{D.S. Kumar
N.H. Dude

89/1/20

Mechanics → It is a branch of that deals with the study of forces & their effect on a body.

1) Rigid Body.
2) Deformable Body

Classification of Mechanics

Mechanics
- Mechanics of Rigid Body
  - Engineering Mechanics
    - Static
    - Dynamic
      - Kinetics
      - Kinematics.
- Mechanics of Deformable body
  - → Solid Mechanics
  - → Fluid Mechanics
  - → Gas Dynamics

Force :- Force is define as an external stimuli that changes / tends to changes the position / motion of a body.

Characterization :-
- → Magnitude
- → Point of Application
- → Nature (Tensile / compressive)
- → Line of Action

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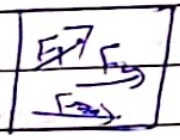
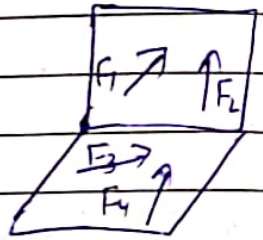
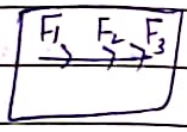
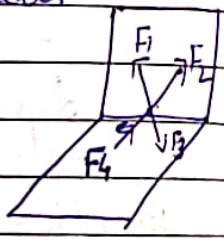
Force System:

1) Coplaner 

2) Non-coplaner 

3) Coplane - colinear 

4) Coplaner concurrent 

5) Non-coplaner concurrent 

6) Non-coplaner non current.

X

* Transmissibility Law of Forces:-
The position or motion of a rigid body remain unchanged by replacing a force acting on it by the another forces along the same line of action of same magnitude

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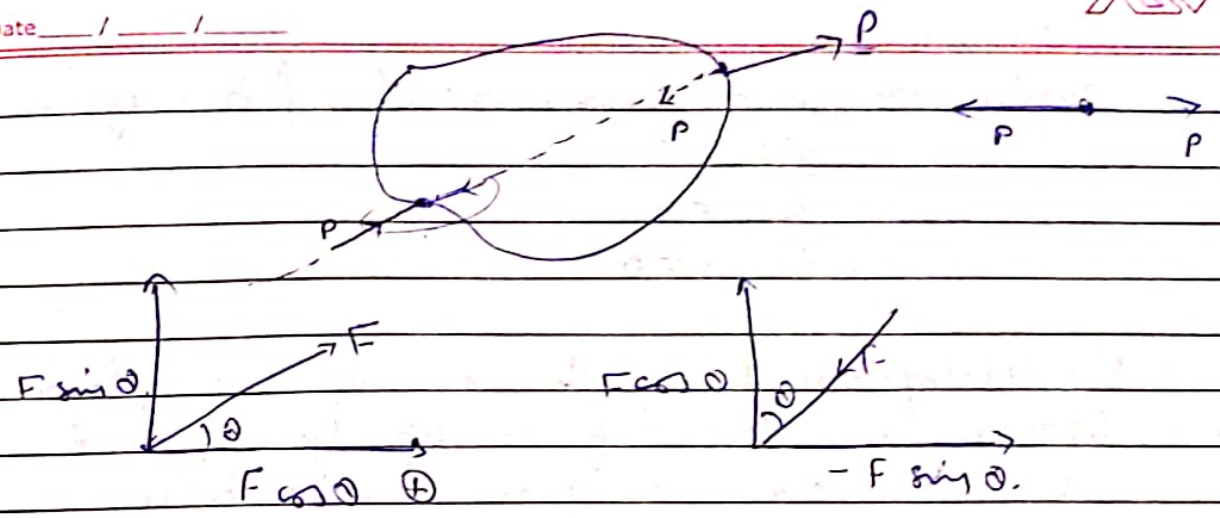

Resultant of a forces:
Resultant forces is a forces which could produces the same effect as produced by the system of forces.

Compositing of forces: (For two forces)
1) Analytical Method:
i) Parallelogram Law of forces.
ii) triangle Law of forces.
3) Polygon Law of forces

2) Graphical Method
3) Method of Resolution

Equillibrium: When the net effect is zero.
" of by the application of moving not going to change its position. (without acceleration & retardation).
Condition of equillibrium for coplanes concurrent systems.

$$\Sigma H = 0 \;,\; \Sigma F_x = 0$$
$$\Sigma V = 0 \;,\; \Sigma F_y = 0.$$

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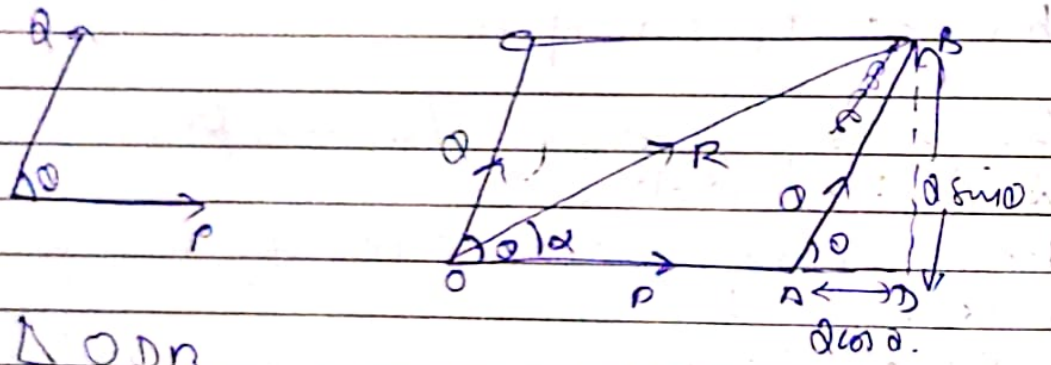
Coplanar, non-concurrent force system

$\Sigma H = 0$

$\Sigma V = 0$

$\Sigma M_A = 0$

Parallelogram Law forces: If two coplanar ~~forces~~ concurrent forces are represent by two sides of ||gram in the both mag. & dirⁿ then their resultant is represented by the diagonal of that ||gram in both mag. & dirⁿ starting from same point.



