = 0$

$R_A + R_B - 5(3) = 0$

$R_A + R_B = 15$

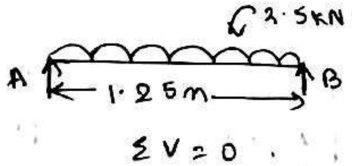
$\Sigma M_A = 0$

$-R_B(3) + 5(3)(3/2) = 0$

$R_B = 7.5\,KN$

$R_A = 7.5\,KN$

4)



$\Sigma V = 0$

$R_A + R_B - 2.5(1.25) = 0$

$R_A + R_B = 3.125$

$\Sigma M_A = 0$

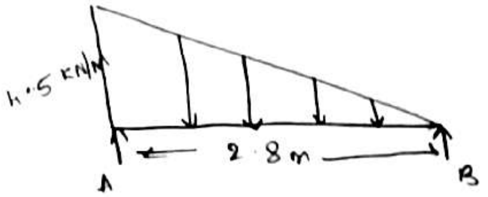
$-R_B(1.25) + 2.5(1.25)\left(\frac{1.25}{2}\right) = 0$

$R_B = \frac{1.953}{1.25}$

$= 1.56\,KN$

$R_A = 1.56\,KN$

) A simple supported beam carries UVL of 5 KN/m.
Determine the reacns at A & B.



$\Sigma V = 0$

$R_A + R_B - \frac{1}{2}(2.8)(4.5) = 0$

$R_A + R_B = 6.3 \text{ KN}$

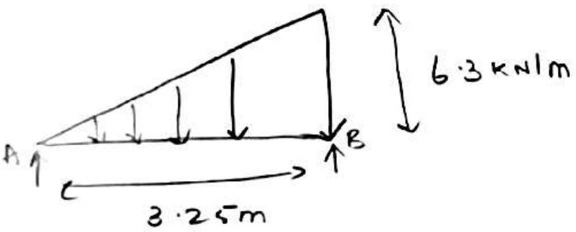
$\Sigma M_A = 0.$

$-R_B \times 2.8 + \frac{1}{2}(2.8)(4.5)\left(\frac{1}{3}(2.8)\right) = 0$

$2.8 R_B = 5.88$

$R_B = 2.1 \text{ KN}.$

$R_A = \underline{4.2} \text{ KN}$



$\Sigma V = 0$

$R_A + R_B - \frac{1}{2}(3.25)(6.3)$

$R_A + R_B = 10.23$

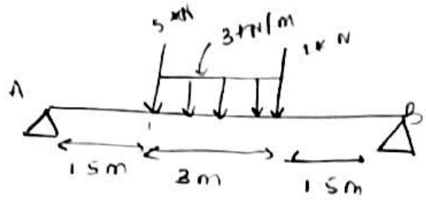
$\Sigma M_A = 0$

$-R_B(3.25) + \frac{1}{2}(3.25)(6.3)\left(\frac{2}{3}(3.25)\right)$

$R_B = \cancel{8.37}\ 6.82$

$R_A = 3.41$

4) A simply supported beam of span of 6m subjected to load. Determine the reac n at A & B.



$\Sigma V = 0$

$R_A + R_B - 2 - 5 - 3(3) = 0$

$R_A + R_B = 9 + 5 + 2$

$= \underline{16}$ KN $\rightarrow$ ①

$\Sigma M_A = 0$

$-R_B(6) + 2(4.5) + 5(1.5) + 3(3) \times \left(3/2 + 1.5\right)$.

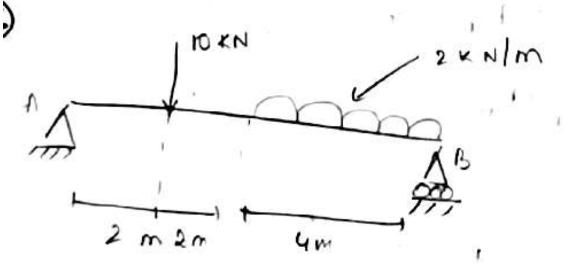
$R_B(6) = 9 + 7.5 + 27$

$= 43.5$

$R_B = 7.25$ KN

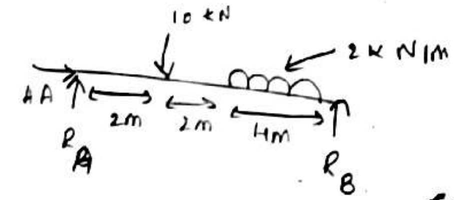
$R_A = 8.75$ KN

)



$\Sigma H = HA = 0$

Ans :-



$\Sigma V = R_A + R_B - 10 - 2(4) = 0$

$R_A + R_B = \underline{18}$ KN

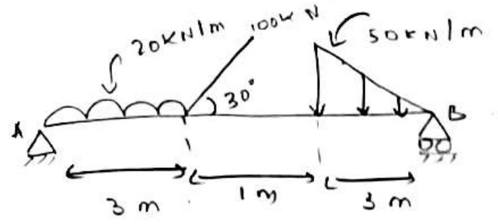
$\Sigma M_A = 0$

$0 = -R_B(8) + 2(4)(4/2 + 4) + 10(2)$

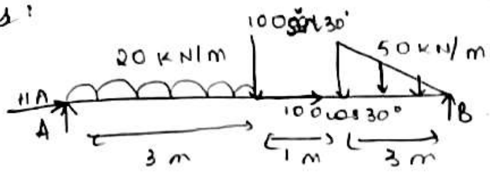
$R_B = 8.5$ KN

$R_A = 9.5$ KN

9)



Ans :



$\Sigma H = HA + 100 \cos 30 = 0$

$HA = -86.60$

$= 86.6 \; (\leftarrow)$

$\Sigma V = 0$

$0 = R_A + R_B - 100 \sin 30 - 50\left(\frac{3}{2}\right) - 20(3)$

$R_A + R_B = 185$

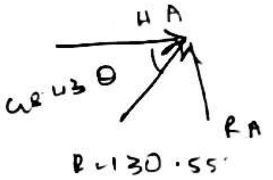
$\Sigma M_A = 0$

$-R_B(7) + \frac{1}{2}(3)(50)\left(4 + \frac{1}{3}\cancel{3}\right) + 100 \sin 30°(3) + 20(3)(3/2)$

$R_B(7) = 150 + 375 + 90$

$R_B = 87.85 \text{ KN}$

$R_A = 97.65 \text{ KN}$

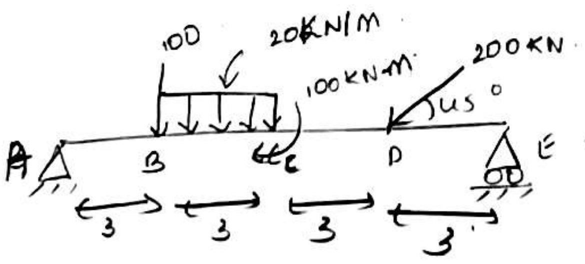


$R = \sqrt{HA^2 + R_A^2}$

$R = 130.55 \text{ KN}$

$\theta = \frac{R_A}{H_A} = \frac{97.65}{86.6} = 48.43$

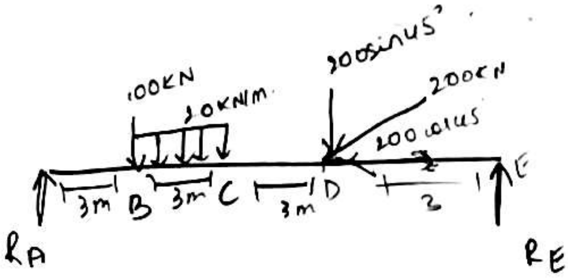
b)



$\Sigma H = 0$

$HA - 100 \cos 30 = 0$

$HA = 86.6 \text{ KN}$



$\Sigma M_A = 0$

$10(2)\left(\frac{2}{2}\right) + 30(2) + 20(3) + 10(x+7) - R_B(7) = 0$

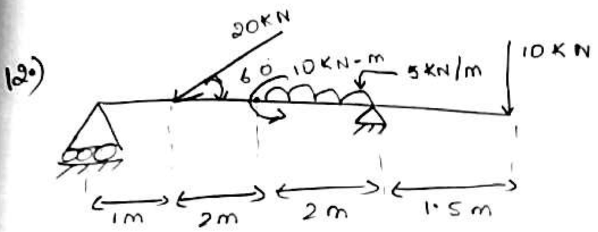
$20 + 60 + 60 + 10x + 70 = 7R_B$

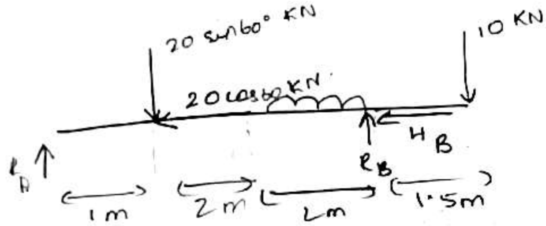
$210 + 10x = 7R_B$

$10x = 7(40) - 210$

$x = 7m$

12.





