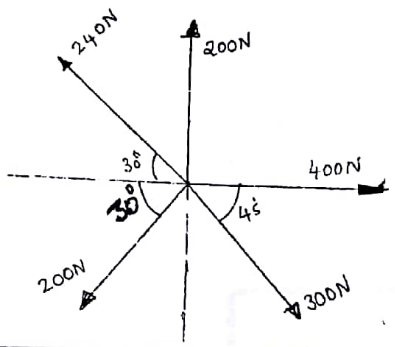
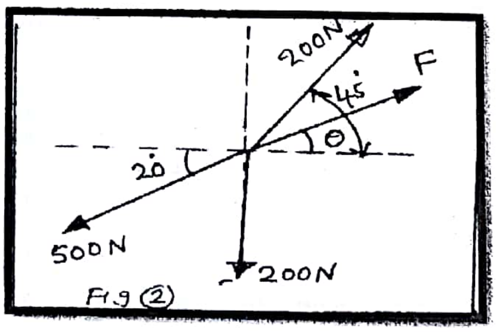
490

USN :

Internal Assessment Test 1 –September. 2019

Sub:	Elements of civil Engineering and Engineering Mechanics		Sub Code:	18CV14	Branch: CV
Date:	19-9-2019	Duration: 90 min's	Max Marks: 50	1st Sem /Sec:All	1 semester

ANSWER ANY FIVE FULL QUESTIONS

Q no.		Marks	CO	RBT
1a	Explain the basic idealizations made in Engineering Mechanics	05	2	L1
1b	State and Explain (i) Principle of transmissibility of forces (ii) Principle of super position of forces	05	2	L1
2a	State and prove Varignon's theorem of moments.	05	3	L1
2b	Find the magnitude and direction of the resultant for the concurrent system of forces shown in figure. 	05	2	L2
3a	Explain 1. Composition of forces 2.Resolution of forces 3.Resultant of a force system.	05	2	L1
3b	Four coplanar concurrent forces acting at a point are as shown in Figure. One of the forces is unknown and its magnitude is shown by F, the resultant is 500N acting along horizontal- axis. Determine the magnitude and direction of force F with respect to horizontal axis. 	05	2	L2
4	Find the magnitude, direction and position of the resultant from the point "O" for the system of forces shown in figure.	10	2	L2

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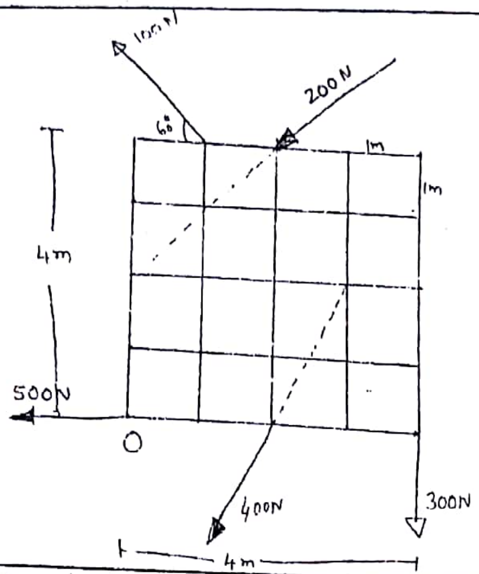
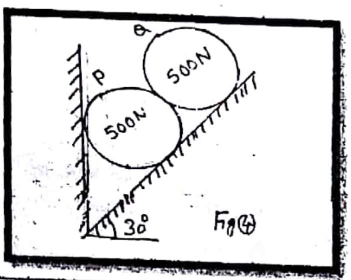
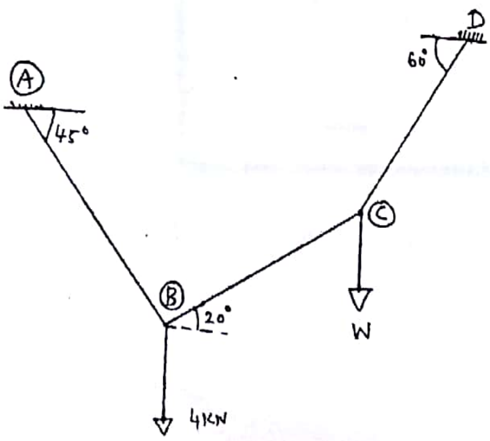
				
