VISVESVARAYA TECHNOLOGICAL UNIVERSITY
BELGAUM

ENGINEERING MECHANICS

(Subject Code: BCIVC203)

LECTURE NOTES

(MODULE-2)

II-SEMESTER

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MODULE - 2

Equilibrium of coplanar force system: Equilibrium of coplanar concurrent force system, Lami's theorem, Equilibrium of coplanar parallel force system, types of beams, types of loadings, types of supports, Equilibrium of coplanar non-concurrent force system, support reactions of statically determinate beams subjected to various types of loads, Numerical examples.

EQULIBRIUM OF FORCE

Equilibrium:

When a stationary body is subjected to external forces, if the body remains in the state of rest under the action of forces, it is said to be in equilibrium.

Principle of equilibrium:

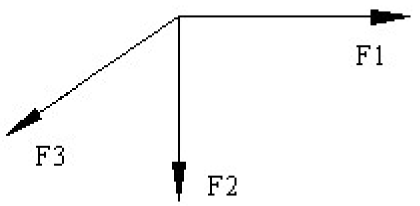
According to this principle 'A body is said to be in equilibrium if algebraic sum of all forces acting on a body = 0 and also the algebraic sum of moments of forces about any fixed point = 0 i.e. $\sum F = 0, \sum Fx = 0, \sum Fy = 0, \sum M = 0$.

A body is said to be in equilibrium if there is no translation and no rotation of the body under the application of external forces.

Condition of equilibrium for different force system

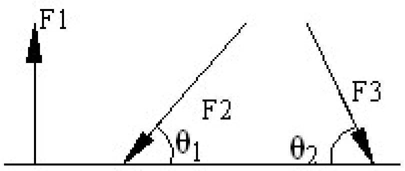
1. **Co-planar concurrent force system:**

$\sum Fx = 0, \sum Fy = 0$ (Moment is already Zero)



2. Co-planar non-concurrent force system:

$$\sum Fx = 0, \sum Fy = 0, \sum M = 0$$



3. Parallel force system

$$\sum F = 0, \sum M = 0$$

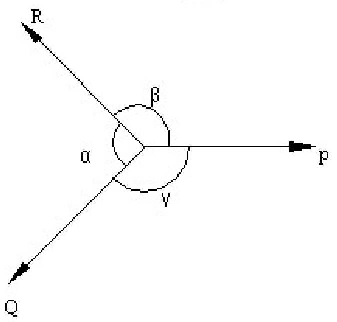
4. Non-coplanar force system

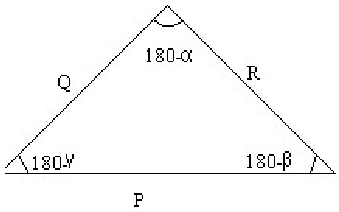
$$\sum Fx = 0, \sum Fy = 0, \sum Fz = 0, \sum M = 0$$

Equilibrant:

Sometimes the resultant of force system is not equal to zero. That means the body is not in equilibrium, the force, which is required to keep the body in equilibrium, is known as equilibrant.

Lami's theorem:





This theorem states that 'if three forces acting at a point are in equilibrium, each force is directly proportional to the sine of angle between the other two forces'.

Let P, Q, R be the three forces acting at a point O and let α, β, γ are the angles between R and Q, P and R, P and Q respectively.

Using Lami's theorem, we have

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

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

It is possible to apply the Lami's theorem if only three forces are acting on a particle or at a point

Free body diagram (F.B.D)

A free body diagram is the diagram which represents the various forces acting on the body.

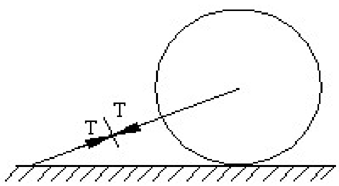


Fig (i)

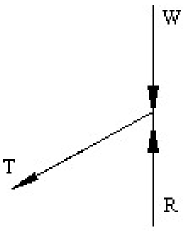


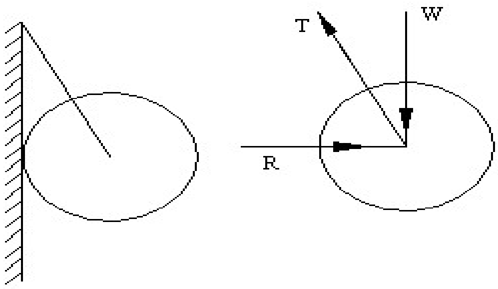
Fig (ii)

Let us consider a spherical ball of mass m, placed on a horizontal plane and tied to the plane by a string as shown in figure (i).

Figure (ii) shows the free body diagram of the spherical ball subjected to various forceslike

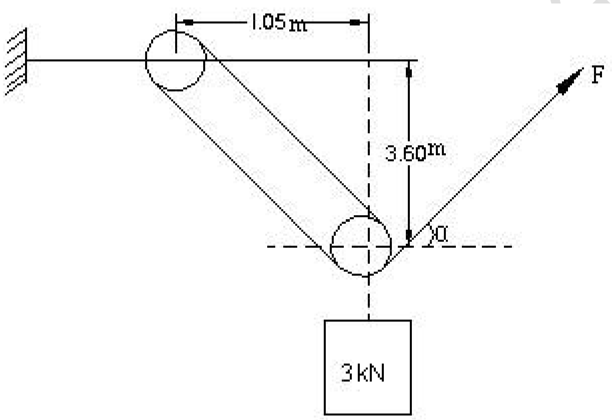
i) Self weight, W always acting vertically downwards.
ii) Normal reaction R, always acting perpendicular to the plane under consideration
iii) Tension T in the string.

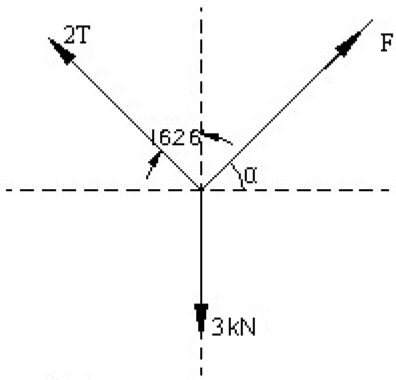
Example:



PROBLEMS

1) A 3kN crate is to be supported by the rope and pulley arrangement shown in figure. Determine the magnitude and direction of minimum force F that should be exerted at free end of the rope.





$$\theta = \tan^{-1}\left(\frac{1.05}{3.6}\right) = 16.26$$

According to Lami's theorem,

$$\frac{F}{\sin(180-\theta)}=\frac{2T}{\sin(90+\alpha)}=\frac{W}{\sin(\theta+90-\alpha)}$$

$$\frac{F}{\sin\theta}=\frac{3}{\sin(\theta+90-\alpha)};\frac{F}{\sin 16.26}=\frac{3}{\sin(\theta+90-\alpha)}$$

$$\sin(\theta+90-\alpha)\, is \max imum$$

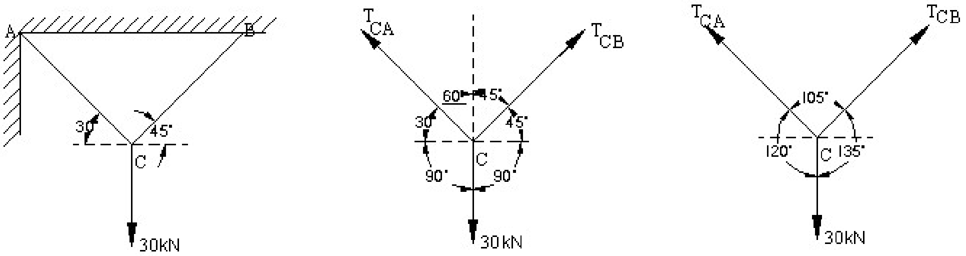
$$\sin(\theta+90-\alpha)=\sin 90$$

$$\theta=\alpha$$

$$\frac{F}{\sin 16.26}=3$$

$$F=3\times\sin 16.26=0.839kN$$

2) Two cables are connected at A and B as shown in figure. And a force of 30 kN is applied at C. Determine the forces in the cable CA and CB.