$\Sigma H = 0$

$-20\cos 60° - H_B = 0$

$H_B = 10\,KN\ (\leftarrow)$

$\Sigma V = 0$

$-20\sin 60° - 10 - 5(2) + R_A + R_B = 0$

$R_A + R_B = 10 + 10 + 20 \times \frac{\sqrt{3}}{2}$

$= 37.32\,KN$

$\Sigma M_A = 10(6.5) - R_B(5) + 5(2)\left(\frac{2}{2} + 3\right)$

$+ 20\sin 60°(1) - 10 = 0$

$R_B = 22.46\,KN$

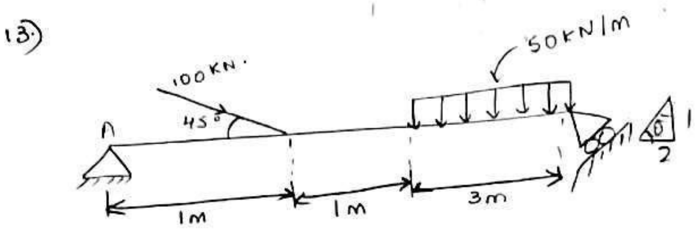
$R_A = 14.9\,KN$

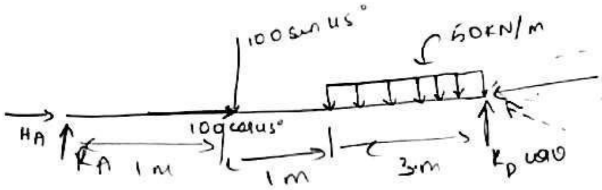
$R = 17.95\ KN$

$\theta = \tan^{-1} \cancel{\frac{\Sigma V}{\Sigma H}} \frac{R_B}{H_B}$

$= \underline{66}$

13.)





no horizontal component for roller support

$\tan\theta = 1/2$

$\theta = \underline{26.56}$

$\Sigma H = 0$

$H_A + 100 \cos 45^\circ = 0$

$H_A = \frac{-100}{\sqrt{2}} = 70.71\ (\leftarrow)$

$\Sigma V = 0$

$R_A - 100 \sin 45^\circ - 50(3) + R_D \cos\theta = 0$

$R_A - 70.71 - 150 + R_D\, 0.894 = 0$

$R_A + R_D (0.894) = \underline{220.71}$

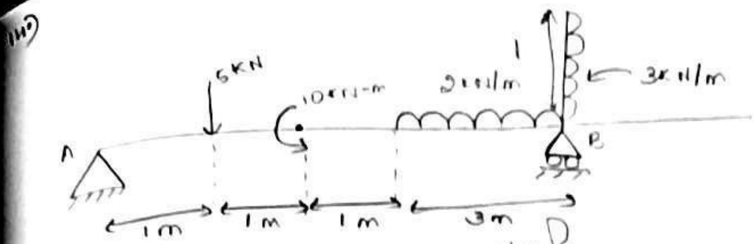
$\Sigma M_A = 100 \sin 45 (1) - R_D \cos(26.56)(5) + 50(3)\left(\frac{3}{2}+2\right) = 0$

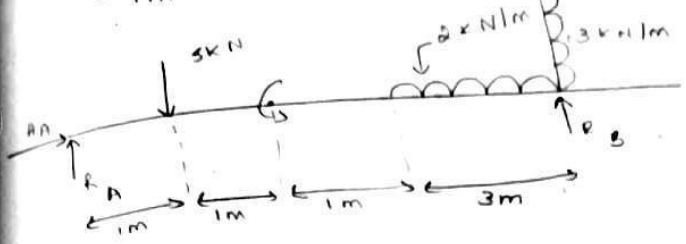
$\frac{70.71 + 525}{4.47} = R_D = \underline{133.26}\ KN$

$R_A = 101.5\ KN$

Shreya J B

14)





$\Sigma H = 0$.

$H_A - 3(1) = 0$

$\underline{H_A = 3 KN}$

$\Sigma V = 0$

$R_A - 5 - 2(3) + R_B = 0$.

$\underline{R_A + R_B = 11 KN}$

$\Sigma M_A = 0$.

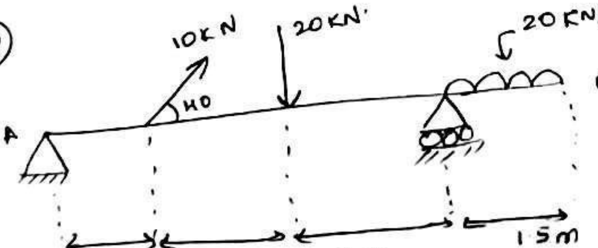
$-3(1)(1/2) - R_B(6) + 2(3)(3/2 + 3) - 10 + 5(1)$.

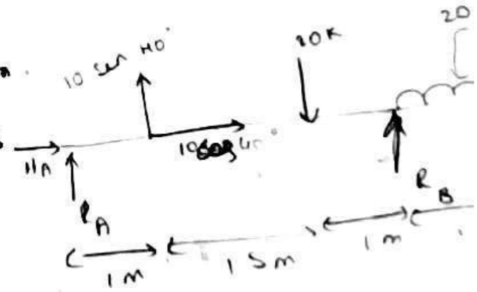
$0 = -1.5 - 6R_B + 27 - 10 + 5$

$6R_B = 20.5 \Rightarrow \underline{R_B = 3.41}$

$\underline{R_A = 7.59}$

15)





$\Sigma V = 0$

$R_A + 10\cos 40 - 20 + R_B - 2$

$R_A + R_B = 20 + 30 - 7.66$

$\underline{= 42.339}$.

$\Sigma H = 0$.

$H_A + 10\sin 40 = 0$

$H_A = 6.427 (\leftarrow)$.

$\Sigma M_A = -10\sin 40(1) + 20(2.5) - R_B(3.5)$

$+ 20(1.5)\left(\frac{1.5}{2} + 3.5\right) = 0$

$3.5 R_B = 43.57 + 12 \cdot 7.5$

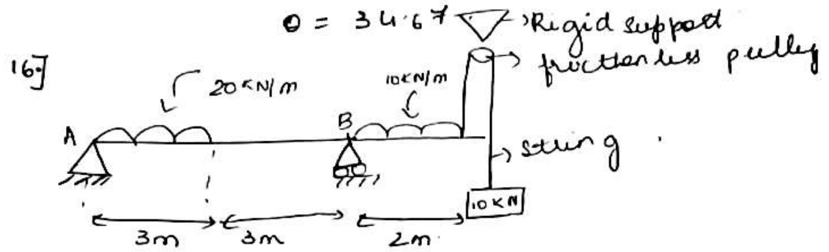
$R_B = 48.87$ kN

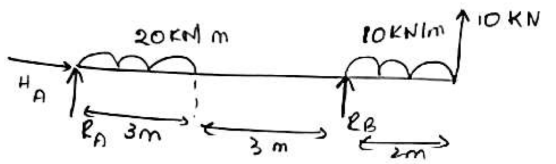
$R_A = 5.3 (\leftarrow)$ kN

$R = 9.314$ kN $= \sqrt{R_A^2 + H_A^2}$

$\theta = 34.67$

16.