5	Two identical rollers each of weight 500 N rest on an inclined plane which makes an angle of 30 ⁰ with the horizontal as shown in figure.. Find the reactions at all contact points assuming that all surfaces to be smooth. 	10	3	L2
6	A string is subjected to the forces 4KN and W as shown in figure. Determine the magnitude of W and tensions induced in various parts of the string to keep the system in equilibrium. 	10	3	L2
7a	State and prove Lami's theorem	5	2	L1
7b	What is free body diagram? Explain with examples.	5	2	L1

C.I.   CCI 13/9/19   HOD

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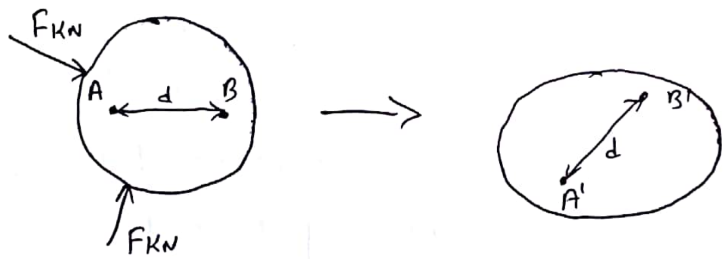
1. a) Ans The basic idealizations made in Engineering Mechanics are:-

(i) Particle = A particle is any body that has mass but not size and is assumed to a single point in the space. such body doesnot exists practically.

For eg:- An aeroplane flying in the sky is particle for a person observing it from the ATC tower.

Earth revolving around the sun is also considered as particle.

(ii) Rigid body = A body that doesnot undergo deformation under the application of force is known as a rigid body. It has the ability to retain it's shape & size. The distance between any two points of a rigid body remains unchanged.



Here, the points A & B are changed or shifted to A' & B', but the distance between the two points remains same.

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(iii) Continuum = An object is made up of combination of particles which are divided into sub-particles. Thus, it is difficult to solve any engineering problem by treating a body as the combination of such discrete particle.

A body consists of continuous distribution of matter which is known as continuum.

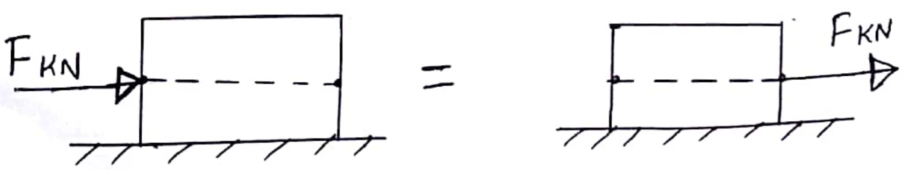
(iv) Point / Concentrated Force = When force is transmitted from one body to another body, they come in contact to each other. If the area of contact is very small & negligible, then the force acting on that area will be called as point force.

1.b) Ans

Principle of transmissibility of forces = It states that, the state of motion or rest of a body remains unaltered if the force acting on the rigid body is moved anywhere along it's line of action.

In other words, a force having magnitude & direction can be replaced by another force having same magnitude & direction along the same line of action in a rigid body.

Eg:-



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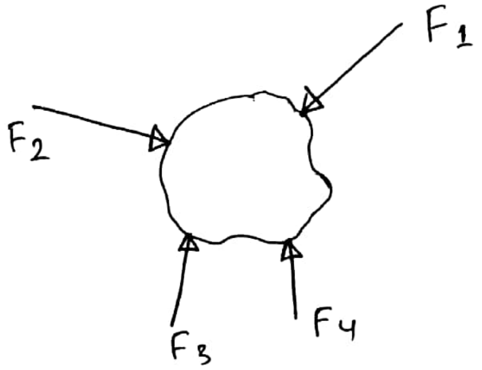
Principle of superposition of forces = It states that, when a body is under the system of forces, the net effect by the forces on it is same as the sum of effect of individual forces.



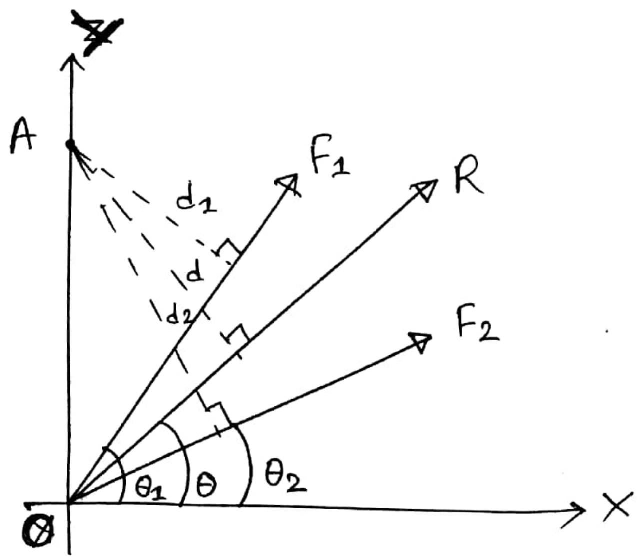
$\therefore$ Net effect $(R) = F_1 + F_2 + F_3 + F_4$