Using Lami's Theorem, we have

$$\frac{T_{CA}}{\sin 135}=\frac{T_{CB}}{\sin 120}=\frac{30}{\sin 105}$$

$$T_{CA}=\frac{30}{\sin 105}\times\sin 135$$

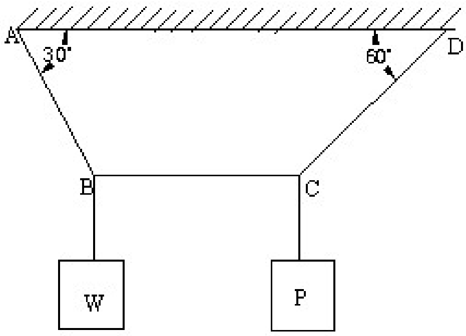
$$=21.961KN$$

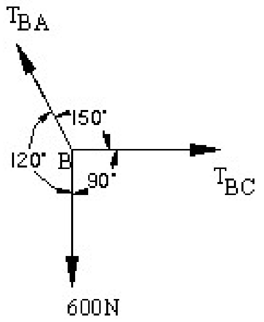
$$\frac{T_{CB}}{\sin 120}=\frac{30}{\sin 105}$$

$$T_{CB}=\frac{30}{\sin 105}\times\sin 120$$

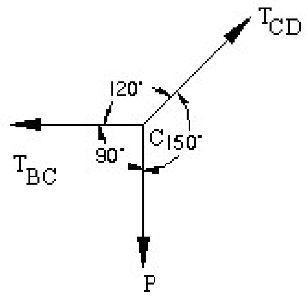
$$=26.897KN$$

3) The figure shows a rope supporting two loads W and P. If BC is horizontal and W =600 N. determine the load P also find the tensile forces developed in the different segments of rope.





F.B.D of B



F.B.D of C

Consider F.B.D of B and Apply the Lami's Theorem

$$\frac{T_{BA}}{\sin 90} = \frac{T_{CB}}{\sin 120} = \frac{600}{\sin 150}$$

$$\frac{T_{CB}}{\sin 120} = \frac{600}{\sin 150}$$

$$T_{BC} = \frac{600}{\sin 150} \times \sin 120$$
$$= 1039.230 N$$

Consider F.B.D of C and Apply the Lami's Theorem

$$\frac{T_{CD}}{\sin 90} = \frac{1039.23}{\sin 150} = \frac{P}{\sin 120}$$

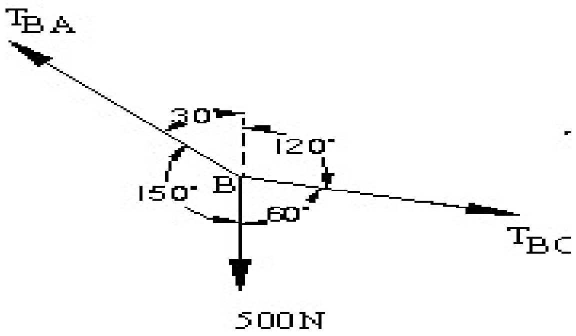
$$P = \frac{1039.23}{\sin 150} \times \sin 120$$
$$= 1800\, N$$

$$T_{BA} = \frac{600}{\sin 150}$$
$$= 1200\, N$$

$$T_{BA} = \frac{1039.23}{\sin 150}$$
$$= 2078.46 N$$

4) A string ABCD attached to two fixed points A and B has two equal weights 500N attached to it at B and C. The weights rest with portions AB and CD inclined at angles of 30° and 60° respectively with the vertical. Find the tensions in the portions AB, BC, and CD of the string. The inclination of BC with vertical is 120°.

Consider F.B.D of B and Apply the Lami's Theorem



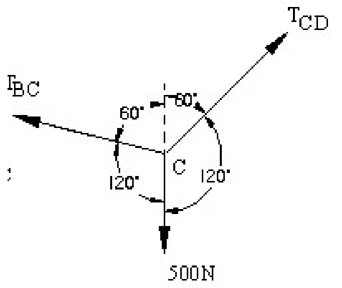
$$\frac{T_{BA}}{\sin 60} = \frac{T_{BC}}{\sin 150} = \frac{500}{\sin 150}$$

$T_{Bc} = 500N$

$$\frac{T_{BA}}{\sin 60} = \frac{500}{\sin 150}$$

T_{BA} =866.03N

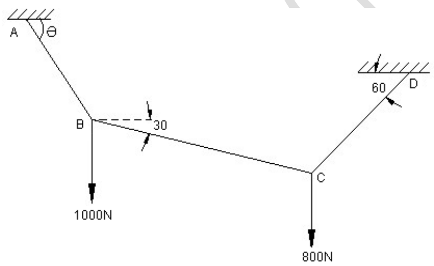
Consider F.B.D of C and Apply the Lami's Theorem



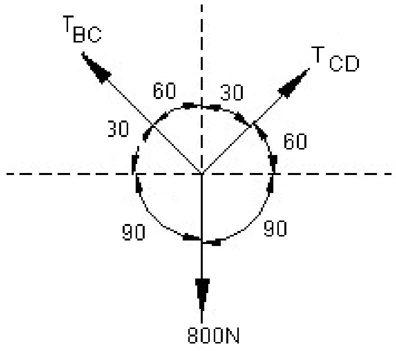
$$\frac{T_{BC}}{\sin 120} = \frac{T_{CD}}{\sin 120} = \frac{500}{\sin 120}$$

T_{CD} = 500 N.

5) Compute the tensions in the strings AB, BC&CD shown in figure.



Consider FBD at C



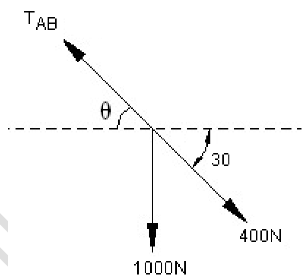
Using Lami's theorem we have

$$\frac{T_{CD}}{\sin 120^0} = \frac{T_{BC}}{\sin 150} = \frac{800}{\sin 90^0}$$

T_{BC}= 400N

T_{CD}=692.82N

Consider FBD at B



Using conditions of equilibrium we have

$\sum Fx = 0$

$-T_{AB}\cos\theta + 400\cos 30^0 = 0$

$T_{AB}\cos\theta = 346.41$-------------- (1)

$\sum Fy = 0$

$T_{AB}\sin\theta - 400\sin 30 - 1000 = 0$

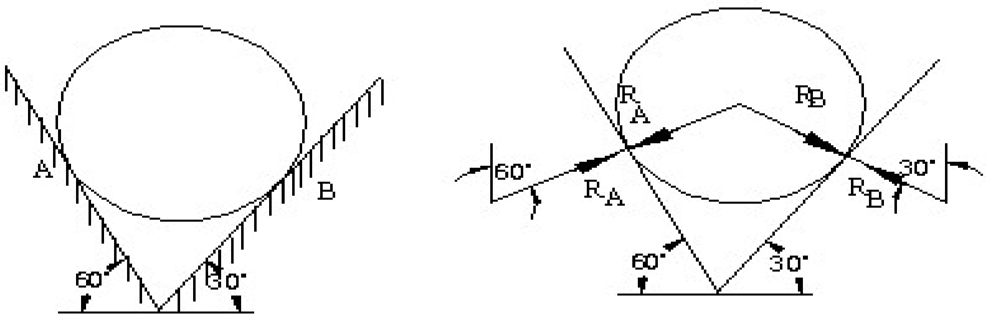
$T_{AB}\sin\theta = 1200$------------------ (2)

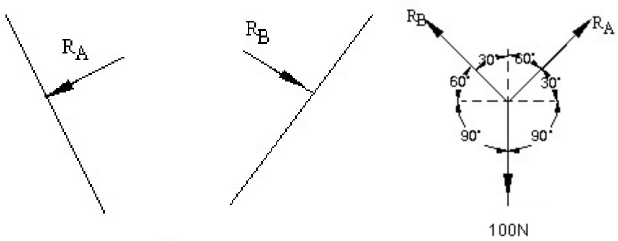
$$= \frac{T_{AB}\sin\theta}{T_{AB}\cos\theta} = \frac{1200}{346.41}$$

$\theta = 73.90^0$ substitute the value of θ in 1, we get

TAB=1249.158N

6)) A sphere weighing 100 N is fitted in a right-angled notch as shown in figure. If all contact surfaces are smooth, determine the reaction at contact surfaces:





At contact point, reaction is developed and is perpendicular to the plane..