$\Sigma H = 0$

$H_A = 0$

$\Sigma V = 0$

$R_A - 20(3) + R_B - 10(2) + 10 = 0$

$R_A + R_B = 20 + 60 - 10$

$= 20 + 50 = 70$ KN

$\Sigma M_A = 0$

$20(3)\left(\frac{3}{2}\right) - R_B(6) + 10(2)\left(\frac{2}{2} + 6\right) - 10(8) = 0$

$6 R_B = \cancel{80 + 180 = 90}$

$6 R_B = \cancel{16} - 80 - 90 + 140$

$R_B = 25$ KN

$R_A = 45$ KN

$R = \cancel{51.07}$ 45, $\theta = \pi/2$

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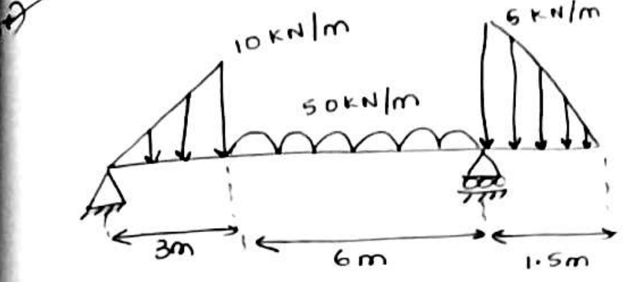
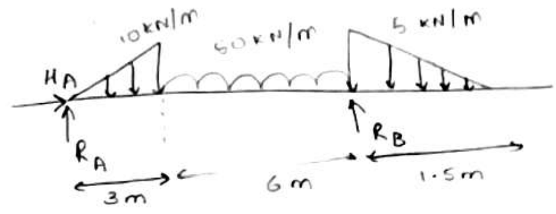
IMP





$\Sigma H = 0 \Rightarrow H_A = 0$

$\Sigma V = 0 \Rightarrow R_A - 10 \cdot \frac{(3)}{2} \cancel{\left(\frac{3}{2}\right)} - 50(6) - 5(0.75) + R_B = 0$

$R_A + R_B = 5(0.75) + 50(6) + 10(1.5)$

$= 3.75 + 300 + 15$

$= \underline{318.75}$

$\Sigma M_A = 10\left(\frac{3}{2}\right)\left(3 \times \frac{2}{3}\right) + 50(6)\left(\frac{6}{2} + 3\right) + 5\left(\frac{1.5}{2}\right)\left(\frac{10.5}{3} + 9\right)$

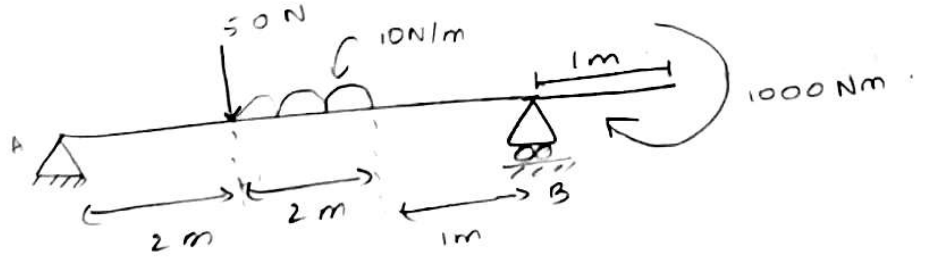
$- R_B (9) = 0.$

$R_B = 207.29 KN$

$R_A = 111.458 KN$

$R = \underline{\underline{235.355}}$

18)



$\Sigma H = 0 \Rightarrow H_A = 0.$

$\Sigma V = 0 \Rightarrow R_A - 50 - 10(2) + R_B = 0.$

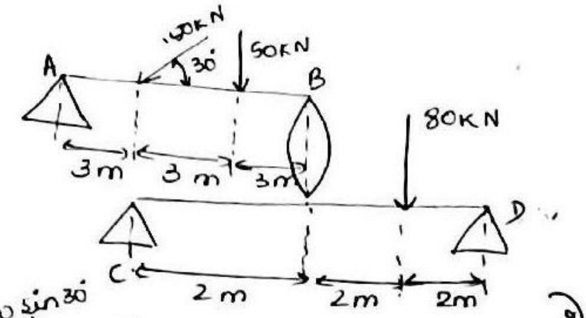
$R_A + R_B = \underline{\underline{70KN}}$

$\Sigma M_A = +50(2) + 10(2)\left(\frac{2}{2} + 2\right) - R_B(5) + 1000$

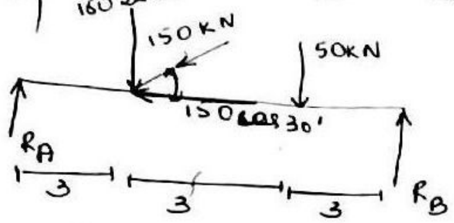
$0 = 100 + 10(2)(3) - R_B 5 + 1000$

$5R_B = 100 + 60 + 1000 \Rightarrow R_B = 232 \Rightarrow R_A = 162N \Rightarrow R =$

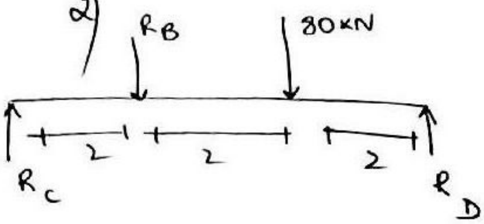
19)



1)



2)



$\Sigma H = 0$

$\Sigma V = R_A + R_B - 50 - 150 \sin 30°$

$\Rightarrow R_A + R_B = 50 + 75$

$= \underline{125}$ KN

$\Sigma M_A = 150 \sin 30°(3) - R_B(9) + 50(6)$

$0 = 75(3) - 9R_B + 300$

$9R_B = 525$

$R_B = 58.33$ KN

$R_A = \underline{66.66}$ KN

2) $\Sigma H = 0$

$\Sigma V = 0 = R_C + R_D - R_B - 80.$

$R_C + R_D = \underline{138.33}$ KN

$\Sigma M_C = R_B(2) + 80(4) - R_D(6)$

$6R_D = 436.66$ KN

$R_D = \overset{72.7}{\cancel{54.58\text{ KN}}} \Rightarrow R_C = \overset{65.55}{\cancel{83.74\ 75\text{ KN}}}$

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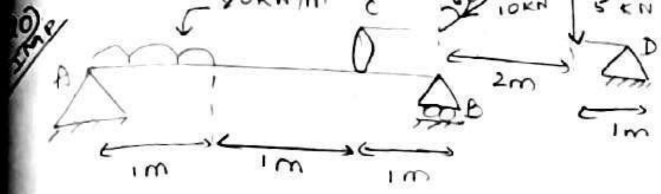
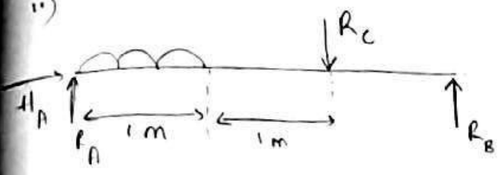
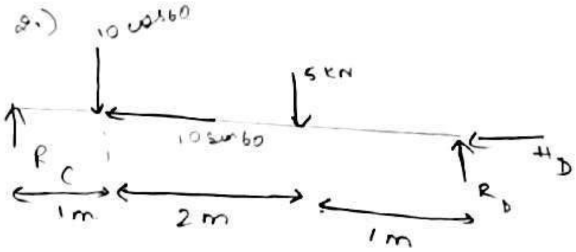


1.)



2.)



1.) $\Sigma H = 0$

$H_A = 0$

$\Sigma V = R_A + R_B - R_C - 20(1) = 0$

$20 = R_A + R_B - R_C$

$\Sigma M_A = 20(1)\left[\frac{1}{2}\right] + R_C(2) - R_B(3)$

$0 = 10 + 2R_C - 3R_B$

$2R_C - 3R_B = -10$

2.) $\Sigma H = 0$

$-H_D - 10\sin 60° = 0$

$H_D = 8.6\ (\leftarrow)$

$\Sigma V = 0 = R_C - 10\cos 60 - 5 + R_D$

$\Rightarrow R_C + R_D = 5 + 5 = 10$

$\Sigma M_C = 10\cos 60(1) + 5(3) - R_D(4) = 0$

$4R_D = 5 + 15$

$R_D = \underline{5}$

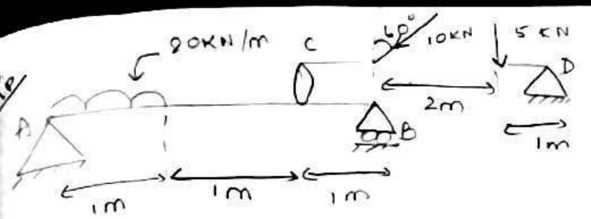
$R_C = \underline{5}$

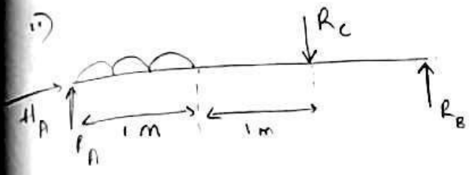
$R_A + R_B = 25$

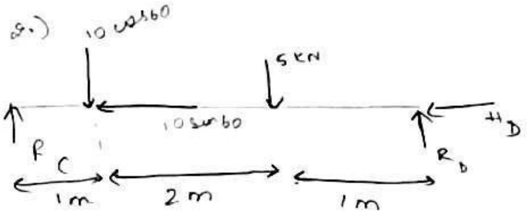
$2(5) - 3R_B = -10$

$3R_B = 10 + 10$

$R_B = \underline{6.6} \Rightarrow R_A = \underline{18.4}$







1.) $\Sigma H = 0$

$H_A = 0$.