2.a) Ans

Varignon's theorem states that,
"The algebraic sum of moment due to several forces acting on a body at any point is equal to the moment of their resultant about the same point."

i.e, $\Sigma M_F = M_R$

Proof



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Let us consider two forces F_1 & F_2 concurrent at a point O & subtending angle θ_1 & θ_2 with x-axis respectively. Let R be their resultant which subtends angle θ with the x-axis. Let d_1, d & d_2 be the perpendicular distance of F_1, R & F_2 w.r.t point 'A' respectively.

Here, the distances d_1, d & d_2 can be written in the form of OA.

$$d_1 = OA \cdot \cos\theta_1 \qquad \text{[from figure]}$$
$$d = OA \cdot \cos\theta$$
$$d_2 = OA \cdot \cos\theta_2$$

Now,

The moment of R wrt A is

$$M_R = R \cdot d$$
$$M_R = R \cdot OA \cdot \cos\theta$$

The x-component of R is given as

$$R_x = R\cos\theta$$

$$\therefore M_R = R_x \cdot OA \quad \text{— (i)}$$

Again, The moment of F_1 wrt. A is

$$M_{F_1} = F_1 \cdot d_1$$
$$M_{F_1} = F_1 \cdot OA \cdot \cos\theta_1$$

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The x-component of F_1 is given as

$$F_1x = F_1 \cos\theta_1$$

$$\therefore M_{F_1} = F_1x \cdot OA \text{ ——— (ii)}$$

Finally,

The moment of F_2 wrt A is

$$M_{F_2} = F_2 \cdot d_2$$

$$M_{F_2} = F_2 \cdot OA \cdot \cos\theta_2$$

The x-component of F_2 is given as

$$F_2x = F_2 \cos\theta_2$$

$$\therefore M_{F_2} = F_2x \cdot OA \text{ ——— (iii)}$$

Now,

By adding Eq^n (ii) & (iii), we get,

$$M_{F_1} + M_{F_2} = OA\,(F_1x + F_2x)$$

or, $M_{F_1} + M_{F_2} = OA \cdot R_x$

$$\therefore \Sigma M_F = OA \cdot R_x \text{ ——— (iv)}$$

Compairing (i) & (iv), we get,

$$\boxed{M_R = \Sigma M_F}$$

Hence, Varignon's theorem is proved.

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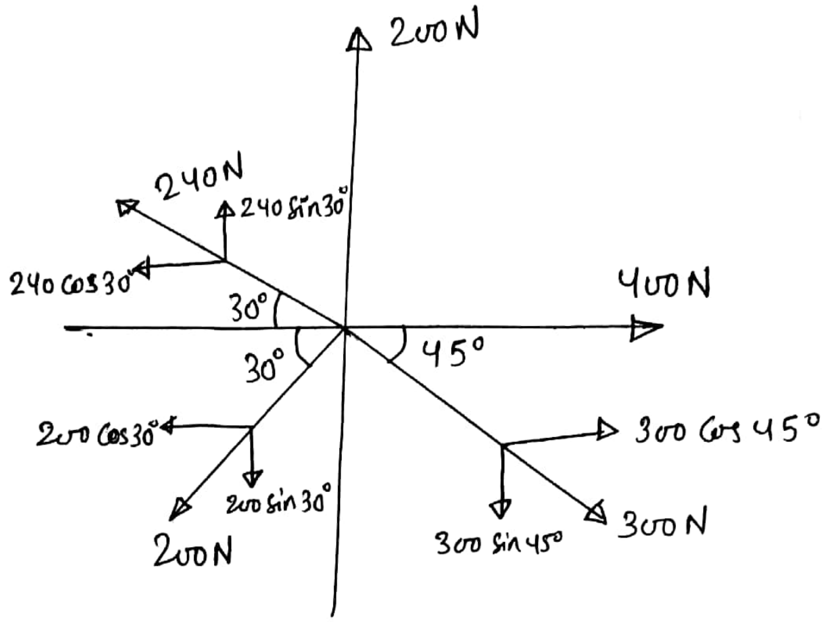
2.b) Ans By the resolution of required forces, we get the sketch as