Applying Lami's theorem, we have

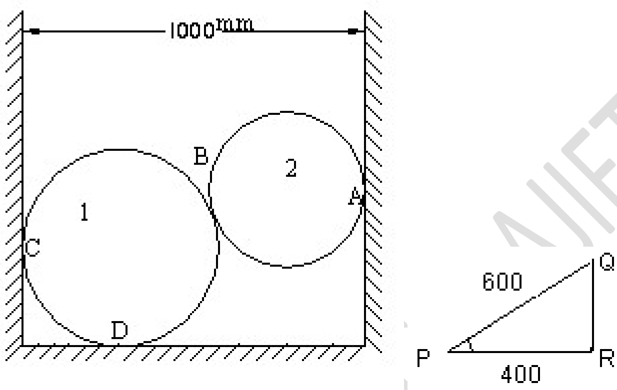
$$\frac{R_B}{\sin 120} = \frac{R_A}{\sin 150} = \frac{100}{\sin 90}$$

$$R_B = \frac{\sin 120 \times 100}{\sin 90}$$

= 86.602 N

$$R_A = \frac{\sin 150 \times 100}{\sin 90} = 50 \text{ N}$$

7) A horizontal shaft with inner clearance of 1000mm carries two spheres of radius 350mm and 250mm. The weights are 600N and 500N respectively. Find the reactions at all the points of contact.

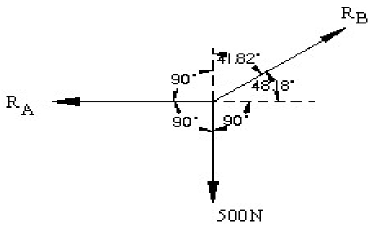


PR=1000-350-250= 400mm

PQ=350+250 =600mm

$$\cos\theta = \frac{PR}{PQ} = \frac{400}{600} = 48.18^0.$$

Consider the F.B.D. of sphere (2)

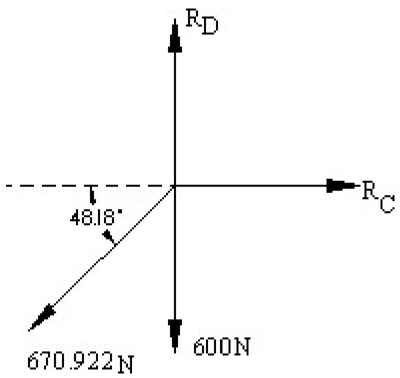


Using Lami’s theorem, we have

$$\frac{R_A}{\sin 138.18} = \frac{R_B}{\sin 90} = \frac{500}{\sin 131.82} = 447.365\text{N}.$$

$$R_B = \frac{500}{\sin 131.82} \times 1 = 670.922\text{N}.$$

Consider the F.B.D. of sphere 1



Applying laws of equilibrium

$\Sigma F_x=0$

$\Sigma F_y=0$ we get

$\Sigma F_x=0$

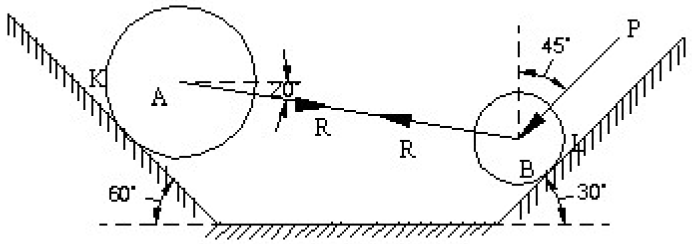
$\Rightarrow R_c - 670.922 \times \cos 48.18 = 0$

$\Rightarrow R_c = 670.922 \times \cos 48.18 = 447.366N$

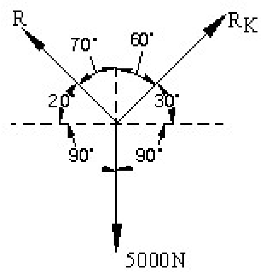
$\Sigma F_y = 0$

$R_D - 600 - 670.922 \sin 48.18 = 0$.: $R_D = 1100N$

8. Two cylinder weighing 5000N and 2500N resting on a smooth inclined plane as shown in fig. Neglecting the weight of connecting bar. Find the force P applied such that the system is in equilibrium.



Consider F.B.D. of A



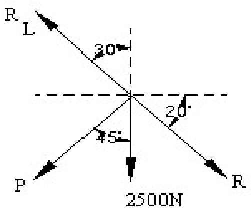
Using Lami's theorem, we have

$$\frac{R}{\sin(120^0)} = \frac{R_K}{\sin(110^0)} = \frac{5000}{\sin(130^0)}$$

$$R = \frac{5000}{\sin(130^0)} \times \sin 120^0 = 5652.579N.$$

$$R_K = \frac{5000}{\sin(130^0)} \times \sin 110^0 = 6133.407N.$$

Consider F.B.D. of sphere B



$F_x=0$

$$R\cos 20 - R_L \sin 30 - P\sin 45^0 = 0$$

$R_L \sin 30 + P\sin 45 = 5311.686$------ (1)

$\Sigma F_y=0$

$+R_L \cos 30^0 - P\cos 45^0 = 4433.29$ --- (2)

(1)+ (2)

$$R_L \cos 30^0 + R_L \sin 30^0 = 9744.981.$$

$R_L\cos30+0.5R_L=9744.981$

1.366 R_L=9744.981, R_L=7133.953N.

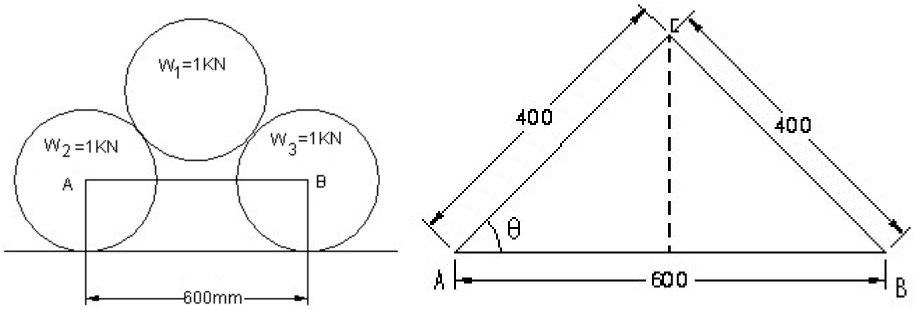
Substitute the value of $R_L$in 2 we get

7133.953×cos30-Pcos45=4433.295N

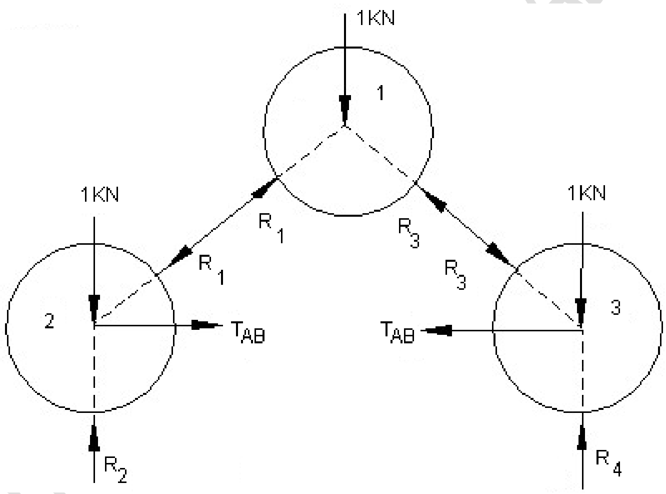
Pcos45=1744.889N

P=2467.645N.