$\triangle ODB$

$OB^2 = OD^2 + BD^2$

$OB^2 = (OA + AD)^2 + BD^2$

$R^2 = P^2 + Q^2 + 2PQ\cos\theta$

$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$ — (1)

$\triangle ODB \quad \tan\alpha = \frac{BD}{OD} = \frac{Q\sin\theta}{P + Q\cos\theta}$

$\alpha = \tan^{-1}\left(\frac{Q\sin\theta}{P + Q\cos\theta}\right)$ — (2)

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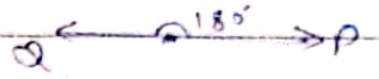
Case - I $\theta = 180^\circ$

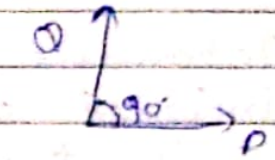


① $R = P - Q$; $P > Q$

$= Q - P$; $Q > P$

② $\alpha = 0$

③ case $\theta = 90^\circ$



$R = \sqrt{P^2 + Q^2}$

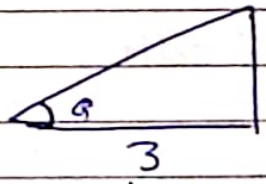
$\alpha = \tan^{-1}\left(\frac{Q}{P}\right)$

case II $\theta = 0^\circ$

$R = P + Q$

$\alpha = 0$

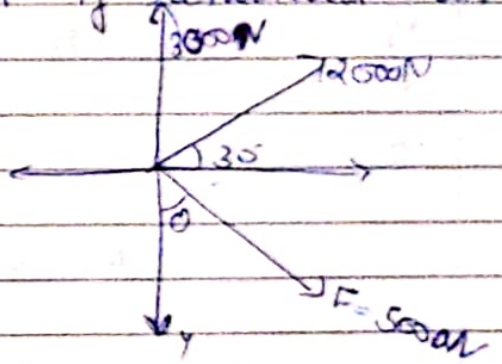
Q. A body is subjected to a three forces as shown in fig identify the dirⁿ of force F if resultant dirⁿ of ⊕ x-axis.



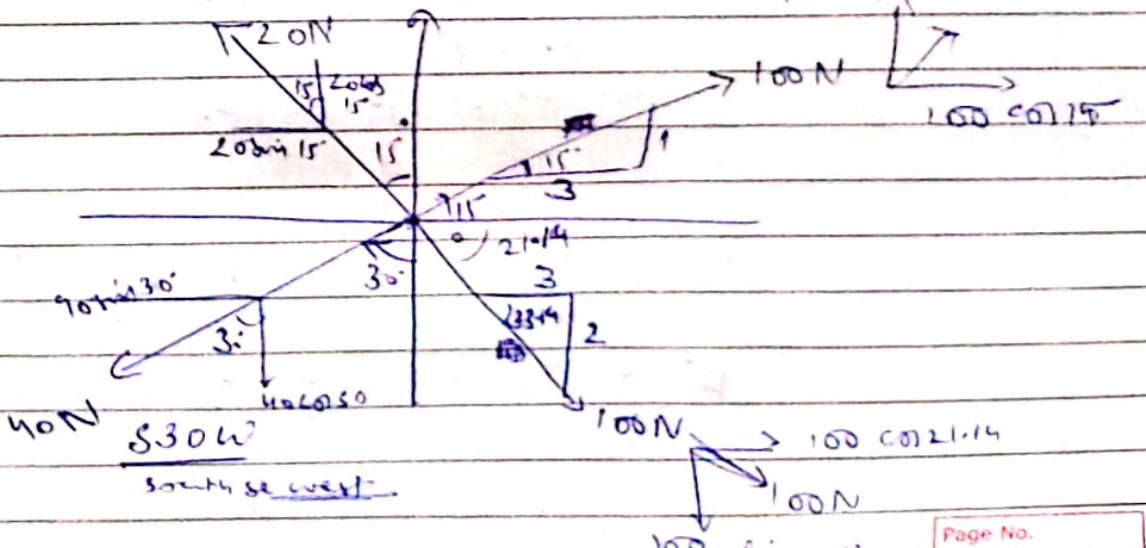
$\tan\alpha = \frac{1}{3}$

$\alpha = \tan^{-1}(1/3)$

$= 18.43$



Q.



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$\Sigma H = 100\cos 15^\circ + 100\cos 33.6 - 20\sin 18.43 - 40\sin 30^\circ$

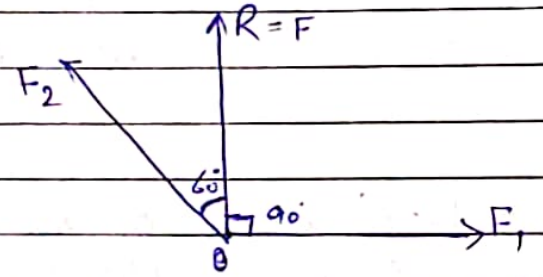
$=$

$\Sigma V = 100\sin 15^\circ - 100\sin 33.6 + 20\cos 18.43 - 40\cos 30^\circ$

$=$

Q. Determine the horizontal force of a force inclined at angle 60° with a vertical whose resultant equal to the vertical force F.