Thus, from the figure,

$$\Sigma F_x = 400\,N + 300\cos 45^\circ - 200\cos 30^\circ - 240\cos 30^\circ$$
$$= 400 + 212.13 - 173.2 - 207.85$$
$$= +231.08\,N \quad \text{or,} \quad 231.08\,N\ (\rightarrow)$$

$$\Sigma F_y = 200 + 240\sin 30^\circ - 200\sin 30^\circ - 300\sin 45^\circ$$
$$= 200 + 120 - 100 - 212.13$$
$$= +7.87\,N \quad \text{or,} \quad 7.87\,N\ (\uparrow)$$

Thus, the magnitude of resultant, $R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$

$$= \sqrt{(231.08)^2 + (7.87)^2}$$
$$= 231.21\,N$$

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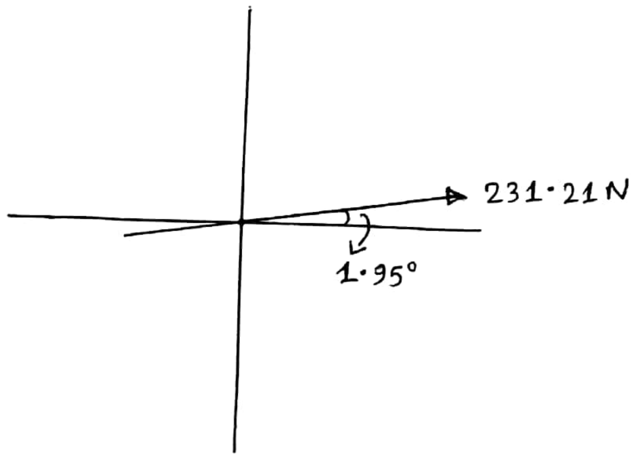
The direction of resultant is given by $\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right)$

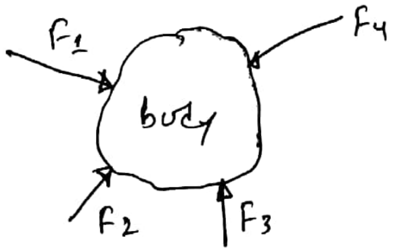
$$= \tan^{-1}\left(\frac{7.87}{231.08}\right)$$

$$\therefore \theta = 1.95^\circ$$



3.a) Ans Composition of forces = It is the process of combining the number of forces acting on a body and make a single force such that the net effect of the single force is equal to the algebraic sum of effect of individual forces.

Eg:-



$\therefore$ Net effect $= \Sigma F$

$$= F_1 + F_2 + F_3 + F_4$$

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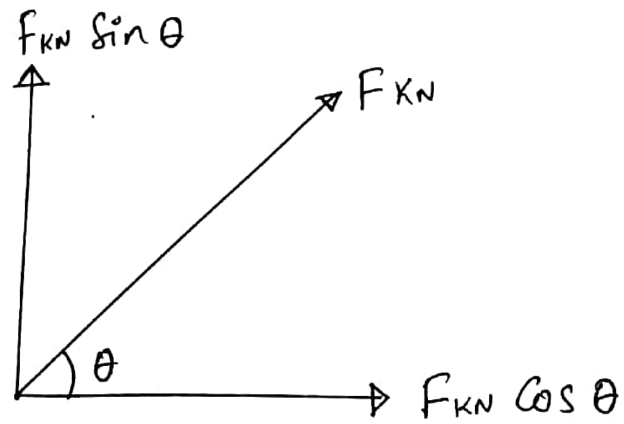
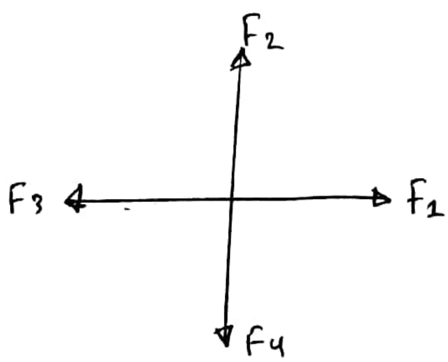
Resolution of forces = It is the process of splitting a single force into it's rectangular components (i.e, Horizontal & Vertical components.).

Eg:-



Here, the force FKN is resolved into it's horizontal & vertical component, $F_{KN}\cos\theta$ & $F_{KN}\sin\theta$ respectively.