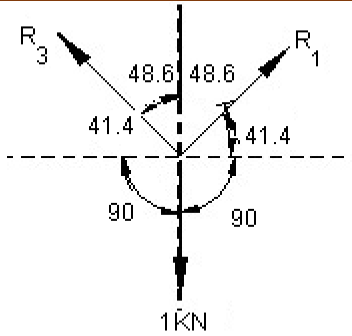
9. Determine the reactions at the surface of contact and tension in the string AB shown in figure.R_1=R_2=R_3 =200mm.



Two equal and opposite reactions will be developed between the contact surfaces of two bodies.



Consider the F.B.D. of sphere 1



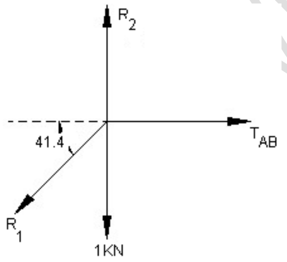
Using Lami's theorem, we have

$$\frac{R_1}{\sin 131.40^0} = \frac{R_3}{\sin 131.40^0} = \frac{1}{\sin 97.20^0}$$

$$\frac{R_1}{\sin 131.40^0} = \frac{1}{\sin 97.20^0}, \therefore R_1 = 0.756kN$$

$$\frac{R_3}{\sin 131.40^0} = \frac{1}{\sin 97.20^0}, R3 = 0.756kN.$$

Consider the F.B.D. of sphere 2



Using the conditions of equilibrium, we have

$$\sum Fx = 0$$

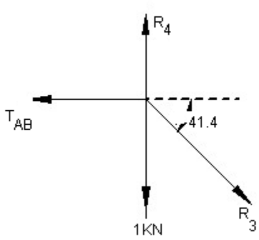
$T_{AB}-0.756\cos 41.40^0 = 0 \therefore T_{AB} = 0.567kN$

$\sum Fy = 0$

$R_2 - 0.756 \sin 41.40^0 - 1 = 0$

$R_2 = 1.5kN$

Consider the F.B.D. of sphere 3



Using the conditions of equilibrium, we have

$\sum Fy = 0$

$R4 - 0.756 \sin 41.40^0 - 1 = 0, R_4 = 1.5kN.$

$R_1 = 0.756kN.$

$R_2 = 1.5kN.$

$R_3 = 0.756kN. R_4 = 1.5kN.\ T_{AB} = 0.567kN.$

Support Reactions:

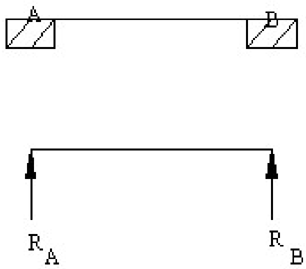
The various structural members are connected to the surroundings by various types of supports. The structural members exert forces on supports known as action. Similarly supports exert forces on structural members known as reaction. A beam is a horizontal member, which is generally placed on supports.

The beam is subjected to the vertical forces known as action. Supports exert forces on beam known as reaction.

Types of supports:

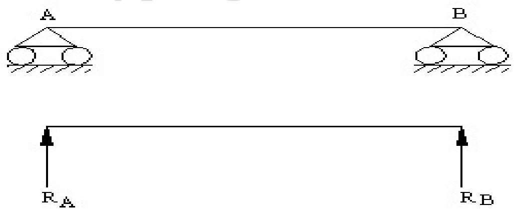
1) Simple supports
2) Roller supports
3) Hinged or pinned supports
4) Fixed supports

1) Simple supports:



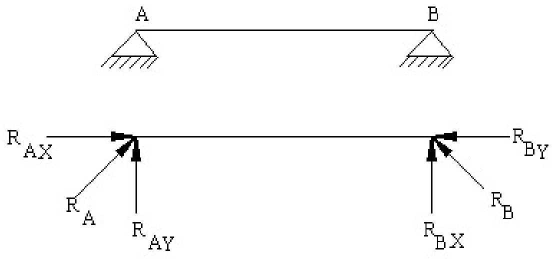
Simple supports are those supports, which exert reactions perpendicular to the plane of support. It restricts the translation of body in one direction only, but not rotation.

2) Roller supports:



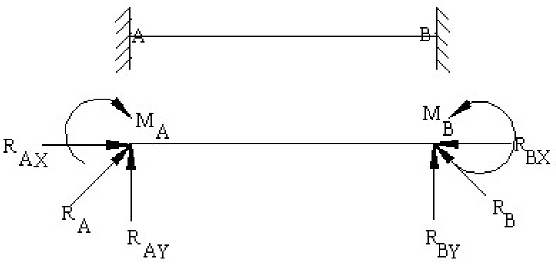
Roller supports are the supports consisting of rollers which exert reactions perpendicular to the plane of the support. They restrict translation along one direction and no rotation.

3) Hinged or Pinned supports:



Hinged supports are the supports which exert reactions in any direction but for our convenient point of view it is resolved in to two components. Therefore, hinged supports restrict translation in both directions. But rotation is possible.

4) Fixed supports:



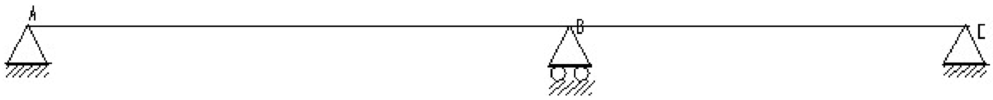
Fixed supports are those supports which restricts both translation and rotation of the body. Fixed supports develop an internal moment known as restraint moment to prevent the rotation of the body.

Types of Beams: -

1**) Simply supported Beam:**

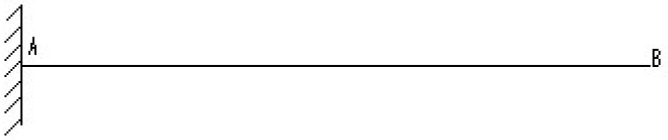
It is a beam which consists of simple supports. Such a beam can resist forces normal to the axis of the beam.

2) Continuous Beam:



It is a beam which consists of three or more supports.

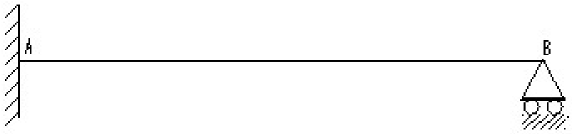
3) Cantilever beam:



It is a beam whose one end is fixed and the other end is free.

4) Propped cantilever Beam:

It is a beam whose one end is fixed and other end is simply supported.

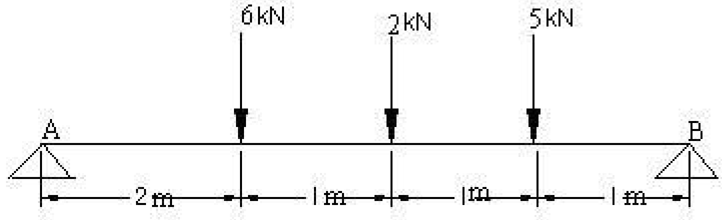


5) Overhanging Beam:

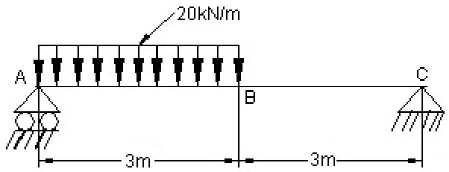
It is a beam whose one end is exceeded beyond the support.

Types of loads:

1) Concentrated load: A load which is concentrated at a point in a beam is known as concentrated load.



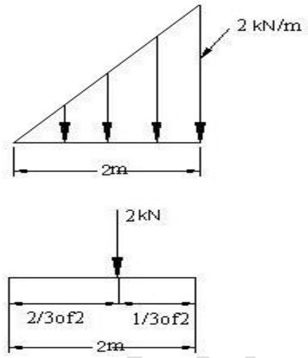
2) **Uniformly Distributed load**: A load which is distributed uniformly along the entire length of the beam is known as Uniformly Distributed Load.



