Elements of Civil Engineering and Engineering Mechanics

IAT - 1 Solutions

K and M. Sections

QNO. 1A Explain the impact of infrastructural development on the economy of the country.

Ans: Infrastructural development has the following impacts on a country

1. Increase in food production: Due to development of water resources, there is a controlled water supply of water to the crops. This will incrase food production

2. Protection from famine: Improvement of irrigation facilities provides employment and assured water supply.

3. Healthy and comfortable housing facility for people.

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4. Safe ~~and~~ domestic and industrial water supply
5. Safe and scientific waste-water disposal
6. Improvement in Communication and transportation
7. Addition to the wealth of the country
8. Increase in prosperity of people
9. Improvement in standard of living and aid in civilization.

QNO 1B: State and explain
1. Principle of transmissibility of forces
2. Principle of superposition of forces.

Ans

Principle of transmissibility of forces

Principle of transmissibility of forces states that if a force acting on a rigid body,

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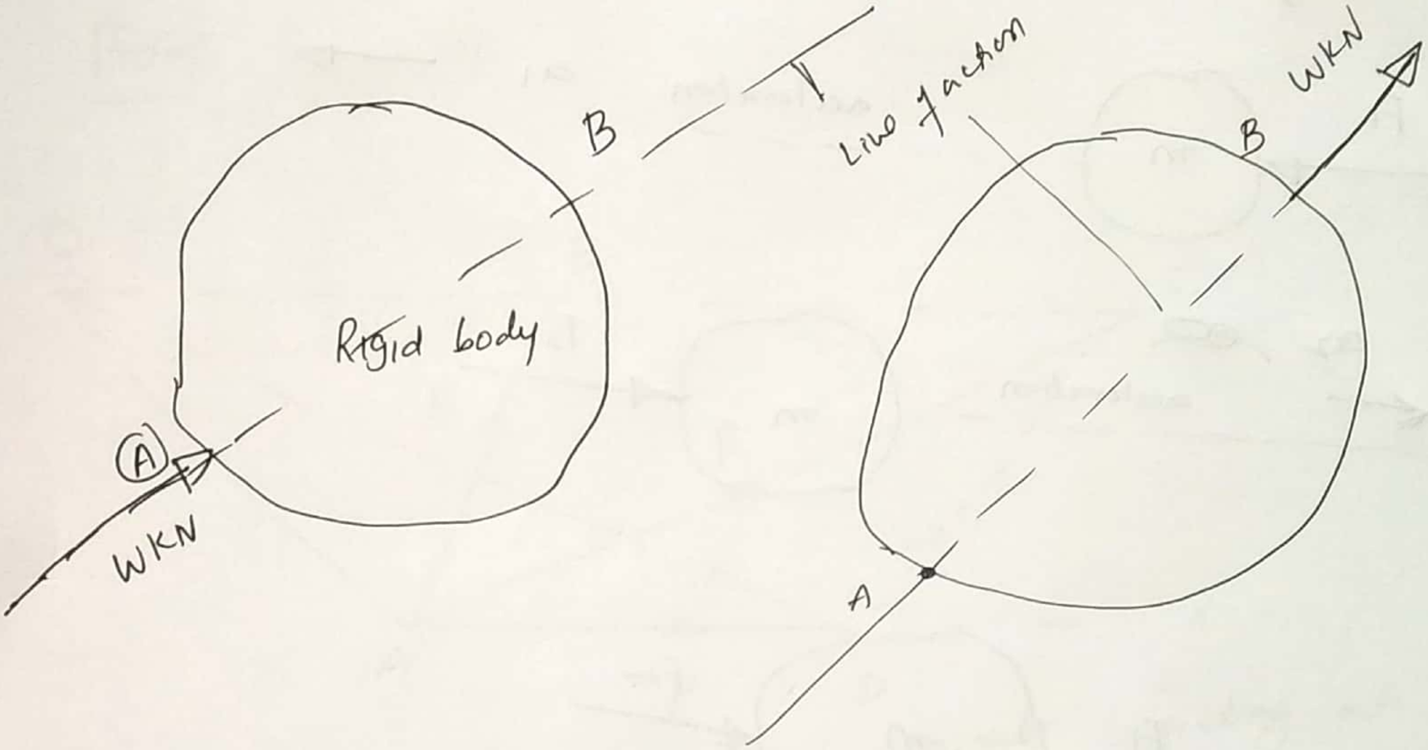
It may also be Considered to act at any Point in the Same line of action Causing Same effect on the body (3)



Applying a force WKN at Point A on a rigid body and changing the position of the force WKN to Point B which is in the Same line of action will cause the Same effect on the body.

Principle of superposition

The net effect of forces applied in any Sequence on a body is

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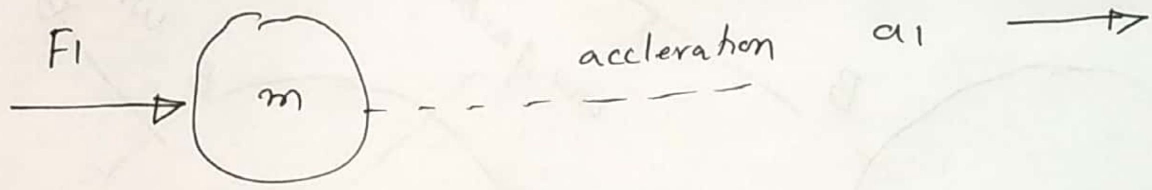
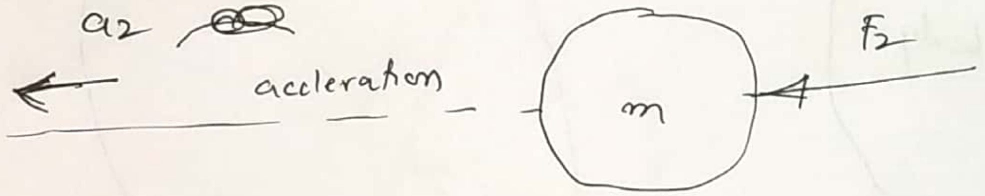
given by the alzebric sum of effect of individual forces on the body.





