* Engineering Mechanics

It is defined as, that branch of physical science which deals about ~~resultant force~~ effect of resultant forces on bodies, both in rest & in motion condn.

classification of Mechanics

on the basis of

- **type of body**
  - **Rigid body** - It is simply assumption.
    1. After applying force on solid body, there will be no change in diamension or shape of the body.
    2. Rigid body does not exist in nature.
  - **Deformable body:-**
    1. After Applying force on solidy there will be change in diamension or shape of body
    2. e.g. any body of rubber.
  - **fluid body**
    1. The body which has tendency to flow
    2. It has no shape or size.
- **state of body**
  - **static**
    1. body is rest condn
  - **Dynamics**
    1. body is motion
    - (a) **kinematics**
      1. After applying force on body, disp., vel., accn of body takes place.
      2. Here force is causes of motion only.
      3. In Kinematics we consider only disp, velo & accn of the body
    - (b) **Kinetics**
      1. we consider velo, disp, accn & force also.

①

* Laws of Mechanics

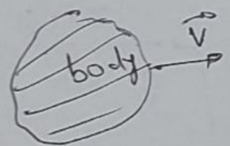
① Newton's first law of motion :- or laws of Inertia

Every body continues in its state of rest unless external force acts on it.

② Newton's second law :-

Rate of change of momentum (linear) is directly proportional to force applied on a body. & directⁿ of momentum takes place in the directⁿ of force applied.

m



linear momentum $(\vec{p}) = m\bar{v} = \vec{p}$

$$\frac{d\vec{p}}{dt} = m\frac{d\vec{v}}{dt} + \bar{v}\frac{dm}{dt}$$ - change in momentum.

$$\vec{F} = \frac{d\bar{p}}{dt}$$

$$\boxed{\therefore \ \bar{F} = m\frac{d\bar{v}}{dt} + \vec{v}\frac{dm}{dt}}$$ General eqⁿ of force accⁿᵈ 2ⁿᵈ law.

Case-I :- If m = const.

$$\vec{F} = m\frac{d\vec{v}}{dt} + \bar{v}\cancel{\frac{dm}{dt}}^{0}$$

$$\bar{F} = m\frac{d\bar{v}}{dt} = m\vec{a}$$ $\vec{a}$ = accⁿ of centre of mass of body

$F = ma$ (only in magnitude) - for single force.

$\boxed{\Sigma F_{net} = ma}$ → for multiple force.

If you want see the effect directⁿ of force applied such as (x, + tangential)

$$\left.\begin{aligned} \Sigma F_x &= ma_x \\ \Sigma F_y &= ma_y \\ \Sigma F_t &= ma_t \\ \Sigma F_{radial} &= ma_r \end{aligned}\right\}$$ we will apply all these eqⁿ in dynamics.

Case II – If $\vec{v}$ = const.

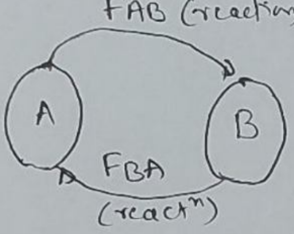
$$\vec{F} = m\frac{d\vec{v}}{dt} + v\frac{dm}{dt}$$

$$\boxed{\therefore \bar{F} = \vec{v}\frac{dm}{dt}}$$

if velo. is const. which is useful in fluid mechanics.

(3) Newton's third law of motion:-

To every action there is an equal & opposite reaction

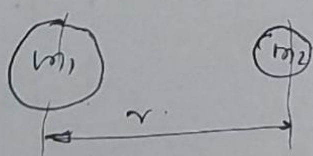


- If body A is applied force on body (ie FAB) (action)
- Then there will be ~~a~~ reaction force (FBA) applied by body B on body A in opposite directn.

$$F_{AB} = -F_{BA}$$

* Newton's law of gravitation:-

The force of attraction betn any two bodies in the universe is directly proportional to the product of their masses & inversly proportional to square of the distance betn them.



$$F \propto \frac{m_1 m_2}{r^2}$$

$$\boxed{F = G \cdot \frac{m_1 m_2}{r^2}}$$

G - Universal gravitional const.
$= 6.673 \times 10^{-11}\ Nm^2/kg^2$.