Sol



$P = F_1$

$Q = F_2$

$\theta = 150^\circ$

$R = \sqrt{f_1^2 + f_2^2 + 2f_1f_2\cos\theta^\circ}$

$F = \sqrt{f_1^2 + f_2^2 + 2F_1F_2\cos 150^\circ}$

$\tan\alpha = \dfrac{F_2\sin 150^\circ}{F_1 + F_2\cos 150^\circ}$

$\dfrac{1}{0} = \dfrac{F_2\sin 150}{F_1 + F_2\cos 150^\circ}$

$F_1 + F_2\cos 150 = 0$

$F_1 = -F_2\cos 150$

$F_1 = \dfrac{\sqrt{3}}{2} F_2$

$\cos 150$

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

$F^2 = \dfrac{3}{4}F_2^2 + F_1^2 - \sqrt{3} \times \dfrac{\sqrt{3}}{2} F_2^2$

$F_1^2 = \left(\dfrac{3}{4} + 1 - \dfrac{3}{2}\right) F_2^2$

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$$F_2^2\left(\frac{3+4-6}{4}\right) = F^2.$$

$$F^2 \times \frac{1}{4} = F^2$$

$$\boxed{F_2 = \frac{1}{2}F}$$

Q. The resultant of two forces P & Q acting at a point is R. The resultant R gets doubled when Q is either doubled or it's direction is reversed show that P, Q & R conform to the ratio of $\frac{P}{\sqrt{2}} : Q : R$ / $\sqrt{3} : \sqrt{2}$

Soln

$$R^2 = P^2 + Q^2 + 2PQ\cos\theta. \quad \text{—(1)}$$

$$Q = 2Q, \quad R = 2R.$$

$$4R^2 = P^2 + 4Q^2 + 4PQ\cos\theta. \quad \text{—(2)}$$

$$Q = -Q, \quad R = 2R.$$

$$4R^2 = P^2 + Q^2 - 2PQ\cos\theta \quad \text{—(3)}$$

(1) + (3) $\quad 5R^2 = 2P^2 + 2Q^2 \quad \text{—(4)} \times 2$

(2) + (3) × 2 ~~$0 = 3P^2 + 6Q^2$~~

$$12R^2 = 3P^2 + 6Q^2 \quad \text{—(5)}$$

(5) × 2 − (4) × 3

$$9R^2 = 0 + 6Q^2$$

$$\therefore 9R^2 = 6Q^2$$

$$\boxed{\sqrt{3}R = \sqrt{2}Q}$$

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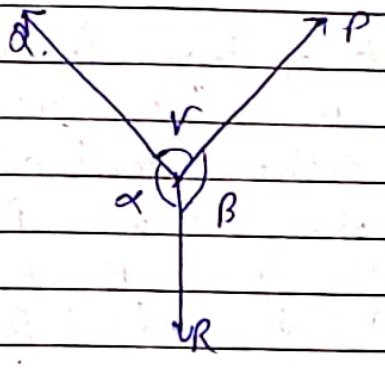
Lami's theorem:

If three coplaner concurrent forces are in equillibrium they each forces is directly proportionatoryal to the sin of angle blw the other two forces.

Condition



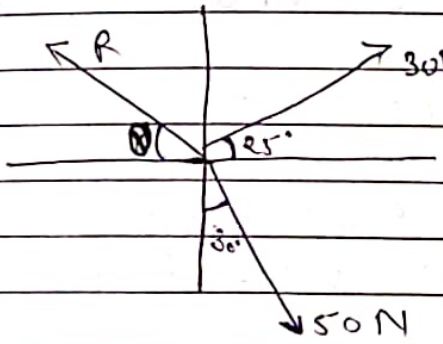
$P \propto \sin\alpha$

$Q \propto \sin\beta$

$R \propto \sin\gamma$

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

Q.



By method of Resolution's

Sol:

$\Sigma H = 0$, $30\cos 25° + 50\sin 30° - R\cos\theta = 0$

$30\cos 25° + 50\sin 30 = R\cos\theta$ — (1)

$\Sigma V = 0$, $30\sin 25° + R\sin\theta - 50\cos 30 = 0$

$50\cos 30 - 30\sin 25° = R\sin\theta$ — (2)

30.9°
R = 40.50 N

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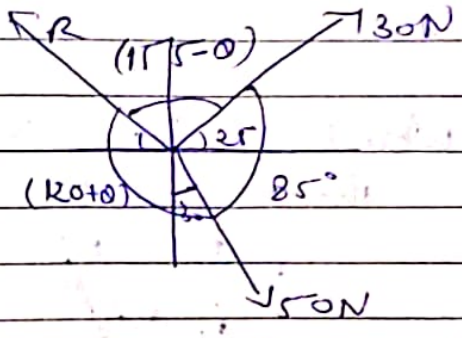
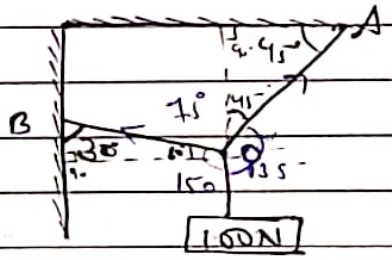
II Methods



$$\frac{30}{\sin(120+\theta)} = \frac{R}{\sin 85} = \frac{50}{\sin(115-\theta)}$$

Q.



$T_{OA} = ?$

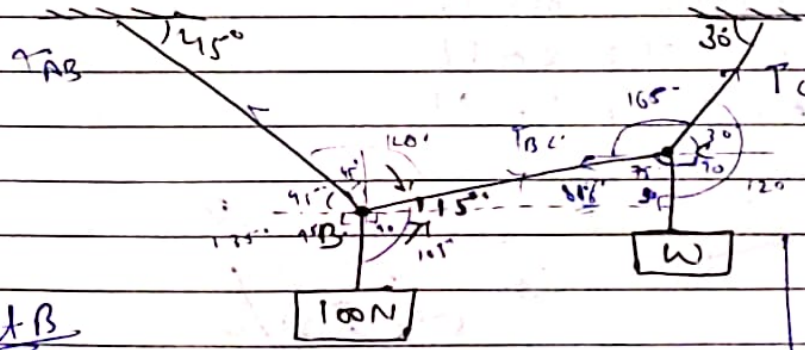
$T_{OB} = ?$

$$\frac{100}{\sin 75} = \frac{T_{OA}}{\sin 150^\circ} = \frac{T_{OB}}{\sin 135^\circ}$$

$T_{OA} = 52\,N$

$T_{OB} = 73.6\,N$

Q.