If F_1 is applied first and then F_2

$$a = +a_1 - a_2$$

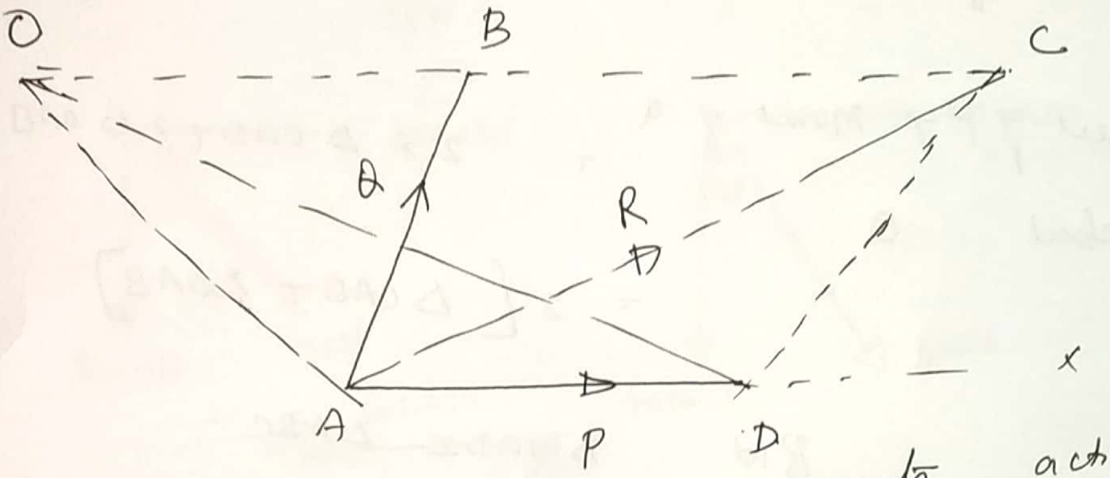
If F_2 is applied first and then F_1

$$a = -a_2 + a_1$$

Q.2 A: State and Prove Vangnon's theorem?

Ans: Vangnon's theorem states that the alzebric sum of moment of a system of forces about any point is equal to the moment of the resultant about the same point.

Proof



Let P and Q be the points acting at A as shown in fig. Let O be the point about which moments are to be taken. Draw a line from O parallel to Ax, with the same scale. Set AD on Ax representing force P. Complete the parallelogram ABCD in which AC represents the resultant R.

Join OA and OB.

From fig $\Delta OAD = \Delta ACD = \Delta ABC$

From Geometrical interpretation of Moment

Moment of P about O = 2 × ΔOAD

Moment of Q about O = 2 × ΔOAB

Moment of R about O = 2 × ΔOAC.

Moment of P + Moment of Q about O = 2 × ΔOAD + 2ΔOAB

= 2[ΔOAD + ΔOAB]

But ΔOAD = ΔABC

= 2[ΔABC + ΔOAB]

= 2[ΔOAC]

Which is ~~o~~ equal to Moment of R about O Here Varignon's theorem is Proved.

Q2B.

Find the magnitude and direction of the resultant for the Concurrent forces Shown in fig.

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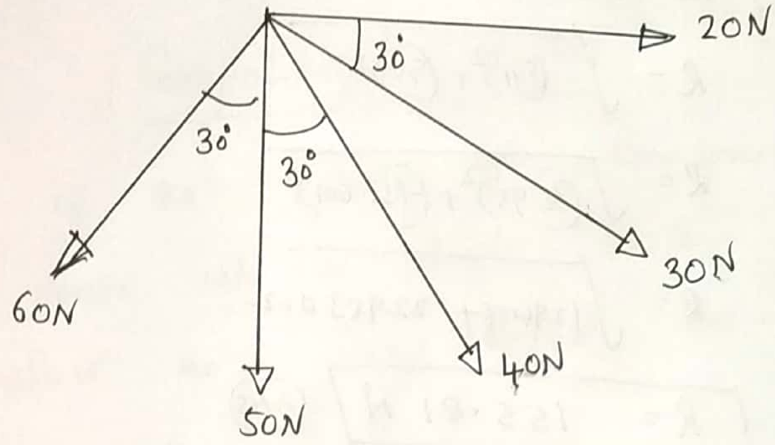