Convert the U.D.L. into point load which is acting at the centre of particular span

Magnitude of point load=20KN/mx3m=60kN

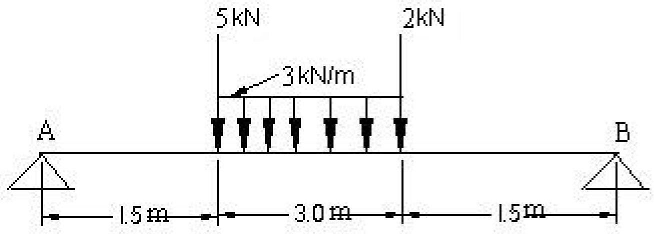
3) **Uniformly Varying load**: A load which varies with the length of the beam is known as Uniformly Varying load

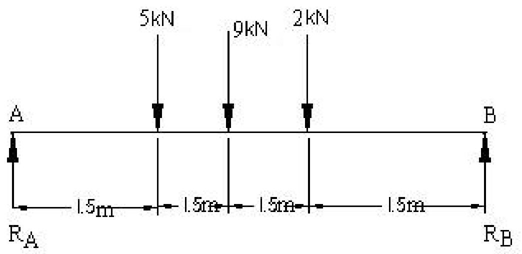


Magnitude of point load=Area of triangle and which is acting at the C.G. of triangle.

PROBLEMS:

1. A simply supported beam of span 6m is subjected to loading as shown in figure. Determine the reactions at A and B.





Applying laws of equilibrium, we get

$F_Y=0$

$R_A + R_B - 5 - 9 - 2 = 0$

$R_A+R_B=16$ -------- (1)

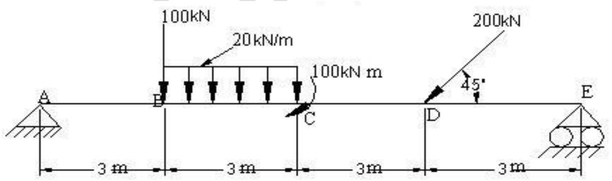
$\Sigma M_B=0$

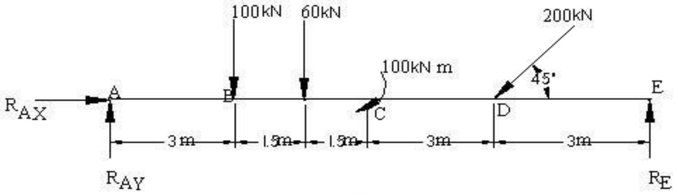
$-2\times1.5-9\times3-5\times4.5+R_A\times6=0$

$R_A=52.5/6=8.75$kN.

$R_B=7.25$kN.

2. Determine the reactions at A&B for the beam shown in the figure.





$\Sigma F_x=0$

R_{AX}-200cos45=0

R_{AX}=141.421kN.

ΣF_Y=0

R_E+R_{AY}-100-60-200sin45

R_E+R_{AY} =301.421. --------------------- (1)

ΣM_A=0

-R_E×12+200sin45×9+60×4.5+100×3+100=0

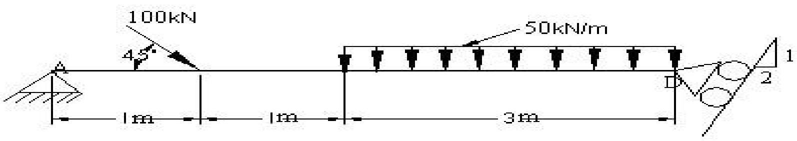
R_E=161.899kN

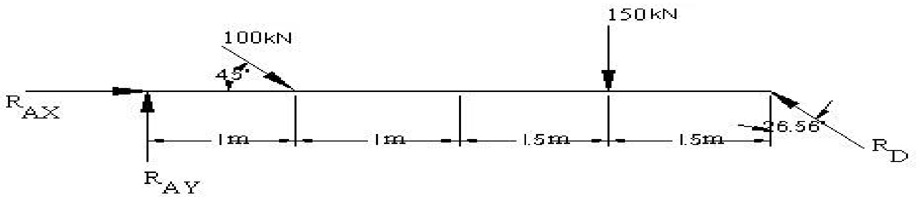
Substitute R_E in (1)

161.899+R_{AY}=301.421

R_{AY} =139.522kN.

3. For the beam with loading shown in the figure. Determine the reactions at the supports.





$$\tan\theta = \frac{1}{2} \Rightarrow \theta = \tan^{-1}\left(\frac{1}{2}\right) = 26.56^0$$

$\Sigma F_x=0$

$$R_{AX} + 100\cos 45^0 - R_D \sin 26.56^0 = 0$$

R_{AX}- 0.477R_D =70.71---------------------- (1)

$\Sigma F_Y=0$

$R_{AY}+R_D\cos 26.56-100\sin 45-150=0$

$R_{AY}+0.894\times R_D=220.71$ ------------------ (2)

$\Sigma M_A=0$

$-5R_D\cos 26.56+150\times 3.5+100\sin 45\times 1=0$

R_D = 133.199KN.

Substitute in (1), we get

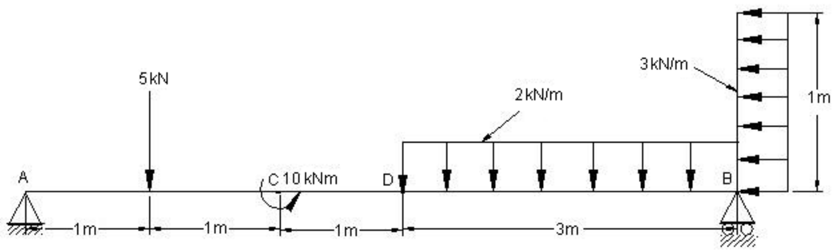
R_{AX}=-7.174KN

Substitute R_D in (2), we get

R_{AY}=101.63 kN

R_A=101.88 Kn

4. Find the support reactions at A&B for the beam loaded as shown in figure



Using the conditions of equilibrium, we have

$\sum Fx=0$

R_{AX}-3=0 ∴ R_{AX}=3kN

$\sum Fy = 0$

R_{AY}+R_B-5-6=0 ∴ R_{AY}+ R_B =11 -------------- (1)

$\sum M_A = 0$

-R_B×6+5×1+6×4.5-3×0.5-10

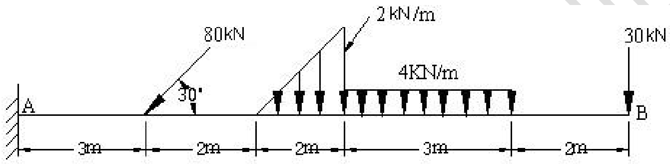
R_B=3.417kN, substitute in (1) we get

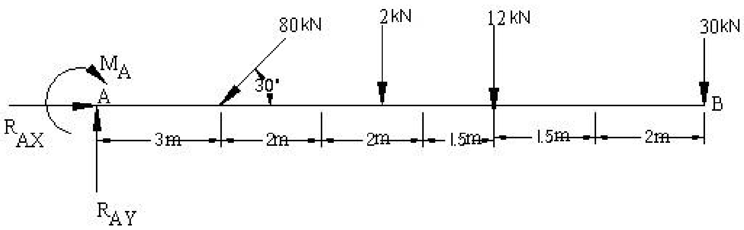
R_{AY}+3.417=11 ∴ R_{AY}=7.583kN.

$R_A = \sqrt{R_{AX}^2 + R_{AY}^2}$

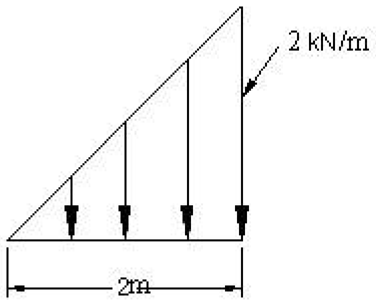
R_A=8.155Kn

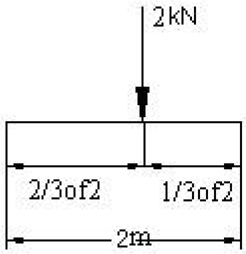
5. Calculate the support reactions for the cantilever beam shown in the figure.