Point B

$$\frac{100}{\sin 180} = \frac{T_{AB}}{\sin(105)} = \frac{T_{BC}}{\sin 135^\circ}$$

$T_{AB} = 111.53\,N$

$T_{BC} = 81.6\,N$

Point C

$$\frac{W}{\sin 165^\circ} = \frac{81.6}{\sin 120} = \frac{T_{CD}}{\sin 75^\circ}$$

$W = 24.5\,N$

$T_{CD} = 91.01\,N$

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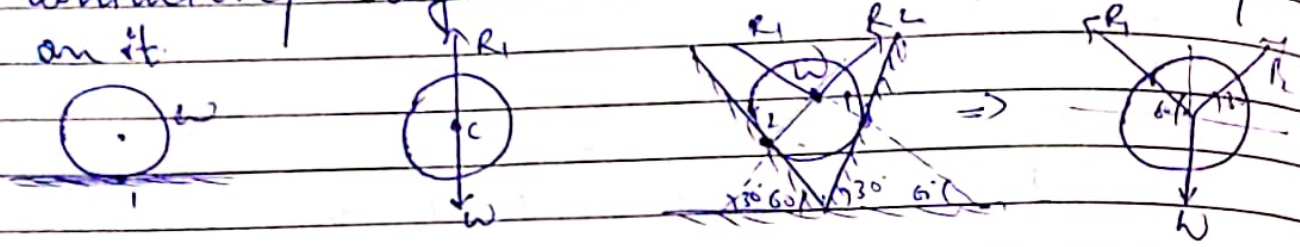
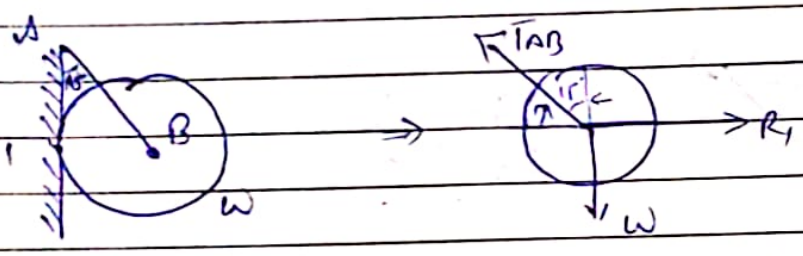
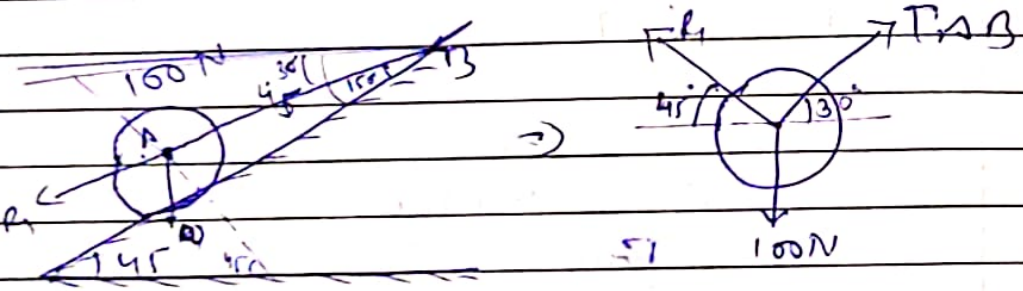
* Free Body Diagram:

Diagram of a Body which is free from all the contacting surfaces. shows all the forces acting on it.





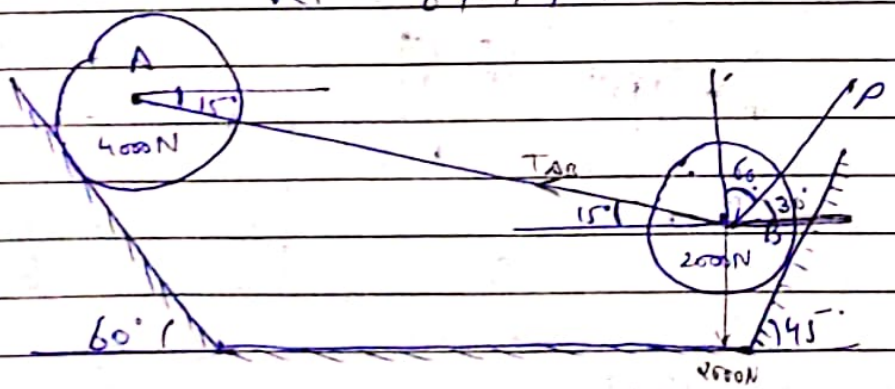


$$\frac{T_{AB}}{\sin 135^\circ} = \frac{R_1}{\sin 120^\circ} = \frac{100}{\sin 105^\circ}$$

$$T_{AB} = 73.20\ N.$$

$$R_1 = 89.77\ N.$$

Assignment Q3



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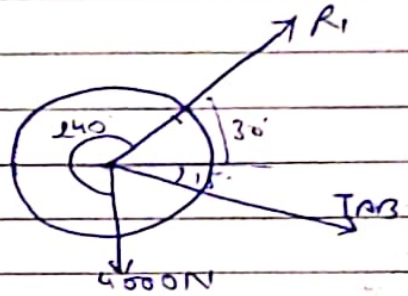
$$\frac{2000}{\sin 135^\circ} = \frac{P}{\sin 105^\circ} = \frac{T_{AB}}{\sin 120^\circ}$$