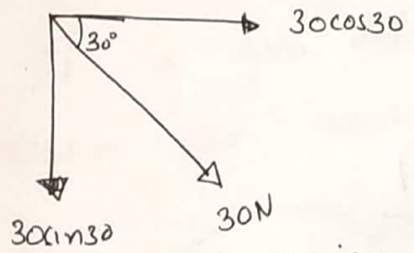

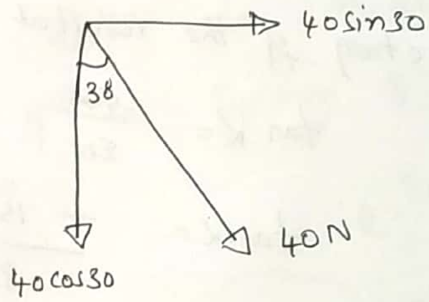

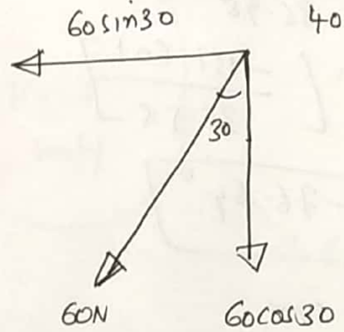

Sum of horizontal forces $\Sigma H = 20 + 30\cos 30 + 40\sin 30 - 60\sin 30$

$$\Sigma H = 20 + 25.98 + 20 - 30$$

$$\Sigma H = 35.980 \text{ N}$$

Sum of vertical forces $\Sigma V = -40\cos 30 - 60\cos 30 - 50$
$- 30\sin 30$

$$= -34.64 - 51.96 - 50 - 15$$

$$= 151.601 \text{ N}$$

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Magnitude of the resultant

$$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2}$$

$$R = \sqrt{(35.98)^2 + (-151.601)^2}$$

$$R = \sqrt{1294.56 + 22983.022}$$

$$\boxed{R = 155.81\ N}$$ ANS

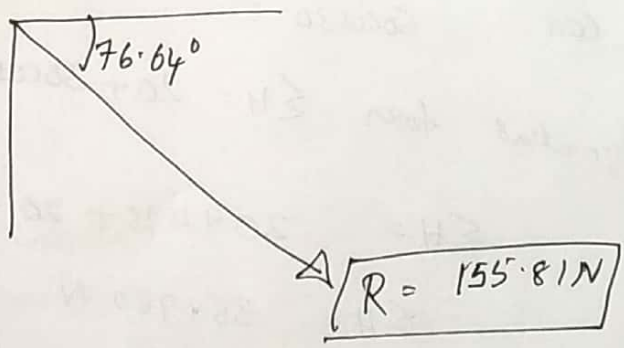
Direction of the resultant

$$\tan \alpha = \frac{\Sigma V}{\Sigma H}$$

$$\tan \alpha = \frac{-151.601}{35.98}$$

$$\alpha = \tan^{-1}\left[\frac{-151.601}{35.98}\right]$$

$$\boxed{\alpha = -76.64^\circ}$$



Q 3A. Explain

1. Composition of forces
2. Resolution of forces

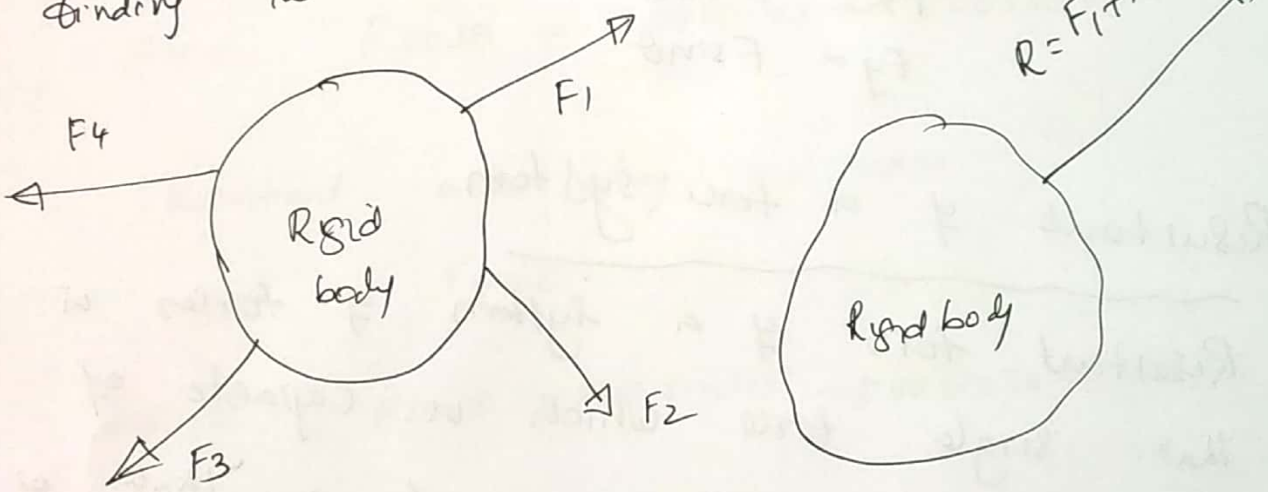
3 Resultant of a force system

Ans

Composition of forces

It is the process of combining number of forces into a single force which would produce the same effect as those number of forces.