Converting rectangular load to point load





Magnitude of load = Area of triangle=1/2×2×2=2kN

Load is acting at CG

$\Sigma F_x=0$

$$R_{AX} = 80\cos 30 = 0$$

$$R_{AX} = 69.282KN.$$

$\Sigma F_Y=0$

R_{AY}-80sin30-2-12-30=0

$\therefore$ R_{AY} =84kN.

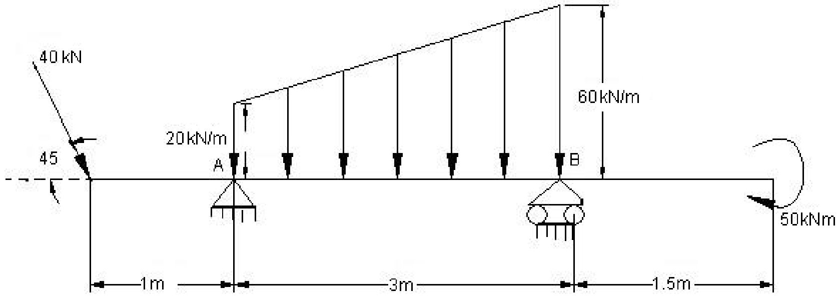
$\Sigma M_A=0$

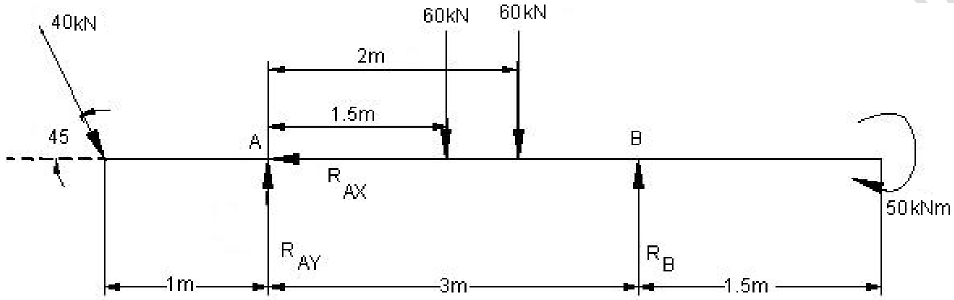
$$+80\sin30\times3+2\left(\frac{2}{3}\times2+5\right)+12\times8.5+30\times12+M_A=0$$

$\therefore M_A$ =-594.667kNm.

M_A is an anticlockwise moment.

6. Determine the reactions at the supports A&B for a beam loaded as shown in figure





Using the conditions of equilibrium, we have

$\sum Fx = 0$

40cos45- R_{AX} =0

∴ R_{AX} =28.284kN

$\sum Fy = 0$

R_{AY} +R_B-40sin45-60-60=0

R_{AY} + R_B =148.284 --------------------- (1)

ΣMA=0

- R_B ×3+60×1.5+60×2+50-40sin45×1=0

R_B =77.238kN.

Substitute the value of R_B in equation (1), we get

R_{AY}=71.046kN.

∴ R_A = $\sqrt{RAx^2 + RAy^2}$

$R_A = \sqrt{(28.284)^2 + (71.046)^2}$

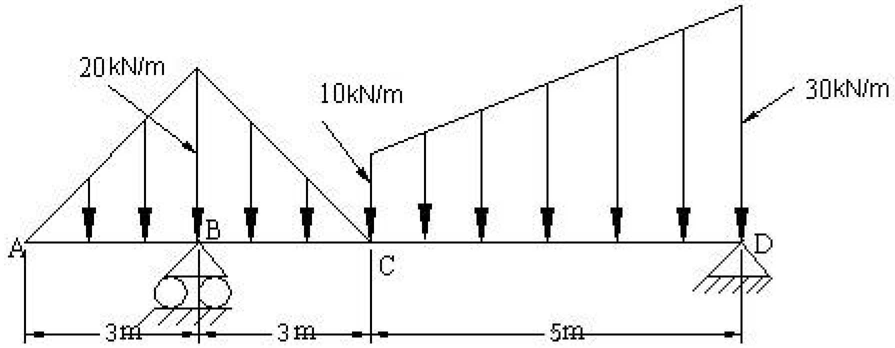
$= 78.469kN.$

$\theta = \tan^{-1}\left(\frac{71.046}{28.284}\right) = 68.29^0.$

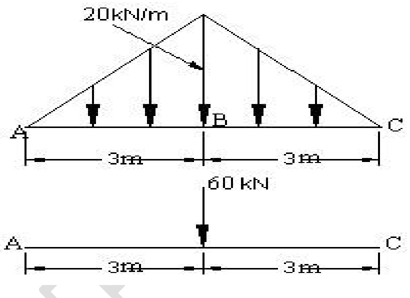
Result: R_A =76.469kN

R_B =77.238kN

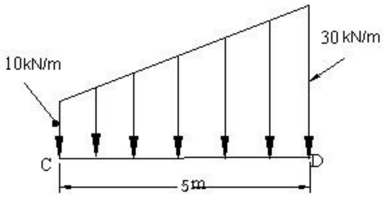
7. Determine the support reactions for the following figure.

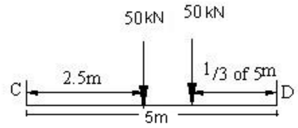


Area of the triangle $= \frac{1}{2} \times 6 \times 20 = 60kN$.



Uniformly varying load to point load

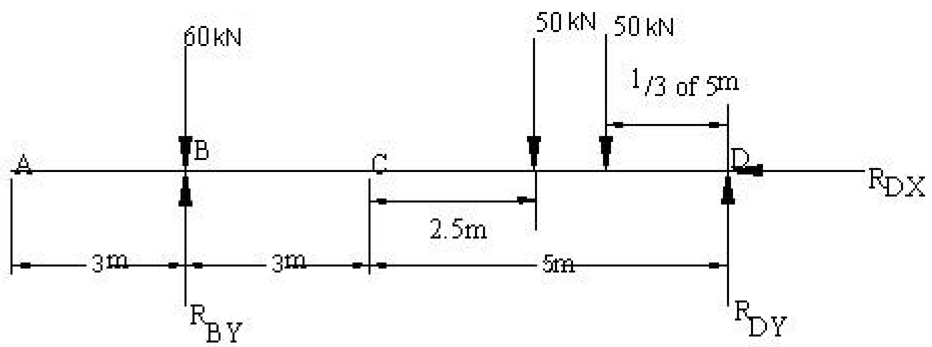




i) Triangular load to point load

Area of the triangle $= \frac{1}{2} \times 5 \times 20 = 50kN$.

ii) U.D.L. to point load = 10kN/m ×5m=50kN.



$\Sigma F_x=0$

$\Rightarrow -R_{DX}=0$

$R_{DX}=0$

$\Sigma F_Y=0$

$R_{BY}+R_{DY}-60-50-50=0$

$R_{BY}+R_{DY}=160$------------------------ (1)

$\Sigma M_B=0$,

$-R_{DY}\times 8+50\times\left(\frac{2}{3}\times 5+3\right)+50(2.5+3)=0$

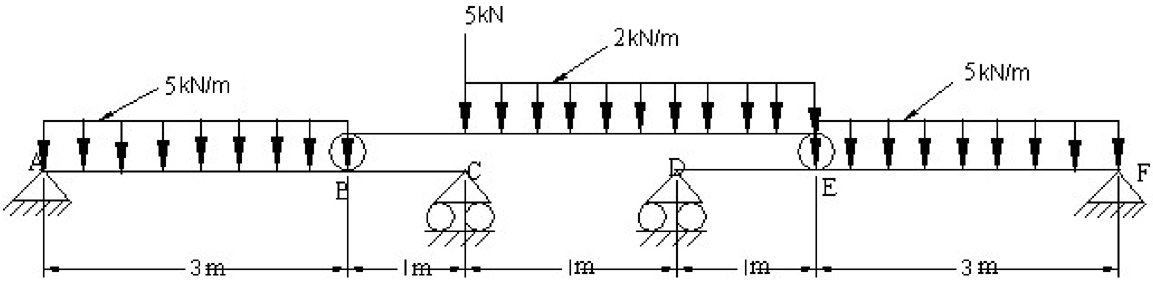
R_{DY}=73.958kN.