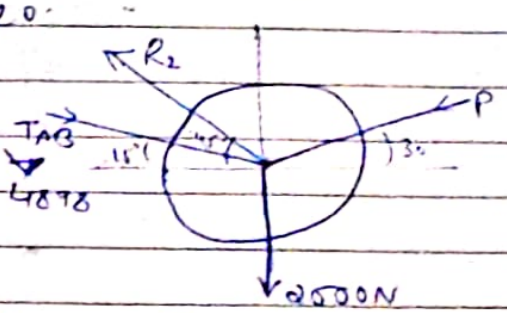
$$P = \frac{0.9 \times 2000}{0.7} = 1.2 \times 2000$$



$$\frac{4000\,N}{\sin 45^\circ} = \frac{T_{AB}}{\sin 240} = \frac{R_1}{\sin 75^\circ}$$

$T_{AB} = -4898\,N$

$R_1 = 5464\,N$



$P\cos 30 + R_2 \cos 45 = T_{AB}\cos 15^\circ$

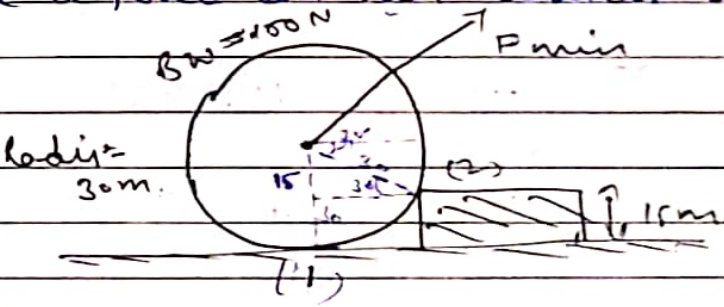
$= 4898\cos 15^\circ$

$R_2 \sin 45 - P\sin 30 = 2000 + 4898\sin 15^\circ$

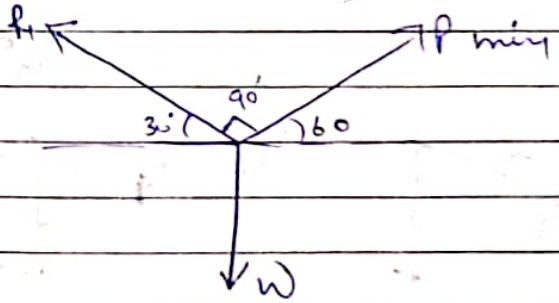
$P = 1071.28\,N$

$R_2 = 5378.73\,N.$

Q. Find a force & Pmin which contact is (2) not (1).



Soln



For Pmin sine will be 90° at (2) contact

$$\frac{100}{\sin 90} = \frac{R_1}{\sin 150} = \frac{P_{min}}{\sin 120}$$

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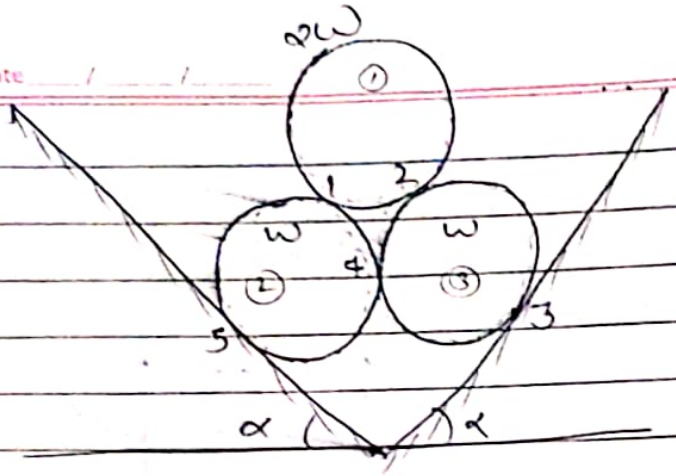
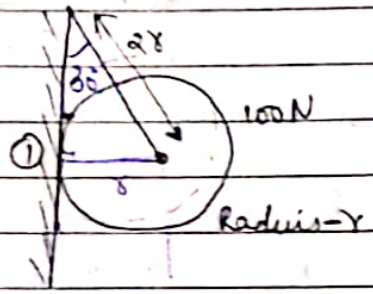
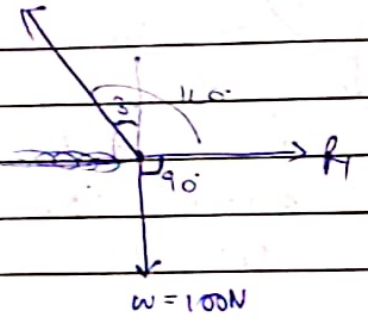
Q.



Q.





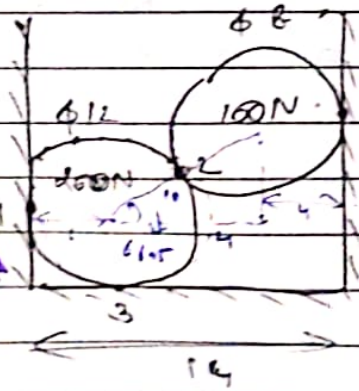
$$\frac{100}{\sin 120^\circ} = \frac{R_1}{\sin 150^\circ} = \frac{T}{\sin 90^\circ}$$

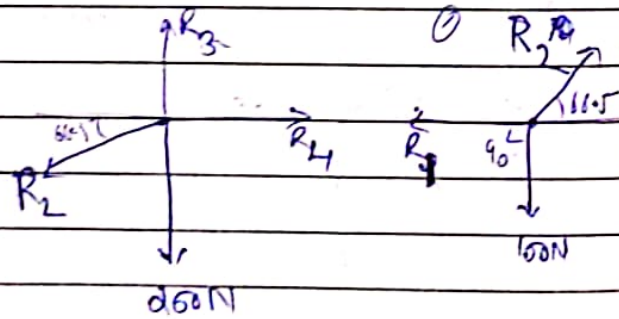
$$T = \frac{100}{\sin 120^\circ} = 115.46\,N$$

$$R_1 = 115.46 \times \sin 150^\circ$$

$$= 57.46\,N.$$

Q.