It is also defined as the technique of finding the resultant of a system of forces



Resolution of forces

It is the process of splitting up a single ~~of~~ force in to number of component forces. Generally force can be resolved in to X and y

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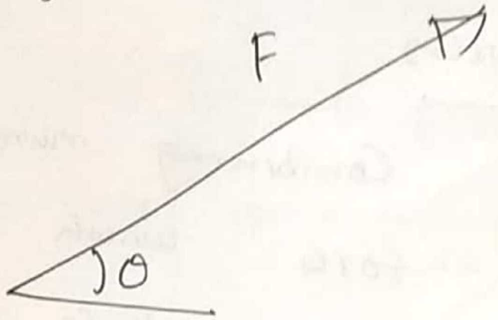
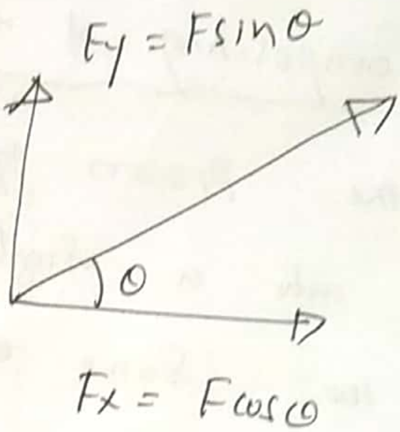
Components





Fx and Fy are called the components of the force

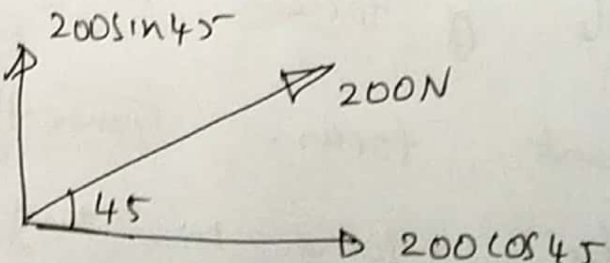
$$F_x = F\cos\theta$$
$$F_y = F\sin\theta$$

Resultant of a force system

Resultant force of a system of forces is that single force which is capable of producing the same effect as that of system of forces acting on a body.

Q, 3B:

Solution



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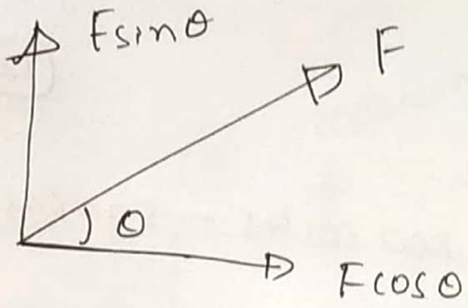

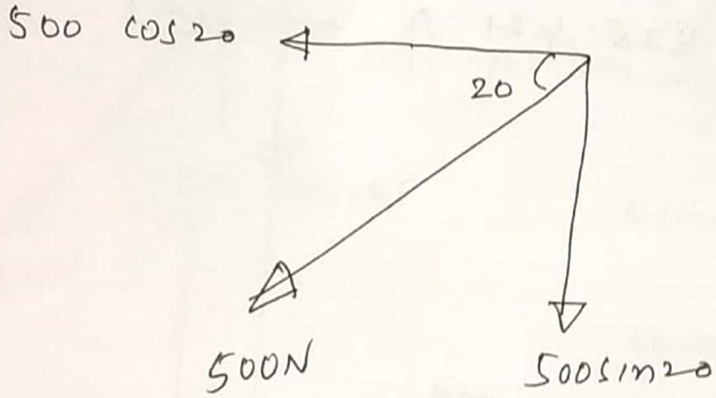

Sum of horizontal forces

$$\Sigma H = F\cos\theta + 200\cos 45 - 500\cos 20$$

Resultant acts along x - axis

$$\Sigma V = 0$$

$$\Sigma V = F\sin\theta + 200\sin 45 - 500\sin 20 - 200$$

$$\Sigma V = 0$$

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

$$F\sin\theta = 229.589\ N \quad \text{——} \quad (1)$$

$$R = \sqrt{\Sigma H^2 + \Sigma V^2}$$

$$R = \sqrt{\Sigma H^2 + 0^2}$$

$$R = \sqrt{\Sigma H^2} \qquad R = \Sigma H.$$

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$R = 500\ N$

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

$F\cos\theta = 828.425\ N$ — (2)