Resultant of a force = It is the single force to the system of forces that has the same effect on the body that the system of forces exert on the same body.



$\Sigma F_x = F_1 - F_3$

$\Sigma F_y = F_2 - F_4$

Thus, the Resultant, $R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$

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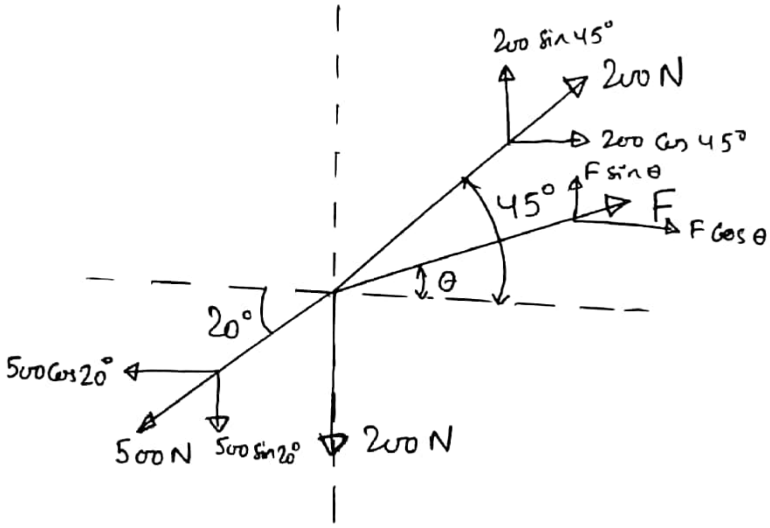
3.b) Soln:



Since, the resultant is acting along the horizontal-axis,

$\Sigma F_y = 0$

or, $-200 - 500 \sin 20° + 200 \sin 45° + F \sin\theta = 0$

or, $-200 - 171.01 + 141.42 + F \sin\theta = 0$

or, $F \sin\theta = 230\ N$ —— (i)

Also, the magnitude of Resultant is 500 N

$\therefore\ 500 = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$

or, $500 = \sqrt{(\Sigma F_x)^2 + (0)^2}$

or, $500 = \sqrt{(\Sigma F_x)^2}$

or, $\Sigma F_x = 500$

or, $F \cos\theta + 200 \cos 45° - 500 \cos 20° = 500$

or, $F \cos\theta + 141.42 - 469.85 = 500$

or, $F \cos\theta = 500 - 141.42 + 469.85$

or, $F \cos\theta = 828.43\ N$ —— (ii)

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Now, Dividing Eqn (i) by (ii), we get,

$$\frac{\cancel{F} \sin\theta}{\cancel{F} \cos\theta} = \frac{230}{828.43}$$

or, $\tan\theta = \left(\frac{230}{828.43}\right)$

or, $\theta = \tan^{-1}\left(\frac{230}{828.43}\right)$

$\therefore \theta = 15.52^\circ$

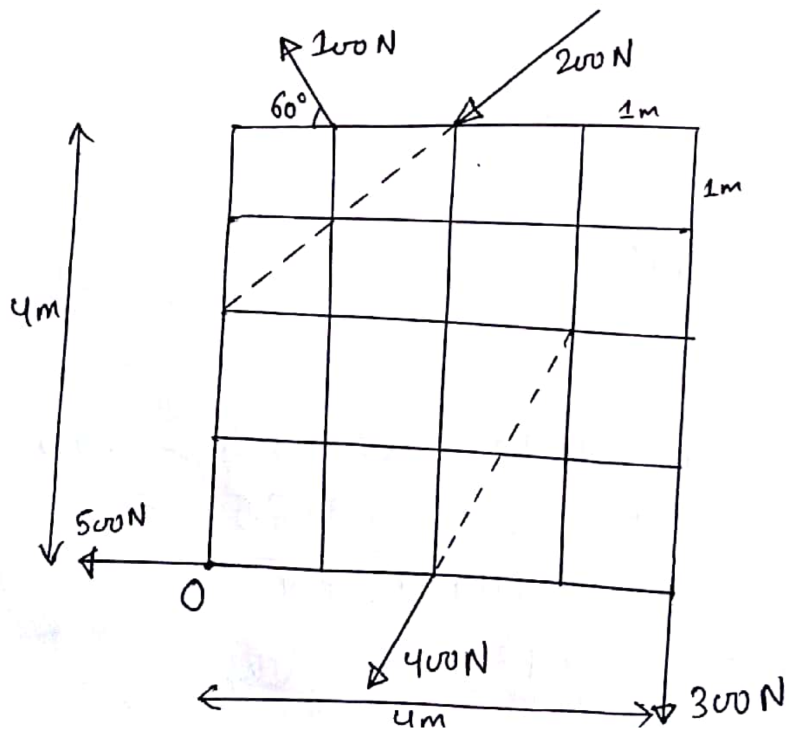
Now, by substituting the value of θ in Eqn (i), we get,