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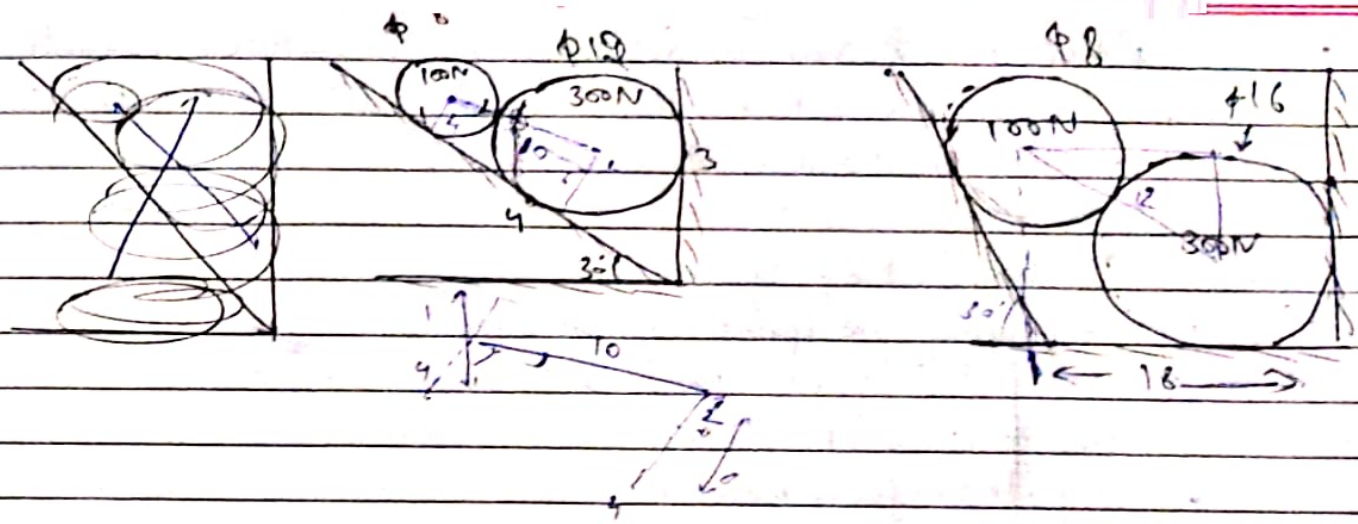
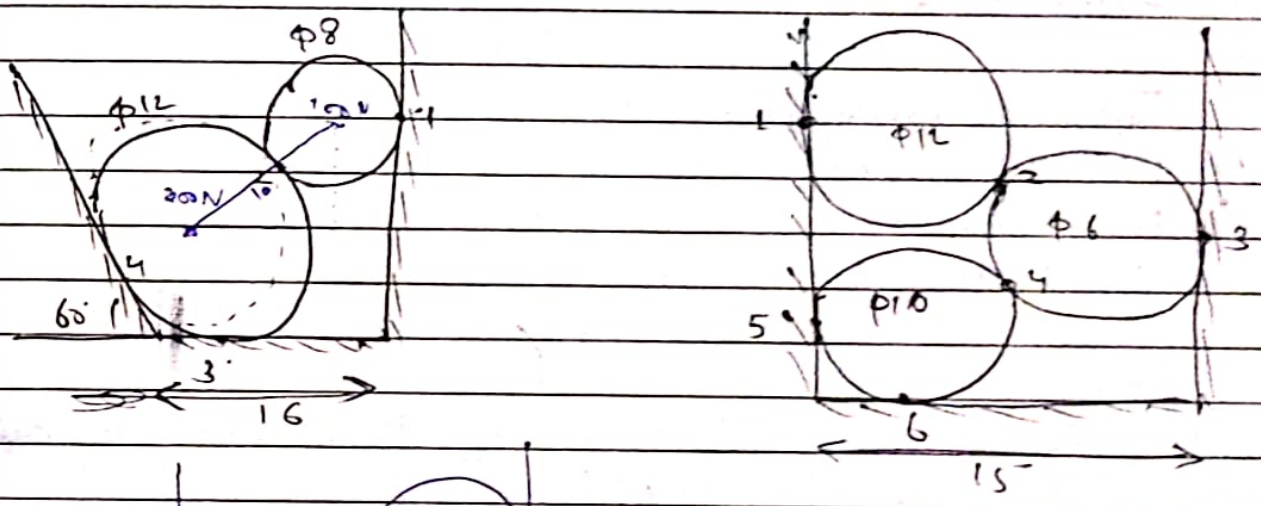
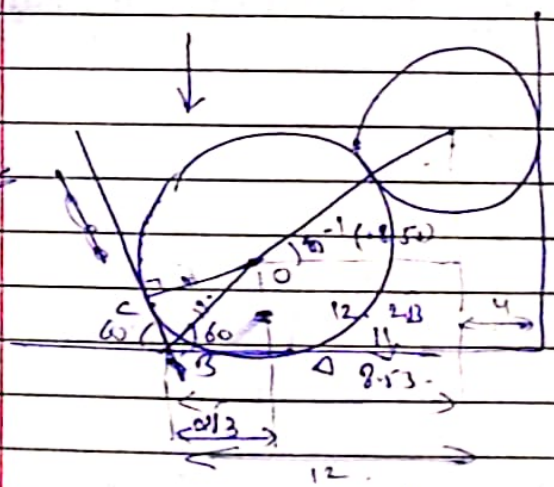
Q.



Q.