$\frac{eq\ (1)}{eq\ (2)}$

$$\frac{\cancel{F}\sin\theta}{\cancel{F}\cos\theta} = \frac{229.589}{828.425}$$

$$\tan\theta = \frac{229.589}{828.425}$$

$$\theta = \tan^{-1}\left[\frac{229.589}{828.425}\right]$$

$$\boxed{\theta = 15.49^{\circ}}$$ Ans

$F\cos\theta = 828.425$

$$F = \frac{828.425}{\cos 15.49}$$

$$\boxed{F = 859.65\ N}$$ Ans

Q4 Ans

Sum of horizontal forces

$\Sigma H = 45\sin 30 + 60\sin 60 - 75\cos 45$

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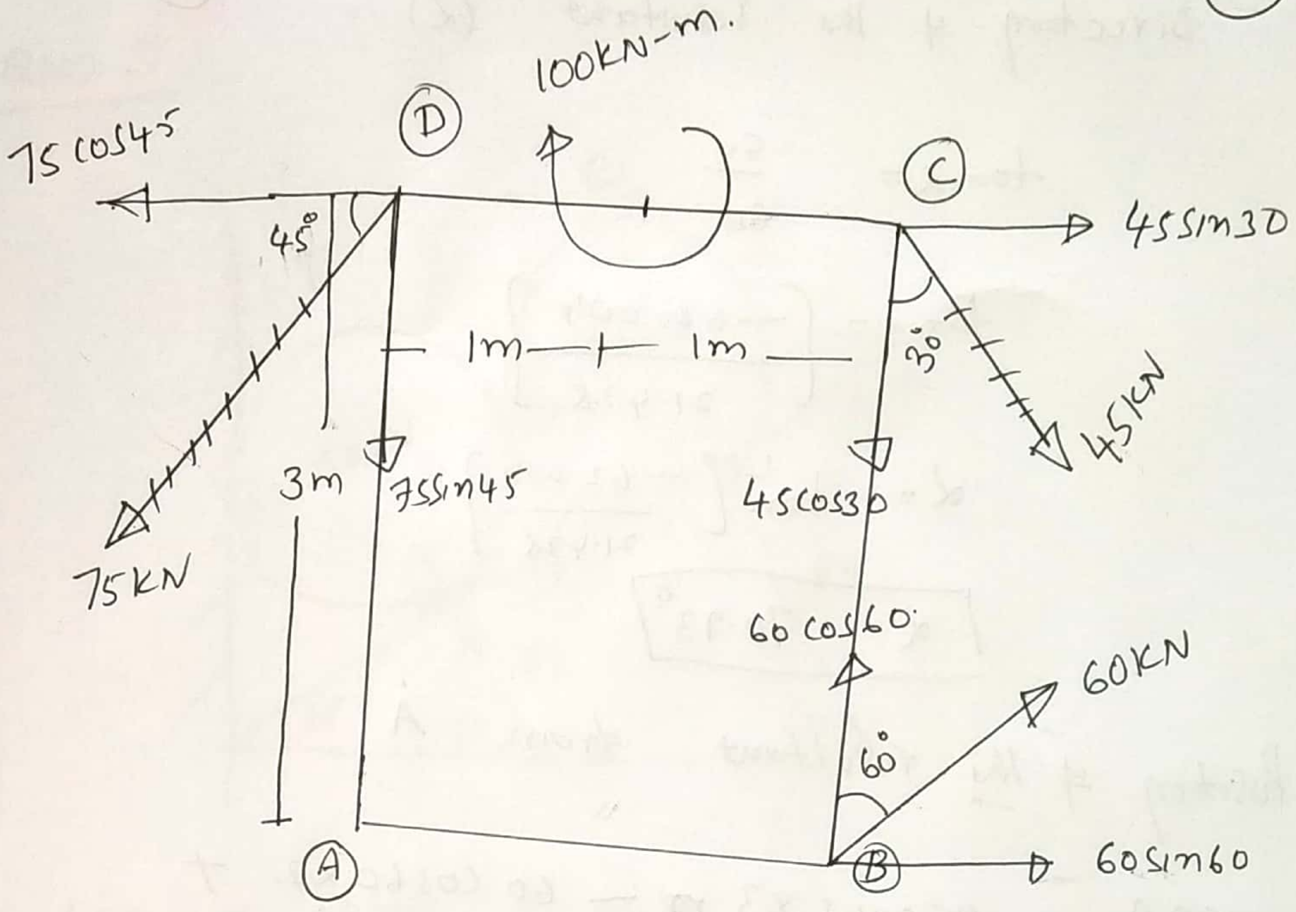

$\Sigma H = 21.428$ KN

Sum of vertical forces

$\Sigma V = -45\cos 30 + 60\cos 60 - 75\sin 45$

$\Sigma V = -62.004$ KN

Magnitude of the resultant

$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2}$

$R = \sqrt{(21.428)^2 + (-62.004)^2}$

$\boxed{R = 65.602 \text{ KN}}$

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Direction of the resultant (α)

$$\tan\alpha = \frac{\Sigma V}{\Sigma H}$$

$$\tan\alpha = \left[\frac{-62.004}{21.428}\right]$$

$$\alpha = \tan^{-1}\left[-\frac{62.004}{21.428}\right]$$

$$\boxed{\alpha = 70.93^{0}}$$

Position of the resultant from 'A'

$$\Sigma M_A = -75\cos45\times3 - 60\cos60\times2 + 100 \cdot 45\sin30\times3 + 45\cos30\times2 +$$

$$\Sigma MA = 26.343 \text{ KN-m}$$

Position of the result

$$R \times d = |\Sigma MA|$$

$$d = \left|\frac{\Sigma MA}{R}\right|$$

$$d = \left|\frac{26.343}{65.602}\right|$$

$$\boxed{d = 0.401 \text{ m}}$$ Ans.