$F \sin 15.52^\circ = 230\ N$

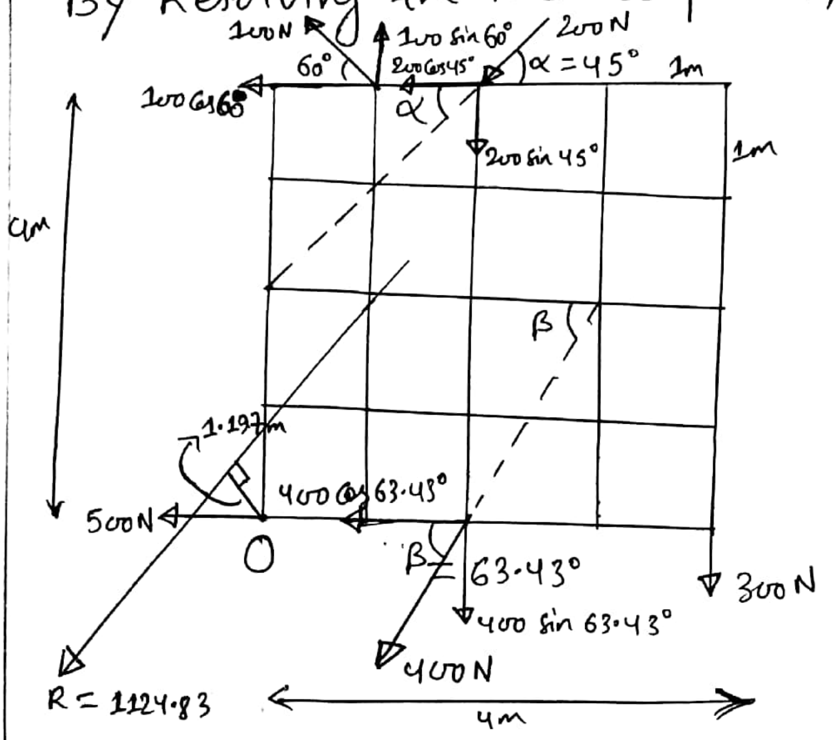
or, $F = \frac{230}{\sin 15.52}$

$\therefore F = 859.57\ N$

4. Soln:-



By Resolving the inclined forces,



From the given sketch,

$$\alpha = \tan^{-1}\left(\frac{2}{2}\right)$$

$$\therefore \alpha = 45°$$

and, $$\beta = \tan^{-1}\left(\frac{2}{1}\right)$$

$$\therefore \beta = 63.43°$$

Thus,

$$\Sigma Fx = -500 - 100 \cos 60° - 200 \cos 45° - 400 \cos 63.43°$$
$$= -500 - 50 - 141.42 - 178.92$$
$$= -870.34 \text{ N}$$

$$\Sigma Fy = 100 \sin 60° - 200 \sin 45° - 300 - 400 \sin 63.43°$$
$$= 86.6 - 141.42 - 300 - 357.75$$
$$= -712.57 \text{ N}$$

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$\therefore$ Resultant is $R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$

$= \sqrt{(-870.34)^2 + (-712.57)^2}$

$\therefore R = 1124.83\ N$

and the direction of resultant is $\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right)$