Sol



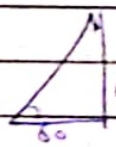
$\triangle OAB \sim \triangle OCB$

SDS:

$\tan 60 = \frac{6}{q}$

$q = \frac{6}{\tan 60}$

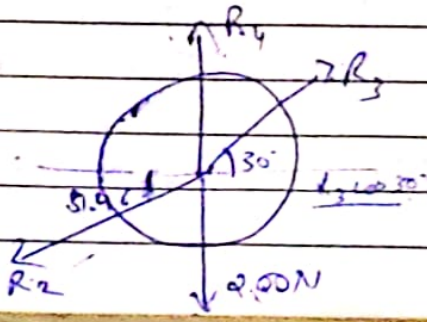
$= 2\sqrt{3}$

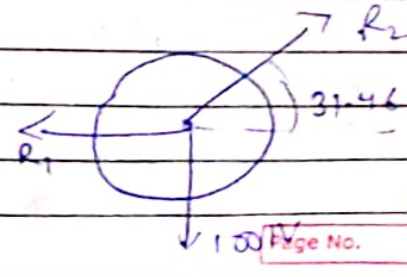


$R_4 = 204.80N$

$R_3 = 160.41N$

$R_2 = 103.44$





$R_2 = 191.58$

$R_1 = 113.44$

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Beam: Beam is define as structural member that is subjected to a load ⊥ar to its axis. or in Lateral Direction.

Classification of Beam:

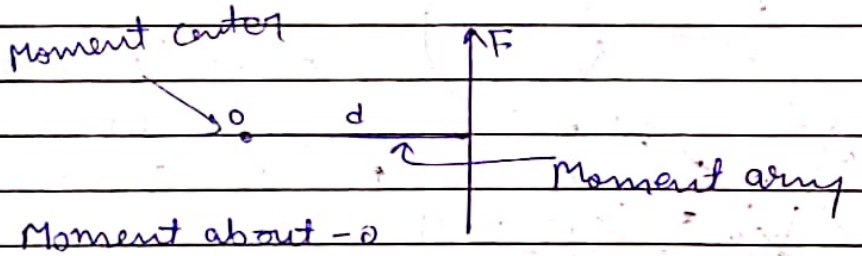
1) Simply supported Beam.
2) Cantilever beam.
3) Continuous Beam
4) Over Hanging Beam.
5) Fixed Beam.

Types of supports:

1) Roller Supports
2) Hinge support
3) Fixed support

Moment:

Measuring of Rotational effect produced by force. also Force ⨯ distance



Principal of Moment or Varignon's Theorem.

Moment of a resultant force is equal to the algebric sum of moments of individual forces forming a system about the same moment center.

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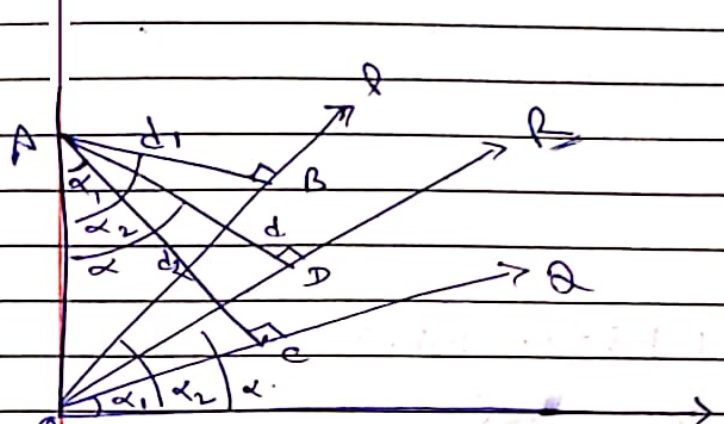
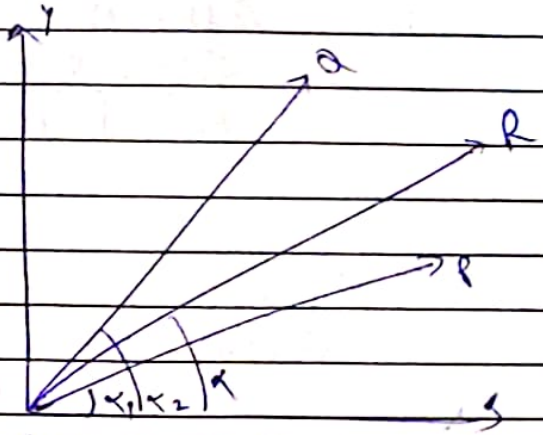
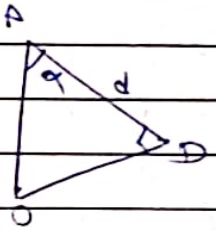




$R\cos\alpha \Rightarrow P\cos\alpha_1 + Q\cos\alpha_2$



$$\sum M_A = P \times d_1 + Q \times d_2$$
$$= P \times OA \cdot \cos\alpha_2 + Q \times OA \cdot \cos\alpha_1$$
$$= OA(P\cos\alpha_2 + Q\cos\alpha_1)$$
$$= OA \times R\cos\alpha$$
$$= R \cdot OA\cos\alpha$$
$$= R \times d$$

$$\boxed{R \times d = P \times d_1 + Q \times d_2}$$

R = Resultant.

P, Q = forming the co-planer, concurrent force system

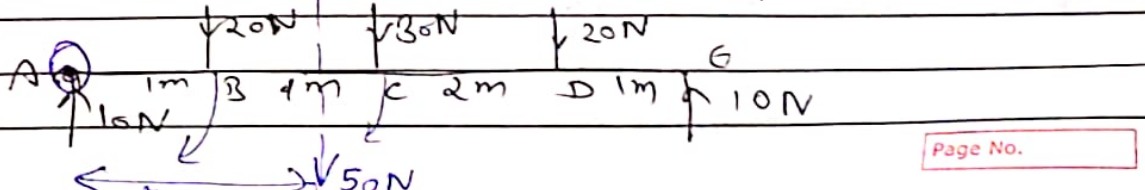
d, d_1, d_2 = moment Arms.

Moment - N×m unit

+ve ↺ -ve.

CW ACW.