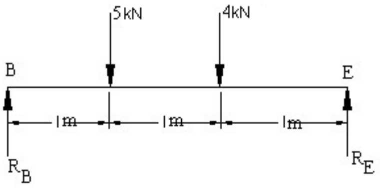
$\Rightarrow$ R_{BY}=160-73.958=86.042kN

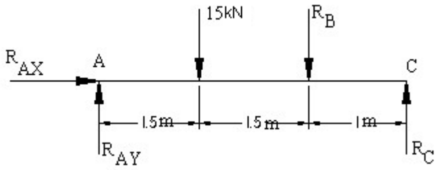
$R_D = \sqrt{R_{DY}{}^2 + D_{DX}{}^2} = \sqrt{(0)^2 + (73.958)^2}$

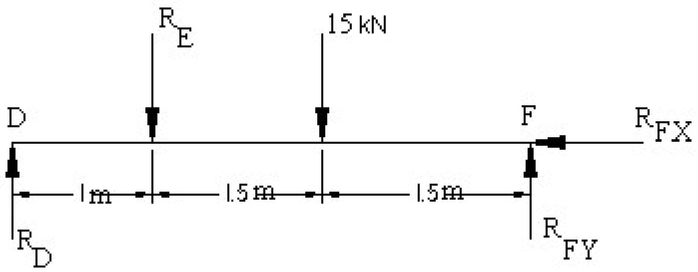
$\therefore$ R_D=73.958KN.

8. Determine the support reactions for the compound beam shown in the figure.









Radius of the roller is negligible.

Consider beam BE

ΣF_Y=0

R_B+R_E=9kN --------------------------- (1)

ΣM_B=0

5 ×1+4 ×2-RE ×3=0

∴3RE=13

R_E=13/3=4.33kN.

∴ R_B=9KN-4.333KN=4.667kN.

Consider beam AC

ΣF_x=0

∴ R_{AX}=0

ΣF_y=0

R_{AY}+ Rc =15+4.667=19.667kN.

ΣM_A=0,

15 ×1.5+4.667 ×3-Rc ×4=0

4Rc=36.501

Rc =9.125KN.

R_{Ay}=19.667-9.125=10.542kN

R_A =10.542kN.

Beam DF:

ΣF_x=0

∴ R_{Fx}=0

ΣF_y=0

R_D+R_{FY}=15+4.333=19.333kN

ΣM_F=0

-15 ×1.5-4.333 ×3+R_D ×4=0

R_D =8.875kN.

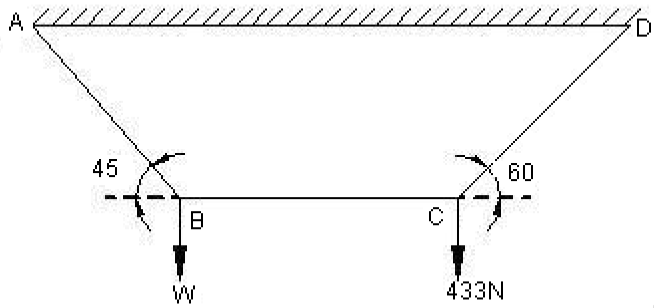
∴R_{FY} =19.333-8.875=10.458kN

∴R_{Fy} =10.458kN.

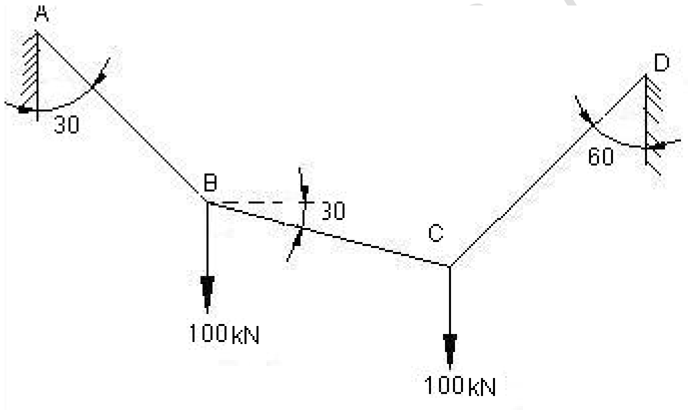
REVIEW QUESTIONS:

1. State and prove Lami's theorem.

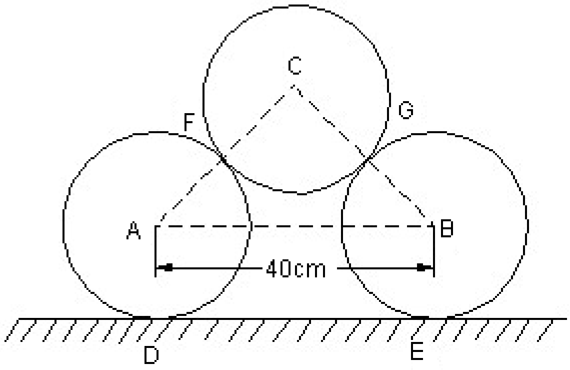
2. A string ABCD is tied at A & D to Hooks as shown in figure. At c, weight of 433N is suspended. And at B, an unknown weight W is suspended such that BC is horizontal and AB &CD are inclined at 450 and 600 respectively to the horizontal Determine the tensions in AB, BC and CD and find magnitude



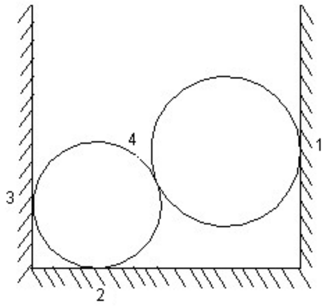
3. A chain ABCD attached to two fixed points A&D has two equal weights of 100kN attached to B & C as shown in figure. Find the tension in the chain AB, BC and CD



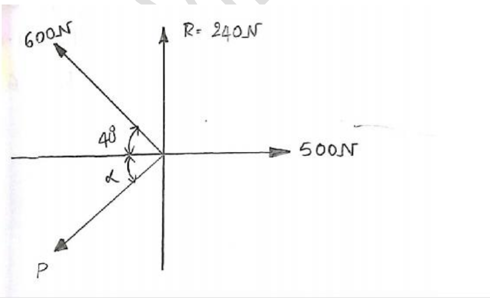
4. Two smooth cylinders, each of weight W=1000N and radius 15cm are connected at their center by string AB of length =40cm and rests upon a horizontal plane supporting above them a third cylinder of weight =2000N and radius 15cm as shown in the figure. Find the force S in the string AB and the pressure produced on the floor at the pointer of contact D &E



5. Two smooth spheres rest between two vertical columns as shown in figure. The larger and smaller spheres weigh respectively 1200N & 360N. The diameters of the larger and smaller spheres are 36cm & 16cm respectively. Find the reactions at 1, 2, 3 and 4.



6. The fore system as shown in fig has a resultant of 240 acting up along the Y axis. Compute the value of force P and its inclination with x axis.



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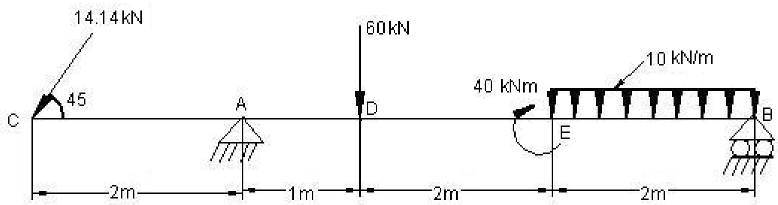
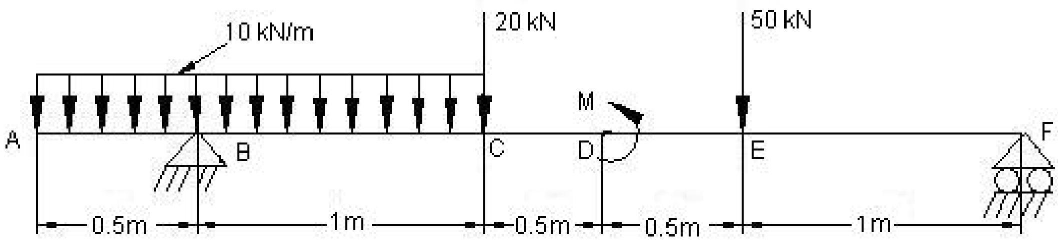
7. Determine the support reactions for the beam supported and loaded as shown in figure.