$\Sigma V = R_A + R_B - R_C - 20(1) = 0$

$20 = R_A + R_B - R_C$

$\Sigma M_A = 20(1)\left[\frac{1}{2}\right] + R_C(2) - R_B(3)$

$0 = 10 + 2R_C - 3R_B$.

$2R_C - 3R_B = -10$

2.) $\Sigma H = 0$.

$-H_D - 10\sin 60^\circ = 0$.

$H_D = 8.6\ (\leftarrow)$

$\Sigma V = 0 = R_C - 10\cos 60 - 5 + R_D$.

$\Rightarrow R_C + R_D = 5 + 5 = 10$

$\Sigma M_C = 10\cos 60(1) + 5(3) - R_D(4) = 0$

$4R_D = 5 + 15$

$R_D = 5$

$R_C = 5$

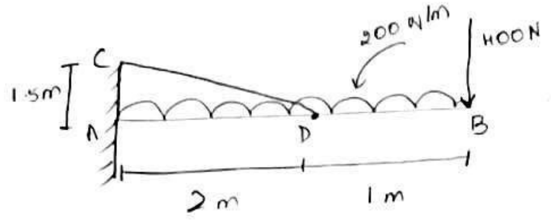
$R_A + R_B = 25$.

$2(5) - 3R_B = -10$

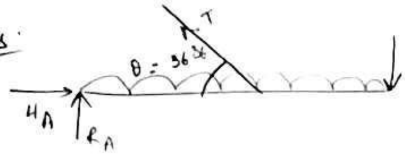
$3R_B = 10 + 10$

$R_B = 6.6 \Rightarrow R_A = 18.4$

21) A beam is loaded as shown in fig. assuming it h... hinged support. Find the tension in cable CD.



Ans:



$\tan\theta = \frac{1.5}{2}$

$= 36.86$

$\Sigma H = 0$

$H_A - T\cos 36.86 = 0$

$H_A = T \cancel{\cos} (0.8)$

$\Sigma V = 0$

$R_A + T\sin 36.86 - 400 - 200(3) = 0$

$R_A + T (0.59) = 1000$

$\Sigma M_A = 0$

$-T\sin 36.86(2) + \cancel{200}^{100}(3)\left(\frac{3}{\cancel{2}}\right) + 400(3) = 0$

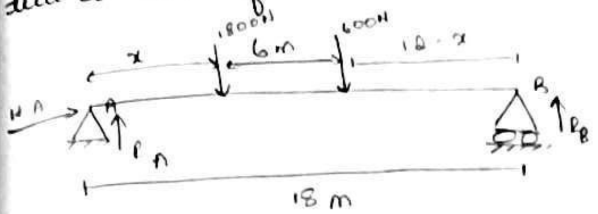
$1200 + 900 = T(0.59)(2)$

$T = \cancel{3500}$

$H_A = 2800$

$R_A =$

2 loads are placed as shown in the figure if the distance find the distance x at which support reaction at A is twice that of B.



$R_A = 2R_B$

$\Sigma H = 0$

$H_A = 0$

$\Sigma V = 0 = R_A - 1800 - 600 + R_B$

$3R_B = 2400$.

$R_B = \underline{800N}$. $\Rightarrow R_A = 1600N$

$\Sigma M_A = 0$.

$1800(x) + 600(6+x) - R_B(\cancel{12}\ 18) = 0$

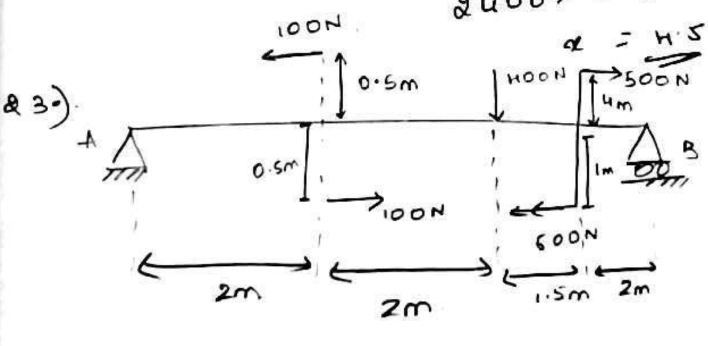
$1800x + 3600 + 600x = R_B(18)$

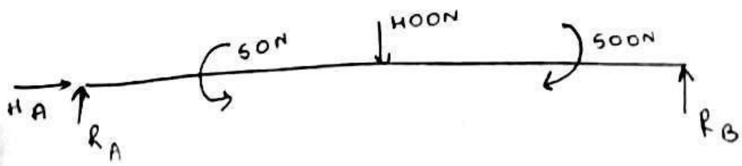
$3600 + 2400x = 14400$.

$2400x = 10800$.

$x = \underline{4.5}$.

Q 3).





$\Sigma H = 0$

$H_A = 0$

$\Sigma V = 0 = R_A + R_B - 400$

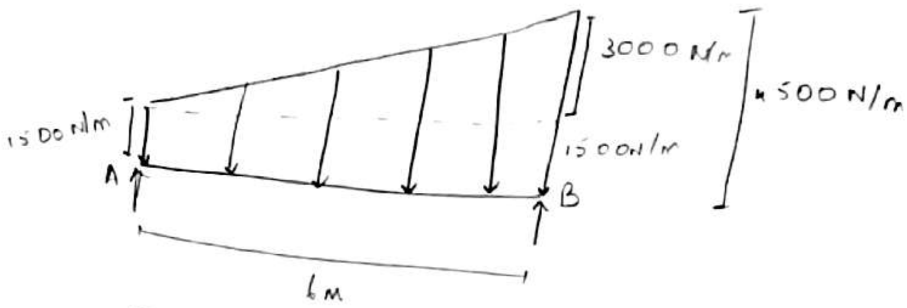
$R_A + R_B = 400N$.

$\Sigma M_A = 0 = -50(2) + 400(4) + 500(5.5) - R_B(7.5)$

$R_B(7.5) = 2750 + 1600 - 100$

$R_B = \underline{566.66}$

24) MP of span 6m carries a uniformly varying load of to 4500 N/m as shown Determine the support reaction A & B.



$\Sigma V = 0$

$\cancel{R_A + R_B - 1500(6) = 0}$

$\cancel{R_A + R_B = 9000}$ 9

$R_A + R_B - 1500(6) - 3000\left(\frac{1}{2} \times 6\right) = 0$

$R_A + R_B = 9000 + 9000$

$= \underline{18000} = 18KN$

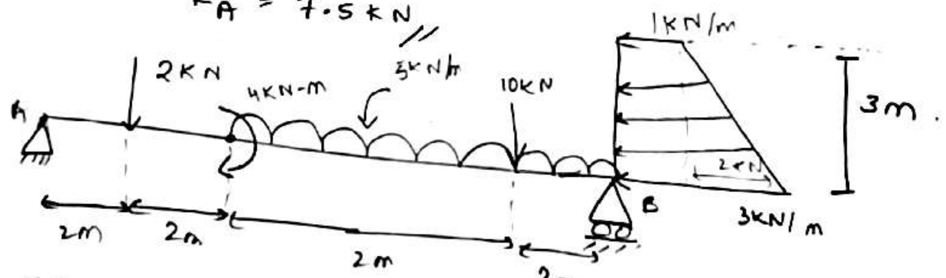
$\Sigma M_A = 0$

$6 R_B = 1500(6/2)(6) + 3000(6/2)\left(\frac{2}{3} \times 6\right)$

$R_B = 10.5 kN$

$R_A = 7.5 kN$

25)



$\Sigma H = 0 = H_A + 3(3/2) - 1(3) \Rightarrow H_A = 7.5 kN$

$\Sigma V = 0$

$R_A - 2 - 5(4) - 10 + R_B = 0$

$R_A + R_B = 10 + 20 + 2$

$= 32 kN$

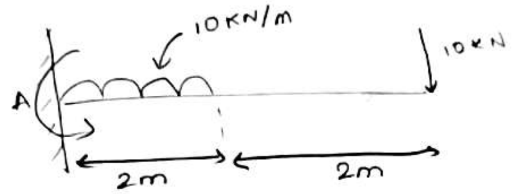
$\Sigma M_A = 2(2) + 4 + 5(4)\left(\frac{4}{2} + 4\right) + 10(6) - R_B(8)$
$- 3(3/2)3 - 3(1)\left(\frac{2}{3} \times 3\right) = 0$

$0 = 4 + 4 + 120 + 60 - 8R_B - 13.5 - 6 = 0.$

$8R_B = 168.5$

$R_B = \underline{21.06}$

26) Find the reacⁿs for a cantilever beam.