Q. Calculate resultant & location of its resultant force.



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$\Sigma H = 0$

$\Sigma V = 50$

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

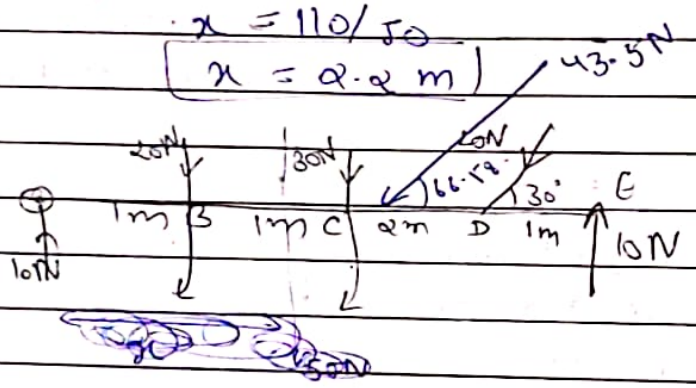
$= 50\,N \downarrow$

ΣM_A.

$50 \times x = 10 \times 0 + 20 \times 1 + 30 \times 2 + 20 \times 4 - 10 \times 7$

$x = 110/50$

$\boxed{x = 2.2\ m}$



$\Sigma H = -20 \cos 30 = -10\sqrt{3}$

$\Sigma V = -30 - 20 \sin 30 = -40$

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

$= \sqrt{1900}$

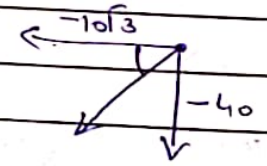
$= 43.5\ N.$

$\tan\theta = \dfrac{\Sigma V}{\Sigma H}$

$= \dfrac{-40}{-10\sqrt{3}}$

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

$\theta = 66.58°$



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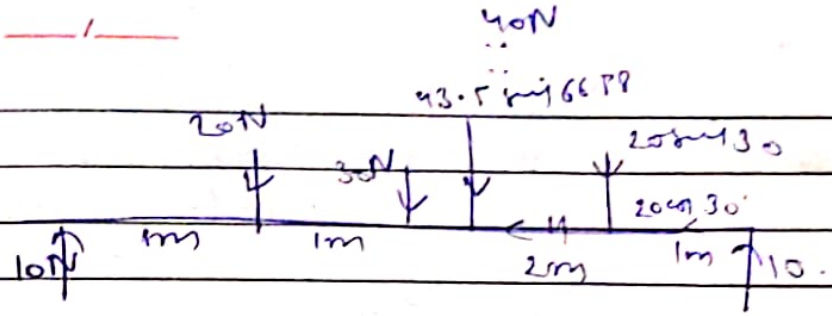
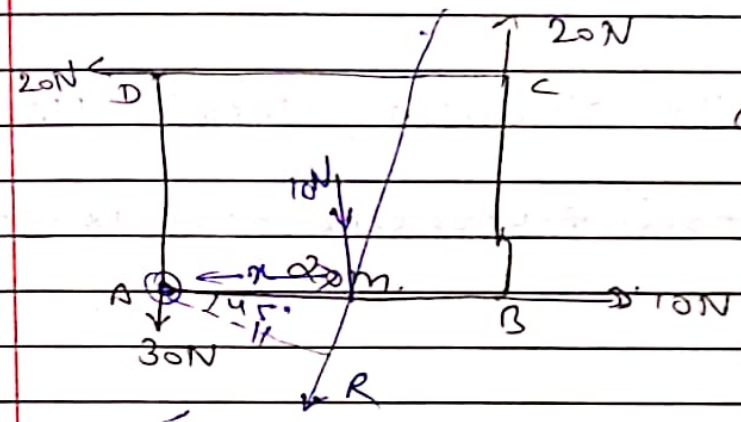


ΣM_A

$40 \times x = 10\times 0 + 20\times 1 + 30\times 2 + 20\sin 30 \times 4 - 10\times 1$

$x =$

Q



Calculate resultant forces & its location

$\Sigma H = 10 - 20 = -10N$

$\Sigma V = 20 - 30 = -10N$

$R = \sqrt{10^2 + 10^2} = 10\sqrt{2} = 14.14$

$\tan\alpha = \frac{-10}{-10} = 1$

$\boxed{\alpha = 45°}$

$\Sigma M_A = 30\times 0 + 10\times 0 - 20\times 20 - 20\times 20$

$10\times x = -800$ Nxm

$(x = -80m)$

Or

$R \times x \cos 45° = -800$

$10\sqrt{2} \times x \times \frac{1}{\sqrt{2}} = -800$

$(x = -80\ m)$

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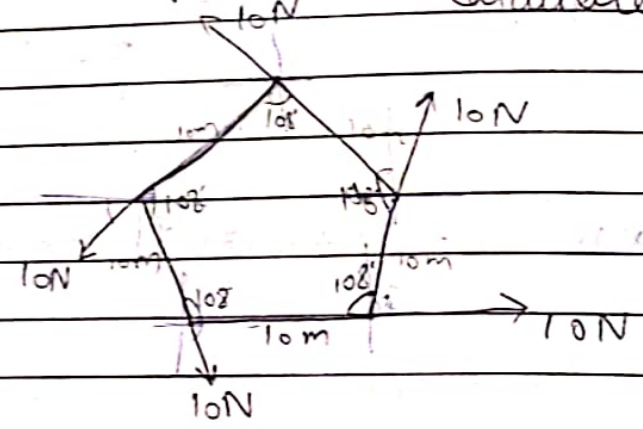
Q Regular pentagon x=10 m each side experience 10N. Calculate resultant location.



$\Sigma H = 10 + 10\cos 72° - 10\cos 72° - 10\cos 72° + 10\cos 72°$

$= 10$

~~$\Sigma V = -10\sin 18° + 10\sin 18° + 10\sin 18° - 10\sin 18°$~~

$= 3.09$

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