$= \tan^{-1}\left(\frac{-712.57}{870.34}\right)$

$\therefore \theta = 39.31^\circ$

Now,
Moment w.r.t point O, $M_o = (500 \times 0) + (400 \cos 63.43 \times 0)$

$- 100 \cos 60 \times 4 - 100 \sin 60 \times 1 +$

$200 \sin 45^\circ \times 2 - 200 \cos 45 \times 4$

$+ 300 \times 4 + 400 \sin 63.43 \times 2$

or, $M_o = 0 + 0 - 200 - 86.6 + 282.84 - 565.68$

$+ 1200 + 715.51$

$\therefore M_o = 1346.07\ Nm$

Now, Applying Varignon's theorem,

$M_R = \Sigma M_F$

or, $R \times d = 1346.07$

or, $d = \frac{1346.07}{1124.83}$

$\therefore d = 1.197\ m$

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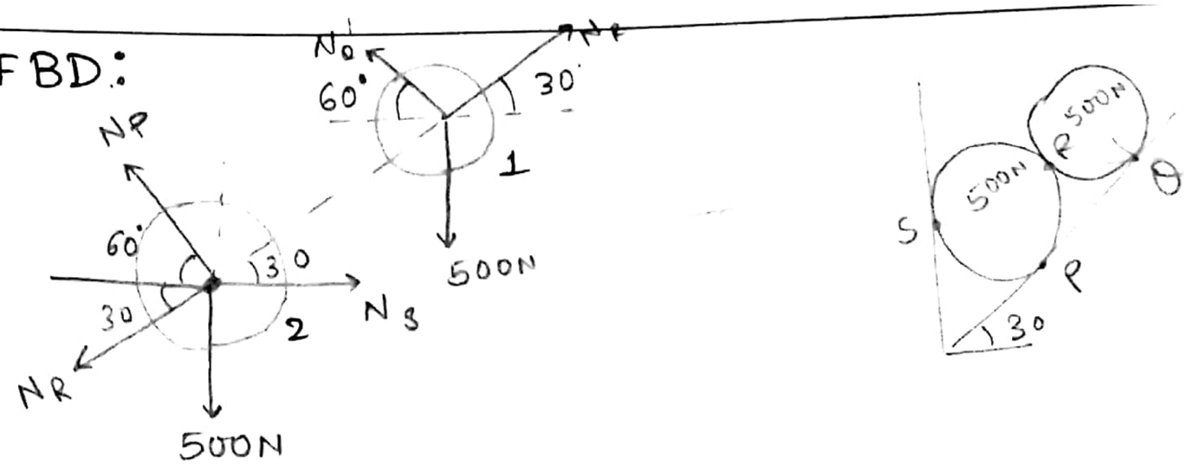
5.

FBD:



Using lami theorem in roller 1.

$$\frac{500}{\sin(180-60-30)} = \frac{N_R}{\sin(90+60)} = \frac{N_Q}{\sin(90+30)}.$$

$$500 = \frac{N_R}{\sin(150)} = \frac{N_Q}{\sin(120)} \qquad (\sin 90 = 1)$$

$$500 = \frac{N_Q}{\sin 120}$$

$$N_Q = 500 \times \frac{\sqrt{3}}{2} = \underline{\underline{433.01 N}} \text{ Ans}$$

$$500 = \frac{N_R}{\sin 150}$$

$$N_R = 500 \times \frac{1}{2} = \underline{\underline{250 N}} \text{ Ans.}$$

For roller 2, using equilibrium condition

$\Sigma F_x = 0$.

$N_S - N_R \cos 30° - N_P \cos 60° = 0$ —— (1)

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$\Sigma F_y = 0.$

$$N_P \sin 60 - N_R \cos 30 - 500 = 0$$

$$N_P \frac{\sqrt{3}}{2} = 250 \times \frac{\sqrt{3}}{2} + 500$$

$$N_P = (216.50 + 500) \times \frac{2}{\sqrt{3}}$$

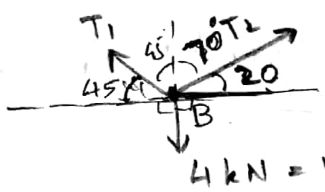
$$= \underline{\underline{827.34}}\ N \text{ Ans}$$

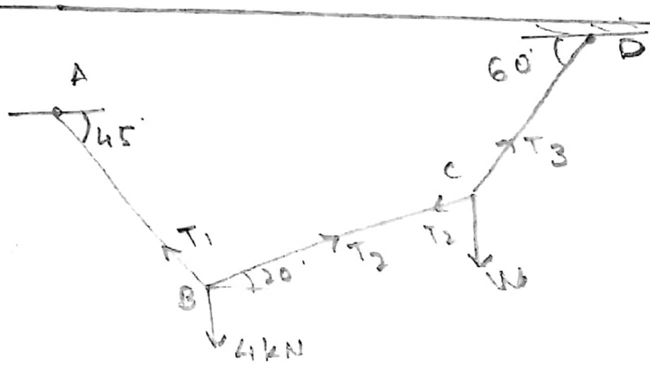
subs. N_P & N_R in 1.