$\Sigma H = 0$

$H_A = 0$

$\Sigma V = 0 = R_A - 10(2) - 10.$

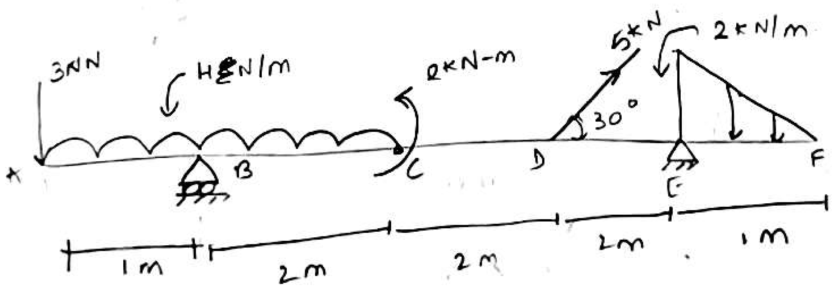
$R_A = \underline{30\ KN}.$

$\Sigma M_A = 10(2)(1) + 10(4).$

$= 20 + 40$

$= \underline{60}\ KN\text{-}m$

27.)



$R_B = ?$

$R_F = ?$

$H_F = ?$

$\Sigma H = 0$

$H_E + 5\cos 30 = 0.$

$H_E = 4.33 (\leftarrow)$

$\Sigma V = 0 = -3 - 4(3) + 5\sin 30 + R_E - 2(1/2)(1) + R_B.$

$R_B + R_E = 3 + \overset{12}{\cancel{13.5}} - 2.5 + 1$

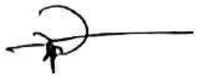
$= \cancel{+36.5\ KN}.\ 13.5.$

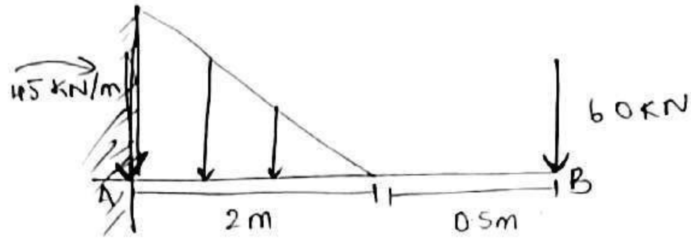
$\cancel{\Sigma M_A = 0.}$

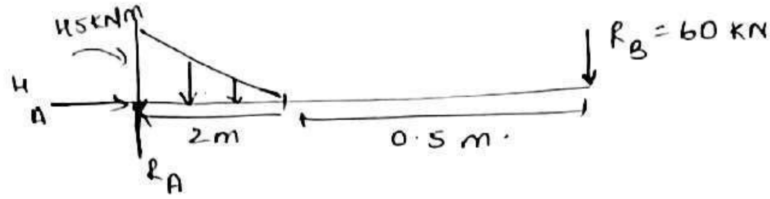
$\cancel{-R_B(1) - 2 - 5\sin 30(5) - R_E(7) + 2(1/2)(2/3 \times 1 + 7) = 0}$

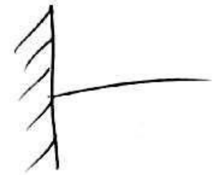
$\cancel{-R\ \ - 2 - 12.5 - 7R_E + 7.6 = 0}\ . -R_B - 7R_E = 6.9.$

28) Find the reac^n at support of the cantilever beam as shown in the figure









$\Sigma H = H_A = 0$

$\Sigma V = R_A - 60 - 45 \times \frac{1}{2} \times 2$

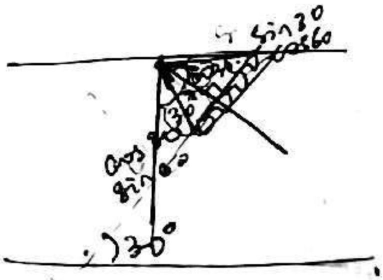
$R_A = 60 + 45$

$= \underline{105 \text{ KN}}$

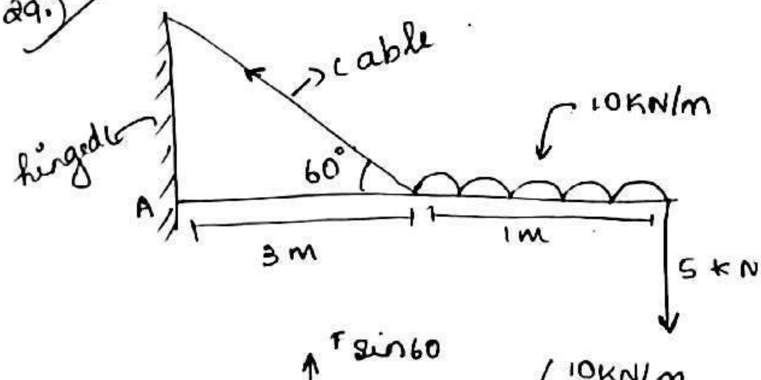
$\Sigma M_A = 45 \times \frac{1}{2} \times 2 \left(\frac{2}{3} \times 2\right) + 60\,(2.5)$

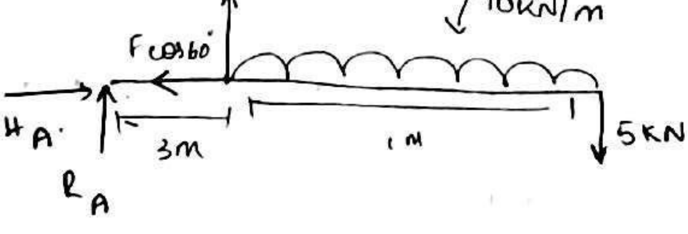
$= \overset{30}{\cancel{60}} + 150 = \cancel{210 \text{ KN-m}}$

$= \underline{180 \text{ KN-m}}$



29.)





$\Sigma H = H_A - F\cos 60^\circ = 0 \Rightarrow H_A = F/2 = 10.58$

$\Sigma V = R_A + F\sin 60^\circ - 10(1) - 5 = 0$

$R_A + \frac{\sqrt{3}F}{2} = 15$

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$\Sigma M_A = 0$ $\quad$ | + 100N

$\cancel{F\cos 60(3)} - F\sin 60(3) + 10(1)(\tfrac{1}{2}$ $\quad$ sin

$= 0$

$\cancel{\frac{3F}{2}} - \frac{3\sqrt{3}}{2}F + \overset{5}{\cancel{10}}\left(\frac{1+6}{\cancel{2}}\right) + 20 = 0$

$-F\left(\cancel{\frac{3}{2}} + \frac{\sqrt{3}\,3}{2}\right) + 35 + 20 = 0$

$F\left(\frac{\cancel{3+}\sqrt{3}\,3}{2}\right) = 55$

$F = 21.16 \quad \cancel{\frac{55 \times 2}{8.98}} = \cancel{13.42}$

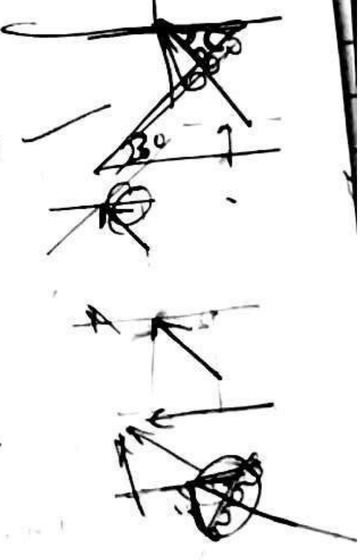
$R_A + \frac{\sqrt{3}F}{2} = 15$

$R_A = 15 - \cancel{\frac{\sqrt{3} \times 13.42}{2}} \quad \frac{\sqrt{3} \times 21.16}{2}$