8. Find the magnitude of anticlockwise couple M to be applied at D so that reaction at 'F' will be 35KN upward Also find the reaction at support B of beam as shown in figure.



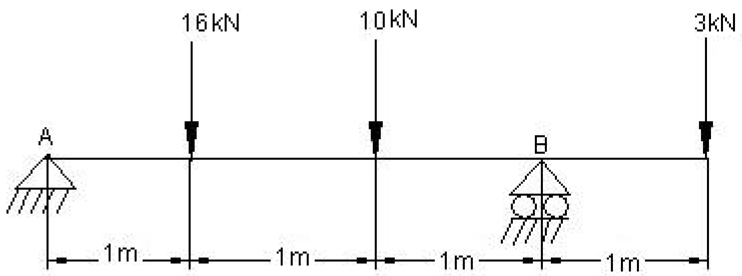
9. Define a beam. Explain the types of beams with a neat sketch.

10. Explain different types of supports in the analysis of the beam.

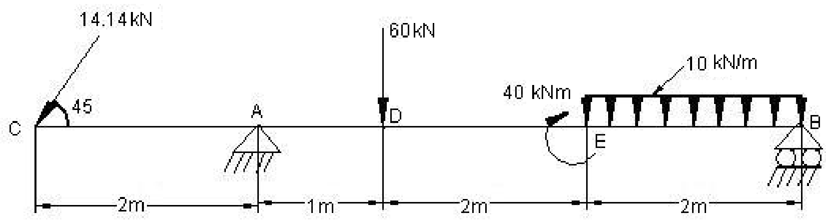
11. Explain the different types of horizontal members which are generally placed on the support.

12. Define equilibrant. Explain the conditions for equilibrium of coplanar concurrent force system and coplanar non-concurrent force system.

13. Calculate the support reactions for the beam loaded and supported as shown in figure. **Ans:** R_A =13 kN R_B = 16kN

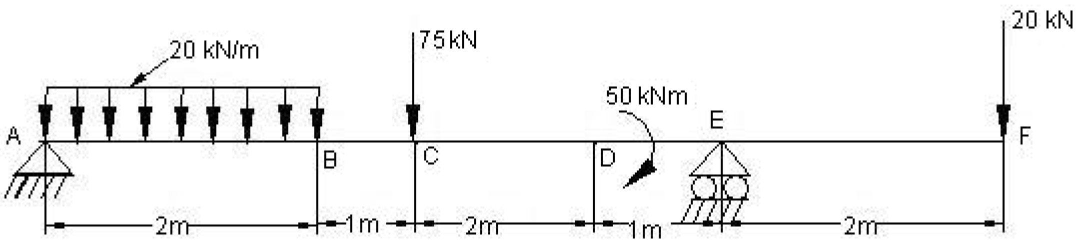


14. Determine the support reactions for the beam supported and loaded as shown in figure. **Ans:** R_B = 32kN, R_A = 58.85kN

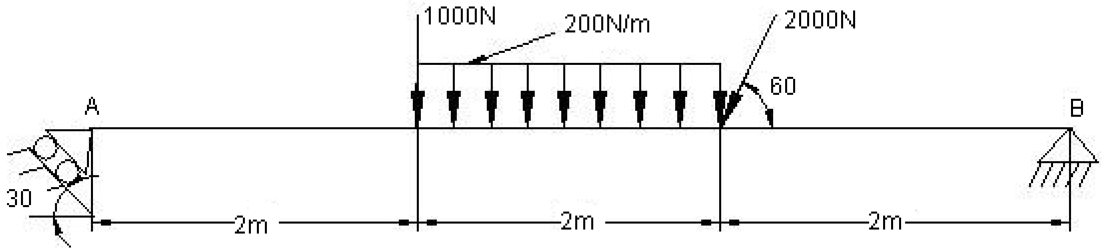


15. Determine the support reactions for a beam loaded as shown in figure.

Ans: $R_A = 55.83kN$, $R_E = 79.17kN$

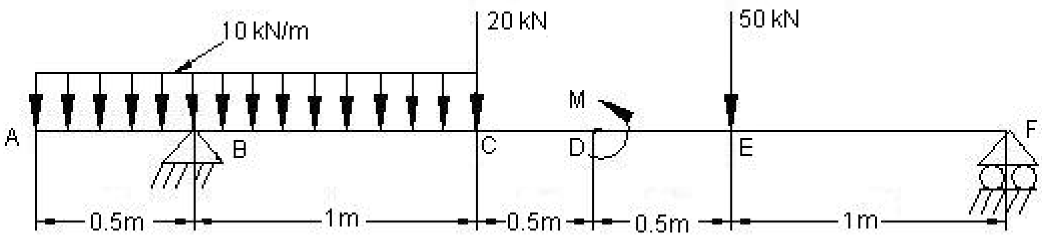


16. A horizontal beam 6mlong is supported on a knife edge at its end B and the end A, rests on a roller support placed on an inclined plane, having an inclination of 30^0 as shown in figure. Find the reactions at the support A & B. **Ans:** $R_A = 1667.44N$, RB = 1696.17N



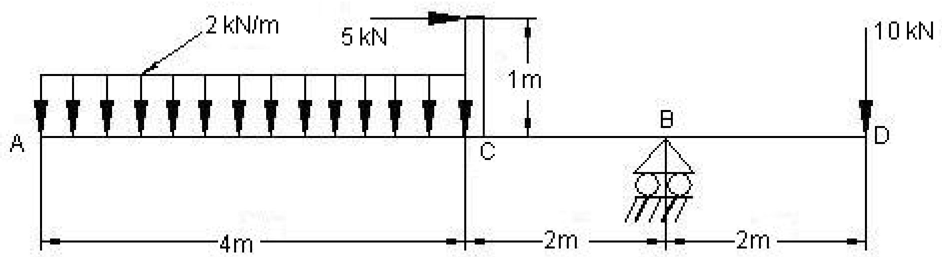
17. Find the magnitude of anticlockwise couple M to be applied at D so that reaction at 'F' will be 35KN upward Also find the reaction at support B of beam as shown in figure.

Ans: M = 18.75N $R_B = 50kN$



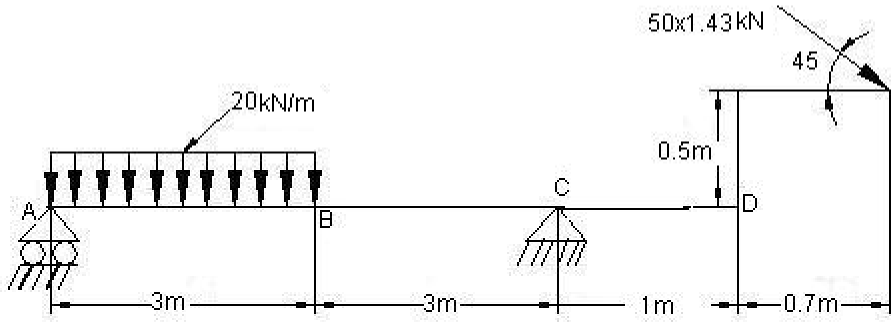
18. Find the support reactions for a beam loaded and supported as shown in figure.

Ans: R_{AX} = 5kN, R_{AY} = 1.17kN, R_B=16.83kN



19. Compute the reactions at the support of beam ABCD is laded and supported as shown in figure.

Ans: R_{CH} = 50.558kN R_A = 26.462kN, R_{CV}=84.096kN



20. A beam ABF is loaded and supported as shown in figure. Find the direction and magnitude of couple to be applied at B will be 50kN upward. Also compute the reaction at 'F' support. **Ans:** couple at D = 18.75kN R_F=35kN