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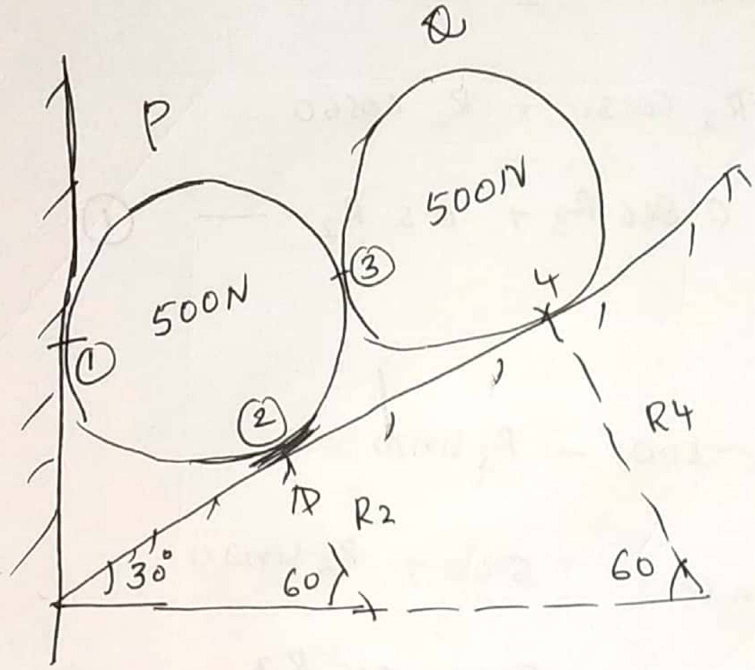
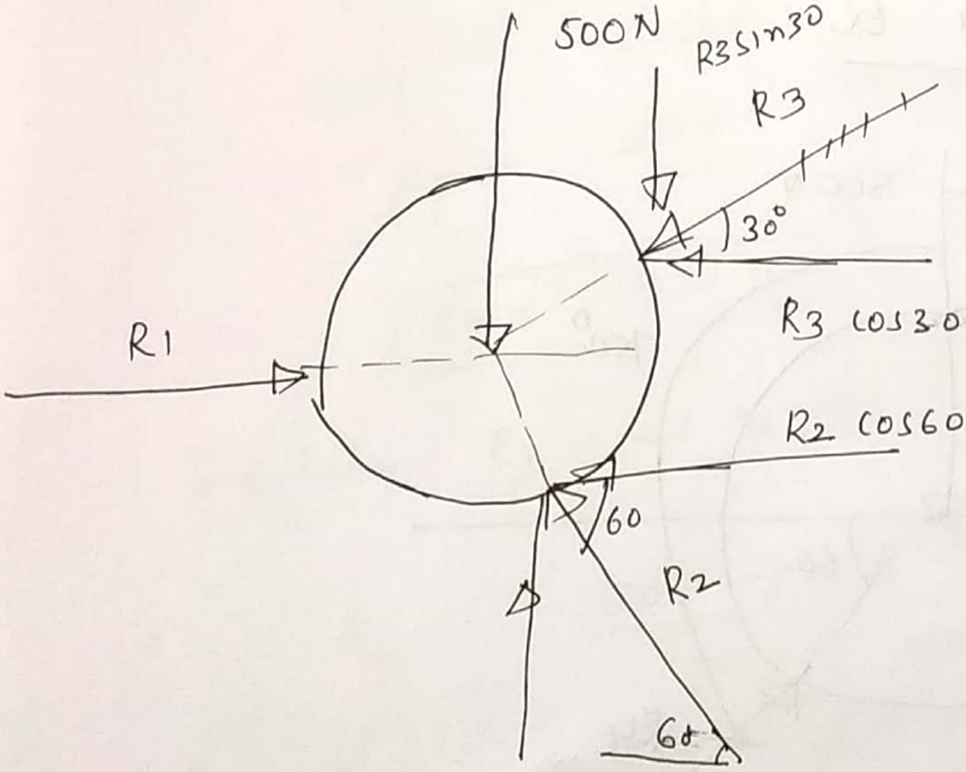
QNO. 5



FBD of sphere P



Applying equlibrium Conditions

$\Sigma H = 0$

$\Sigma V = 0.$

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$\Sigma H = 0$

$R_1 - R_3 \cos 30 - R_2 \cos 60 = 0$

$R_1 = R_3 \cos 30 + R_2 \cos 60$

$R_1 = 0.866 R_3 + 0.5 R_2$ — (1)