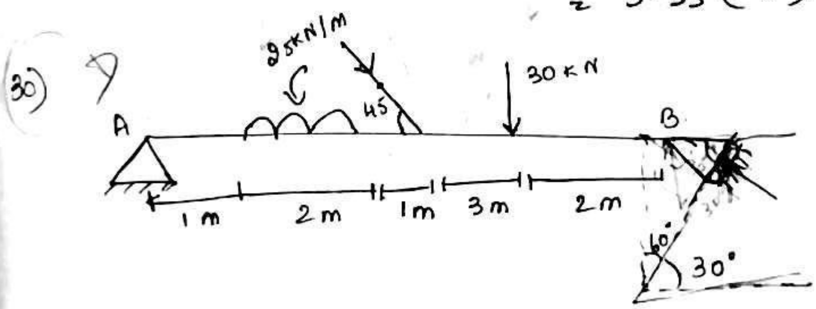
$= \cancel{3.37}$

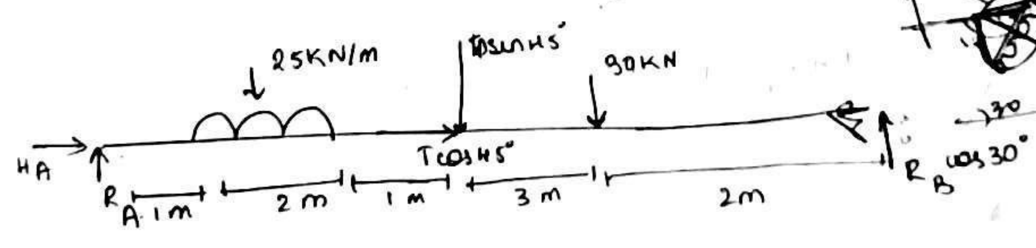
$= -3.32$

$= 3.33\,(\downarrow)$



30)





$\Sigma H = HA + T\cos 45° = 0 \Rightarrow H_A = -T/\sqrt{2}$

$\Sigma Y = R_A - 25(2) - T\sin 45 - 30 + R_B\cos 30° = 0$

$R_A - \frac{T}{\sqrt{2}} + \frac{R_B\sqrt{3}}{2} = 80$

$\Sigma M_A = 25(2)(1+1) + \frac{T}{\sqrt{2}}(4) + 30(7) - R_B\cos 30°(9) = 0$

28) ~~2.828 + 210 = R_B 7.79~~

$R_B = 40.15$

$100 + 113.137 + 210 = R_B\, 7.79$

$R_B = 54.31$ KN

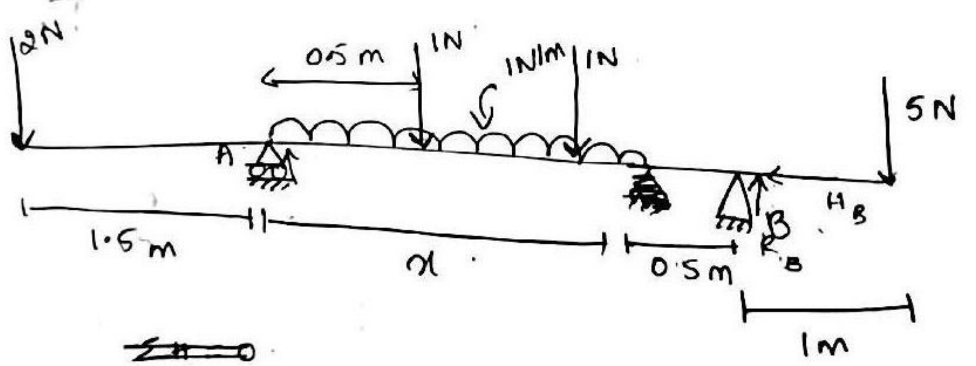
$R_A = 80 - R_B \frac{\sqrt{3}}{2} + \frac{40}{\sqrt{2}}$

$= 80 - 47.03 + 28.28$

$= 61.25$ KN

$H_A = 28.28 (\leftarrow)$

31) Find the support reac^n for the beam loaded such that the reac^n at hinge is 1.5 times the reac^n at rollers. find the distance x b/w the supports.



~~$\Sigma H = 0$~~

$\Sigma H = 0 = H_B$

$\Sigma V = 0 = -2 - 1 + R_A - 1 - 1(x) - 5 + R_B$

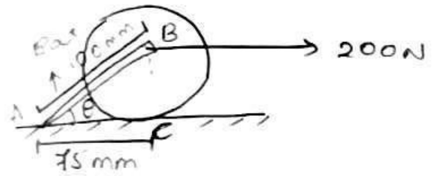
$R_A + R_B = 5 + 2 + 1 + 1 + x$

$= 9 + x$

$\Sigma M_A = -2(1.5) + 1(0.5) + 1(x)\left[\frac{x}{2}\right] - R_B$

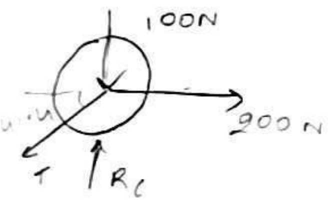
Spheres

A circular roller of radius 50mm and weight 100N rests on a horizontal surface and held in position by an inclined bar AB of length 100mm as shown in the figure. Determine reac^n at C and also tension force in the bar if horizontal force of 200N acts



$$\theta = \cos^{-1}\left[\frac{75}{100}\right]$$

$$= \cos^{-1}\left[3/4\right] = 41.4$$



$$\Sigma H = 200 - T\cos 41.4 = 0$$

$$\frac{200}{\cos 41.4} = T \Rightarrow T = \frac{200}{3} \times 4$$

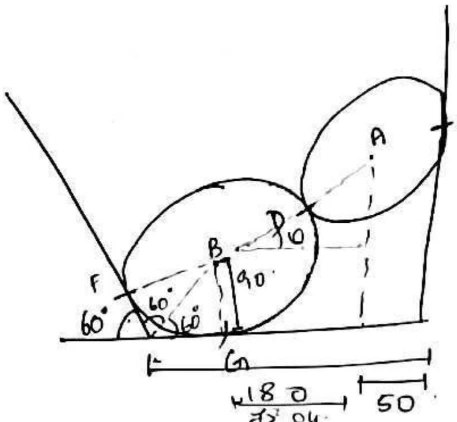
$$= \underline{\underline{266.66}} \; (\rightarrow)$$

$$\Sigma V = 0 = -100 + R_C - T\sin 41.4$$

$$R_C = 100 + 266.66 \sin 41.4$$

$$= \underline{276.345} \, N \; (\uparrow)$$

2 cylinders A & B rest in a channel as shown in the figure. A has diameter of 100mm and B has dia of 180mm and weighs 50KN. Self weight of A is 20KN resp. The channel is 180mm wide at the bottom with one side vertical and other side ~~[illegible]~~ inclined at an angle of 60°. Find the reac^n at all the points of contact.



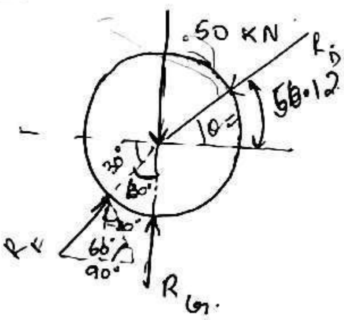
$\tan 60 = \frac{BG = 90}{OG}$

$OG = \frac{BG}{\tan 60^\circ} = \frac{90}{\sqrt{3}} = \underline{51.96\,mm}$

$\theta = \cos^{-1} \frac{78.04}{140}$

$= \underline{56.12}$

B



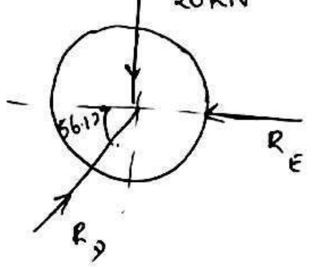
$\Sigma H = 0$

$R_F \cos 30 - R_D \cos 56.12 = 0$

$\Sigma V = 0$

$-50 - R_D \sin 56.12 + R_G + R_F \cos 60 = 0$

A



$\frac{20}{\sin(123.88)} = \frac{R_E}{\sin(146.12)} = \frac{R_D}{\sin 90^\circ}$

$R_E = \underline{13.42\,KN}$

$R_D = \underline{24.09\,KN}$

$R_F = 15.50 \, KN$

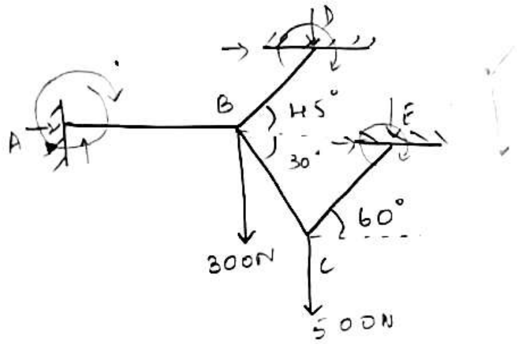
$$R_G = 50 + R_D \sin(56.12) - R_F \cos 60$$

$$= 50 + 24.09 \sin(56.12) - 15.5 \cos 60^\circ$$

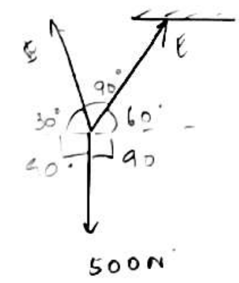
$$= 50 + 19.99 - 7.75$$

$$= \underline{62.24} \, KN.$$

Fig ? shows the system of forces in equilibrium under 2 verti all loads 300 & 500 N determine the forces developed in different segments.