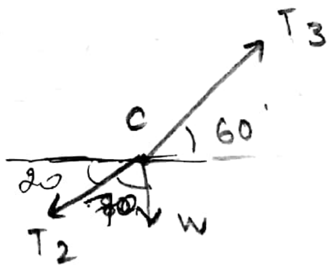
$$N_S = 250 \cos 30^\circ + 827.34 \cos 60^\circ$$

$$= \underline{\underline{630.17}}\ N \text{ Ans.}$$

6.







Applying lami's theorem at pt. B.

$$\frac{4000}{\sin(115)} = \frac{T_2}{\sin 135} = \frac{T_1}{\sin(110)}$$

$$\frac{4\sin(135)}{\sin(175)} = T_2$$

$T_2 = 3.120\text{ kN}$ Ans.

$$T_1 = \frac{4\sin(110)}{\sin(175)}$$

$T_1 = 4.147\text{ kN}$ Ans

Applying lami's theorem at C.

$$\frac{T_2}{\sin 150} = \frac{W}{\sin(130)} = \frac{T_3}{\cancel{\sin(80)}\ \sin(70)}$$

$$W = \frac{3.12 \times \sin 130}{\sin 150} = 4.780\text{ kN}$$ Ans

$$T_3 = \frac{3.12 \times \overset{\sin 70}{\cancel{\sin 80}}}{\sin 150} = \overset{5.86\text{ kN}}{\cancel{6.145\text{ kN}}}$$ Ans.

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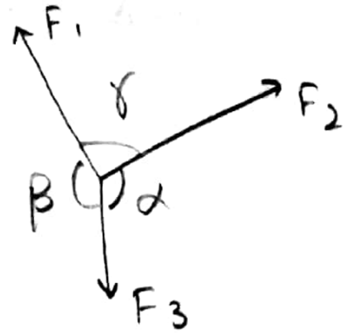
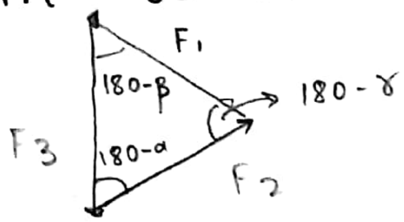
7.a) Lami's Theorem states that when three concurrent forces are in equilibrium then the ratio of any force to the sine of angle between the other two forces are constant.

$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}.$$



Rearranging the given forces to form a triangle.



Using the sine rule in the formed triangle.

$$\frac{F_1}{\sin(180-\alpha)} = \frac{F_2}{\sin(180-\beta)} = \frac{F_3}{\sin(180-\gamma)}$$

$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma} \qquad (\sin(180-\theta) = \sin\theta)$$

proved.

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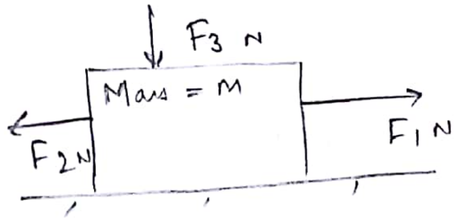
7.b) Free body diagram of the body is the diagram where the body is free from all contact surfaces and all forces are represented in it including own weight and reaction.

eg:



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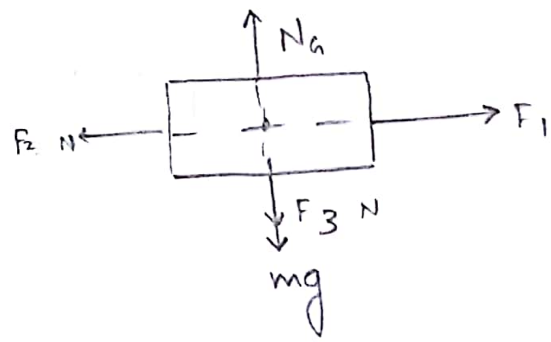

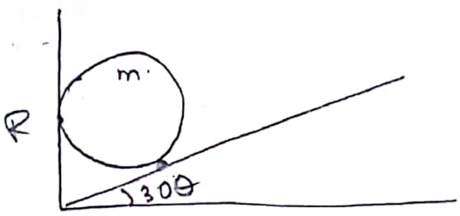

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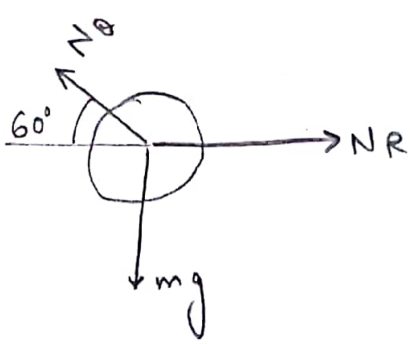

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