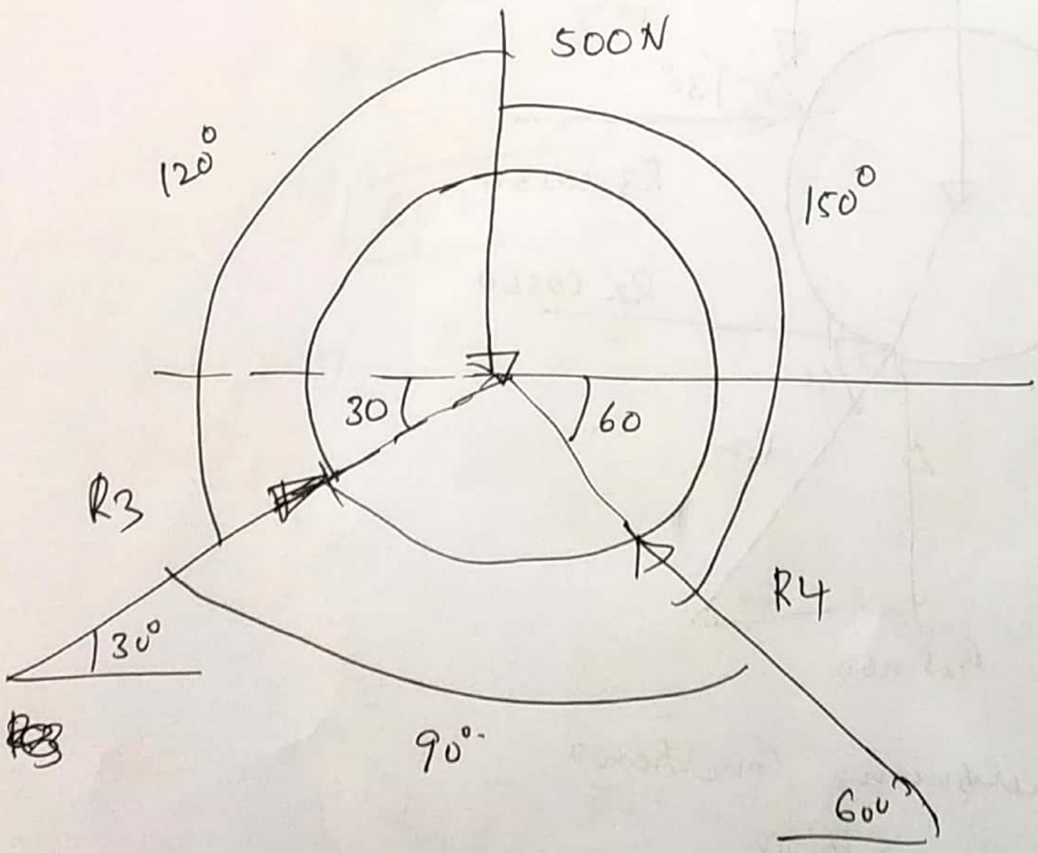
$\Sigma V = 0$

$R_2 \sin 60 - 500 - R_3 \sin 30 = 0$

$R_2 \sin 60 = 500 + R_3 \sin 30$

$R_2 = \dfrac{500 + 0.5 R_3}{0.866}$ — (2)

FBD of sphere Q



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Applying Lami's theorem

$$\frac{500}{\sin 90} = \frac{R3}{\sin 150} = \frac{R4}{\sin 120}$$

$$\frac{500}{\sin 90} = \frac{R3}{\sin 150}$$

$$R_3 = \frac{500 \times \sin 150}{\sin 90}$$

$$\boxed{R_3 = 250\ N}$$

$$\frac{500}{\sin 90} = \frac{R4}{\sin 120}$$

$$R4 = \frac{500 \times \sin 120}{\sin 90}$$

$$\boxed{R4 = 433.012\ N}$$

Substituting R_3 in eq 2

$$R_2 = \frac{500 + 0.5\ R3}{0.866}$$

$$R_2 = \frac{500 + 0.5\ (250)}{0.866}$$

$$R_2 = \frac{500 + 125}{0.866} = \frac{625}{0.866}$$

$$\boxed{R_2 = 721.709\ N}$$

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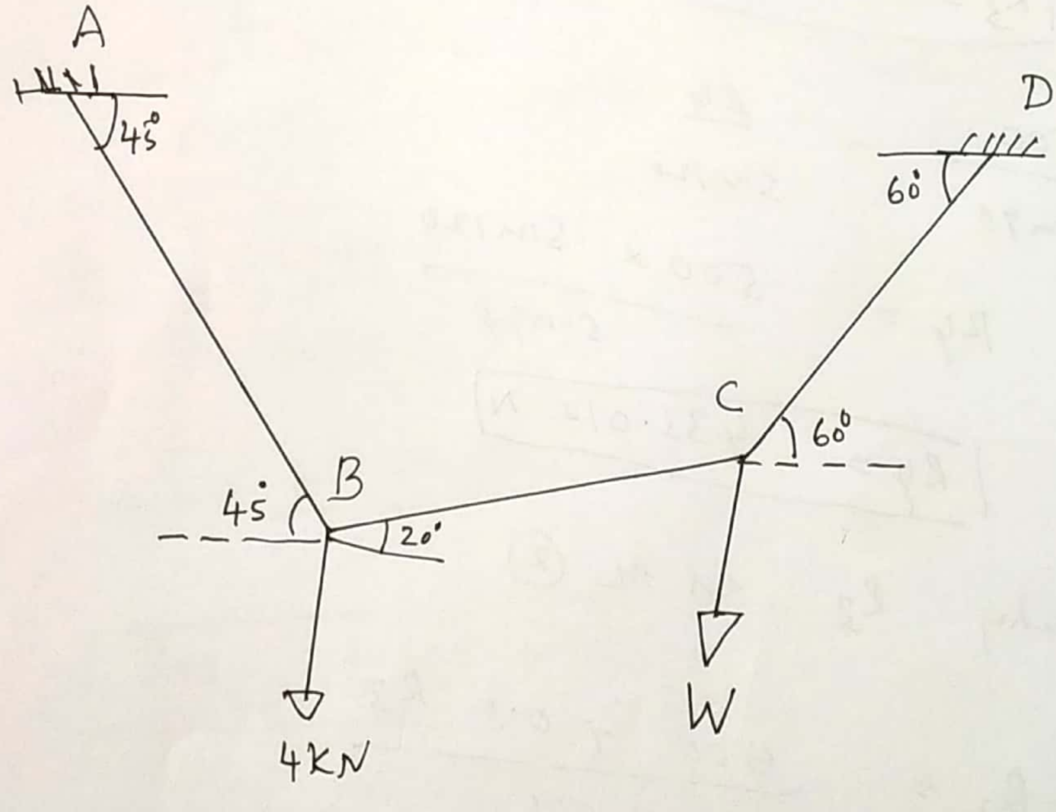
Substituting R_2 and R_3 in eq ①