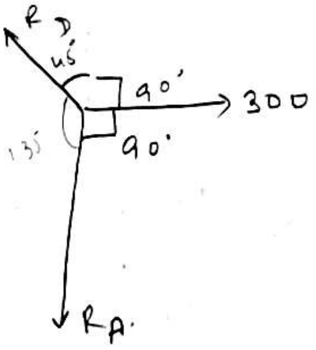


Node C



$$\frac{500}{\sin 90} = \frac{R_B}{\sin 150} = \frac{R_E}{\sin 120}.$$

$$R_B = 250 \, N \qquad R_E = 433.01 N.$$

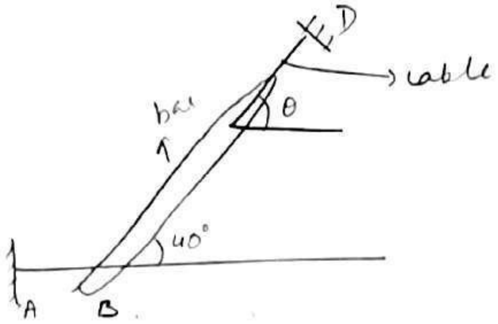


$$\frac{300}{\sin(135)} = \frac{R_A}{\sin(135)} = \frac{R_D}{\sin(90)}$$

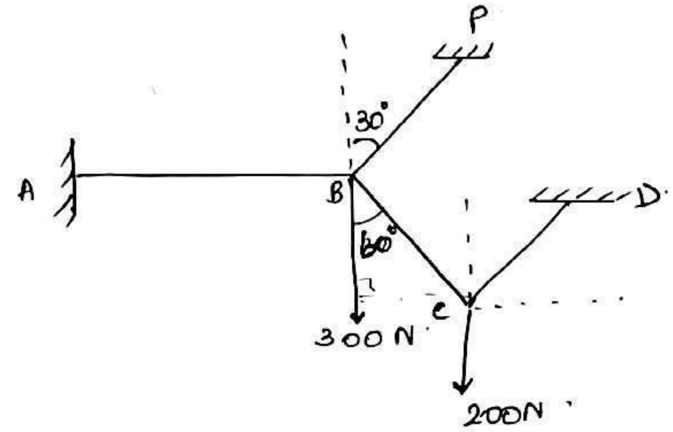
$$R_A = \underline{300}.$$

$$R_D = \underline{424.26}$$

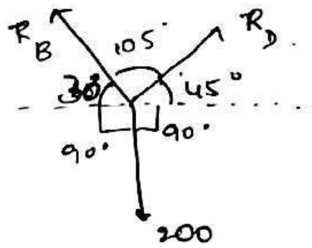
4) A rod BC of length.



5)



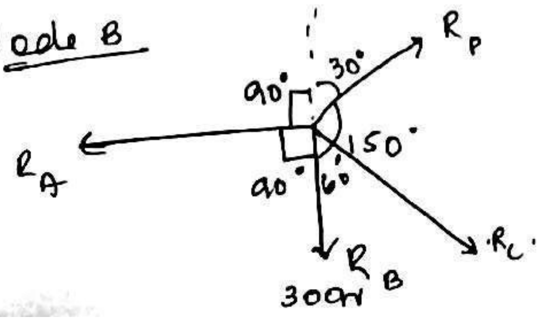
Node C :



$$\frac{R_D}{\sin 120} = \frac{R_B}{\sin(135)} = \frac{200}{\sin(105)}$$

$R_D = \underline{179.3N}$ $R_B = 146.41 N$

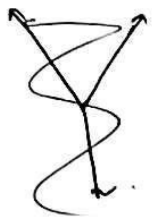
Node B



$$\cancel{\frac{300}{\sin 120} = \frac{R_P}{\sin 90} = \frac{R_A}{\sin(150)}}$$

$\cancel{R_P = 346.41 N}$

$\cancel{R_A = 173.205 N}$

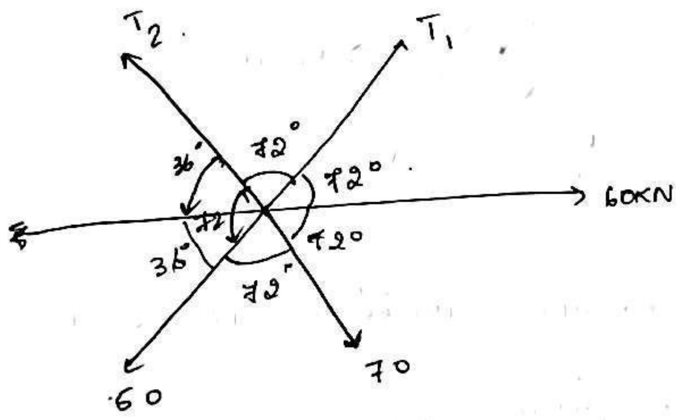


$\Sigma H = 0$

$-R_A \cos 90^\circ + R_p \sin 30^\circ + R_c \sin 60^\circ = 0$

$R_A \cos 90^\circ = R_p \sin 30^\circ + R_c \sin 60^\circ$.

6) 4 wires tied at a point are pulled in a radial direcⁿ equally spaced from one another if the mag. of pull in three subsequent wires is 50KN, 70KN & 60KN. Determine the magnitude of pulls on the 2 other wires.



$\Sigma H = 0$

$60 + T_1 \cos 72^\circ - T_2 \cos 36^\circ - 50 \cos 36^\circ + 70 \cos 72^\circ$

$T_1 \cos 72^\circ - T_2 \cos 36^\circ = -60 + 50 \cos 36^\circ - 70 \cos 72^\circ$

$= -41.18$ N.

$\Sigma V = 0$

$T_2 \sin 36^\circ + T_1 \sin 72^\circ - 70 \sin 72^\circ - 50 \sin 36^\circ = 0$.

$T_2 \sin 36^\circ + T_1 \sin 72^\circ = 95.96$.

$T_1 \cos 72^\circ - T_2 \cos 36^\circ = -41.8$

$T_2 \sin 36^\circ + T_1 \sin 72 = 95.96$

$T_1^2 \cos^2 72^\circ + T_2^2 \cos^2 36^\circ + T_2^2 \sin^2 36^\circ + T_1^2 \sin^2 72$

$+ 2T_1 \sin 72\, T_2 \sin 30^\circ - 2T_1 \cos 72^\circ T_2 \cos 36^\circ = 10955.5616$

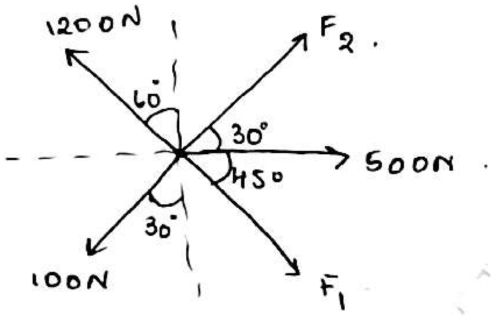
$T_1^2(1) + T_2^2(1) + 2T_1T_2(\sin 72 \sin 36^\circ - \cos 72 \cos 36) = 1095$

$T_1^2 + T_2^2 + 2T_1T_2(0.559 - 0.25) = 10955.56$

$T_1^2 + T_2^2 + 2T_1T_2(0.309) = 10955.56$

$T_1 = 56.62 \quad T_2 = 72.70$

7) Determine the forces F_1 & F_2 as shown which is in equilibrium



45.399

$\Sigma H = 0$

$500 + F_2 \cos 30^\circ + F_1 \sin 45^\circ - 100 \cancel{\cos}\sin 30^\circ - 1200 \sin 60^\circ = 0$

$F_2 \cos 30^\circ + F_1 \cancel{\sin}\cos 45^\circ = \cancel{516.219}$

$\Sigma V = 0$

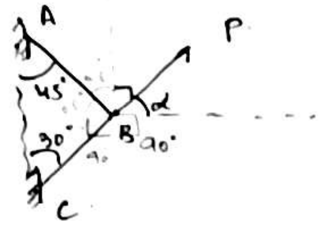
$F_2 \sin 30^\circ - F_1 \sin 45^\circ - 100 \cos 30^\circ + 1200 \cos 60^\circ = 0$

$F_2 \sin 30 - F_1 \sin 45^\circ = -616.24$

$F_2 = -74.36$

$F_1 = 896.88$

Q) Determine the value of mag. and direction of T for A, B & AC. are 5KN each



Ans

$$\frac{R_P}{\sin(105)} = \frac{R_C}{\sin(45+90-\alpha)} = \frac{R_A}{\sin(120+\alpha)}$$

$$\frac{5}{\sin(120+\alpha)} = \frac{5}{\sin(135-\alpha)} = \frac{P}{\sin(105)}$$

$$\sin(120+\alpha) = \sin(135-\alpha)$$

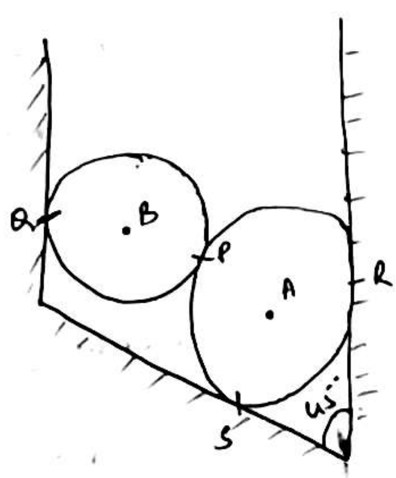
$$120+\alpha = 135-\alpha$$

$$2\alpha = 15$$

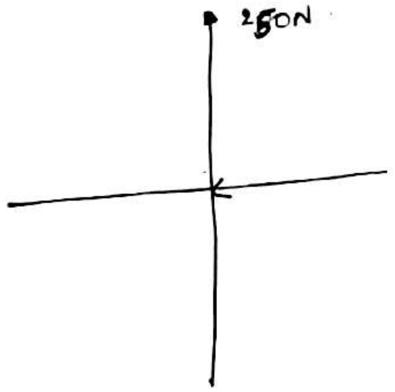
$$\alpha = 7.5$$

$$\frac{5}{\sin(127.5)} = \frac{5}{\sin(127.5)} = \frac{P}{\sin(105)} \Rightarrow P = 6.087\text{ KN}$$

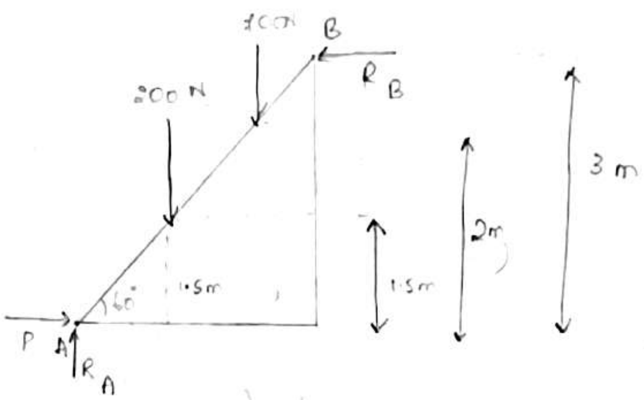
Q) 2 cylinders A & B are placed as shown in fig.. Find reacn at contact surface if dia of A is = 120mm. dia of B = 60mm. self weight self weight of = 250N of B 100N. Determine the reacns at all points



at A



A ladder weighing 200 N is kept in position as shown resting on smooth floor and leaning against a smooth wall. Determine the horizontal force P required to prevent it from slipping when a man of 700N is at a height of 2 metres above the floor level.



$\Sigma H = P - R_B = 0$

$P = R_B$

$\Sigma V = -200 - 700 + R_A = 0.$

$R_A = 900$

~~$\Sigma M_A = 200(1.73) + 700$~~

$\tan 60° = \frac{1.5}{d}$

$d = \frac{1.5}{\sqrt{3}} = 0.866$

$\sin 60°$

~~$\sin 60° = \frac{1.5}{d}$~~

~~$d = \frac{1.5 \times 2}{\sqrt{3}}$~~

$= \frac{3}{\sqrt{3}} = \sqrt{3}$

~~$= 1.73$~~

$\sin 60° = \frac{2}{d}$

$d = \frac{2}{\sqrt{3}} \times 2$

$= \frac{4}{\sqrt{3}}$

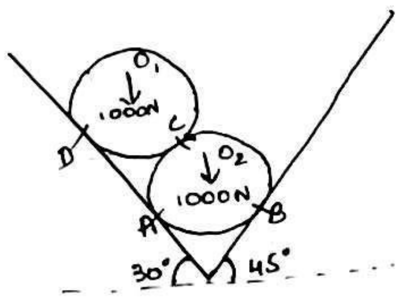
$= 2.309$

$\tan 60° = \frac{\cancel{1.5}\ 2}{d}$

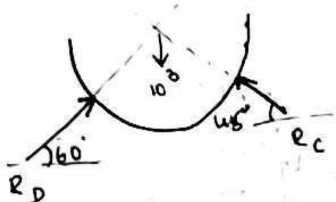
$d = \frac{2}{\tan 60°}$

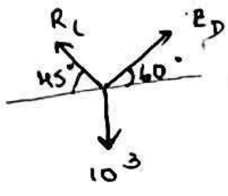
$\Sigma M_A = 200\,(0.866) + 700\,(1.154) - R_B\,($

A sphere of weight rests on a groove whose sides are inclined at angle of 30° & 45° to the horizontal. Another identical sphere of same weight 1000 N rests on the first sphere in contact with the side inclined at an angle of 30°. Find R_A and R_B



O_1



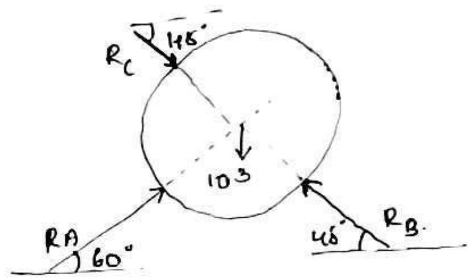


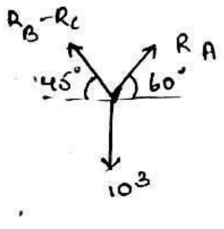
$$\Rightarrow \frac{10^3}{\sin(75)} = \frac{R_D}{\sin(135)} = \frac{R_C}{\sin(150)}$$

$R_D = 732.05$ N

$R_C = 517.63$

Sphere 2

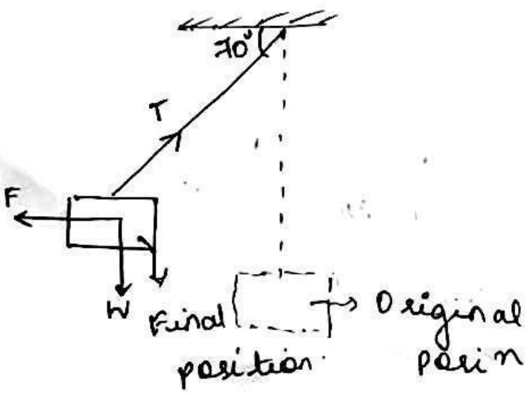


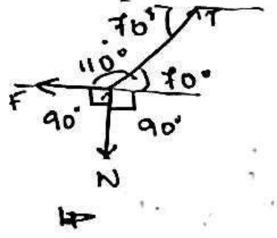


By Lami's theorem,

$$\frac{1000}{\sin 75} =$$

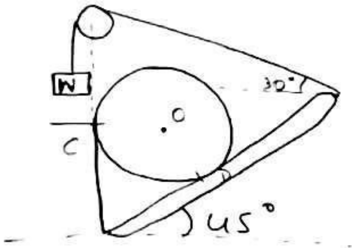
Determine the horizontal force & tension in the rope when mass of 450kg is suspended by a rope ~~of~~ from centering and pulled by the horizontal force F until the rope makes an angle of 70°





$$\frac{450\times10}{\sin(110°)} = \frac{F}{\sin(160°)} = \frac{T}{\sin 90°}$$

T = ~~[illegible]~~ 4788.7N   F = 1637 N.



A cylinder of 2000N is support on 800N.
Find weight W for equilibrium to exist if diameter of cylinder is 750mm & length of AB is 3m. Determine the reaction components.