$$R_1 = 0.866 \times \cancel{721.709}^{250} + 0.5(721.709)$$

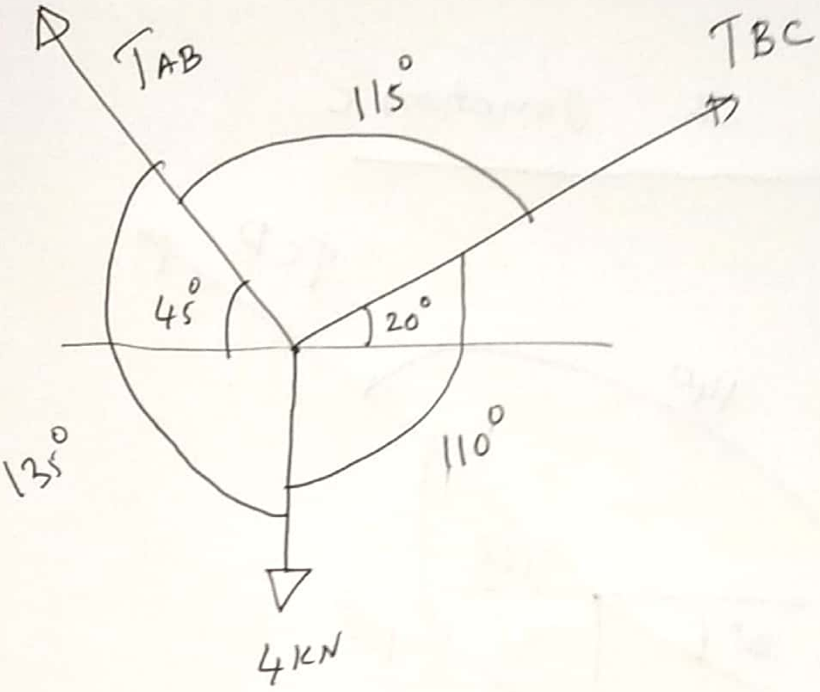
$$R_1 = 216.5 + 0.5(721.709)$$

$$\boxed{R_1 = 577.354\ N}$$

QNO. 6



F.B.D at Junction B



Applying lami's theorem

$$\frac{4}{\sin 115} = \frac{T_{AB}}{\sin 110} = \frac{T_{BC}}{\sin 135}$$

$$\frac{4}{\sin 115} = \frac{T_{AB}}{\sin 110}$$

$$T_{AB} = \frac{4 \times \sin 110}{\sin 115}$$

$$\boxed{T_{AB} = 4.147 \text{ KN}}$$

$$\frac{4}{\sin 115} = \frac{T_{BC}}{\sin 135}$$

$$T_{BC} = \frac{4 \times \sin 135}{\sin 115}$$

$$\boxed{T_{BC} = 3.120 \text{ KN}}$$

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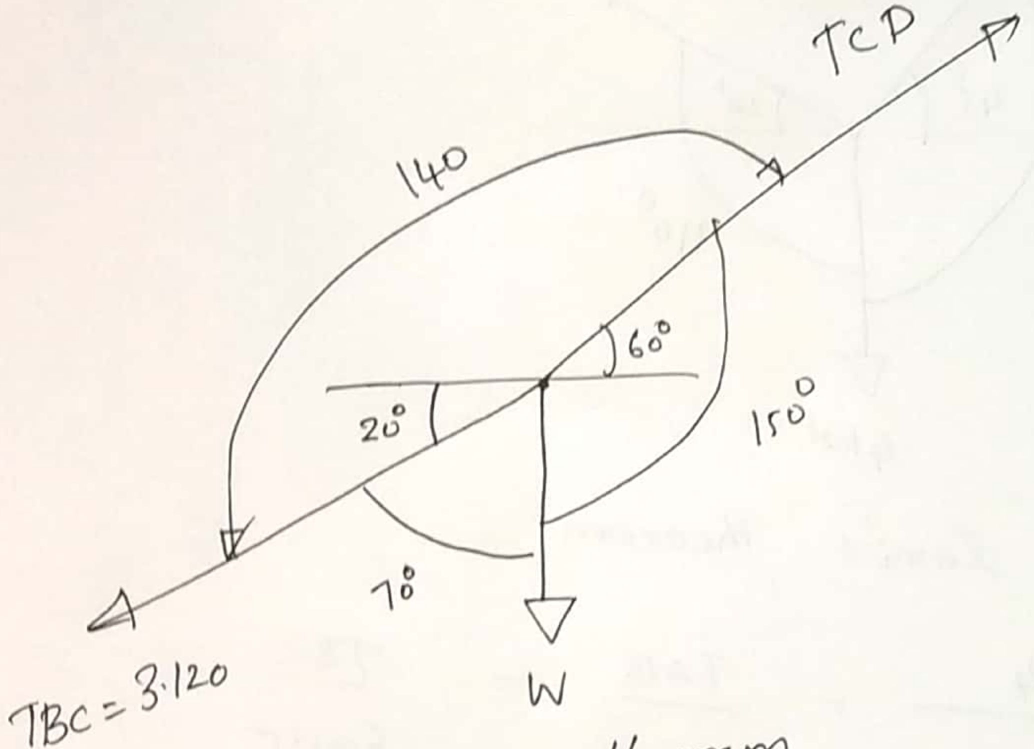
FBD at Junction C



Applying lamis theorem

$$\frac{W}{\sin 140} = \frac{3.120}{\sin 150} = \frac{TCD}{\sin 70}$$

$$\frac{W}{\sin 140} = \frac{3.120}{\sin 150}$$

$$W = \frac{3.120 \times \sin 140}{\sin 150}$$

$$\boxed{W = 4.010\ kN}$$

$$\frac{3.120}{\sin 150} = \frac{TCD}{\sin 70}$$

$$TCD = \frac{3.120 \times \sin 70}{\sin 150}$$

$$\boxed{TCD = 5.863\ KN}$$

End.

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