* Force System

<u>force</u> :- The external energy req^d to move the body from one place to other is called as force.

OR

The external energy ~~reqd~~ which tends to change the state of rest or of uniform motion is called as force.

($\vec{F}$) Force is vector quantity (magnitude & direct^n)

<u>unit</u> — SI — N

MKS — KgF (kilogram force)

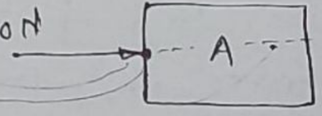
CGS — Dyne.

1 Kgf = 9.81 N.

1 N = 10^5 dyne.

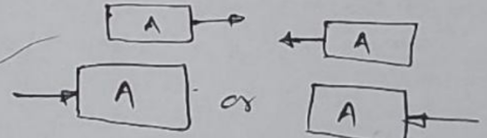
characteristic of force

1. Magnitude.
2. Direction
3. pt. of application
4. line of action.

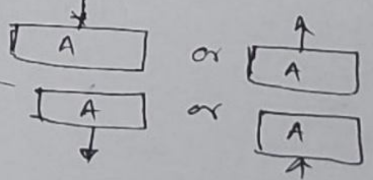


Types of forces

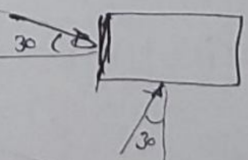
- Horizontal force.



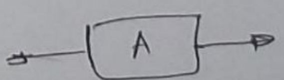
- vertical force



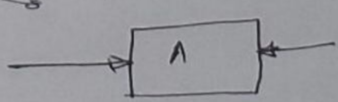
- inclined force



- tensile force



- compressive force



Force system:- It is the group two or more than two forces.

Force system types

Coplanner forces
1. collinear
2. concurrent.
3. Non concurrent
4. Parallel → like, unlike.

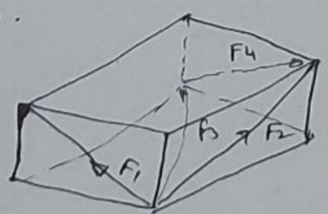
Non coplanner forces.
- (A) concurrent
- (B) Non concurrent
- (C) parallel.

~~Coplanner~~

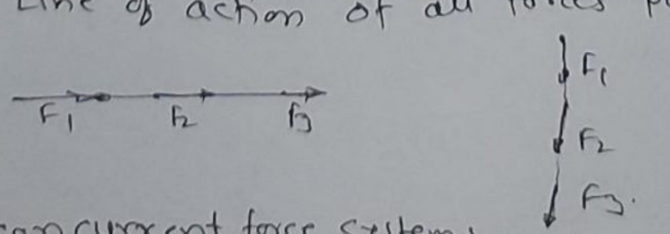
~~(1) Collinear~~ —

Coplanner force system:-
when all the forces lie in a single plane that force system is called as Coplanner force system.

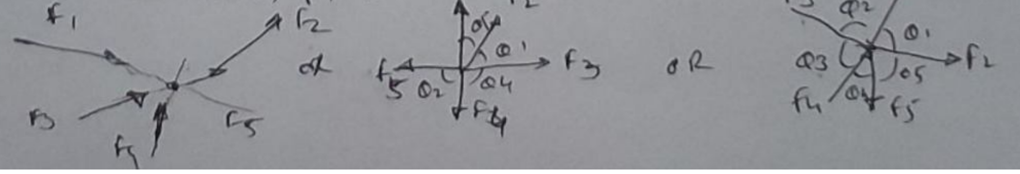
Non coplanner force system
when all the forces lie in different plane then that force system is called as non-coplanner force system.



* **Collinear Force system:-**
Line of action of all forces passes thro' single line

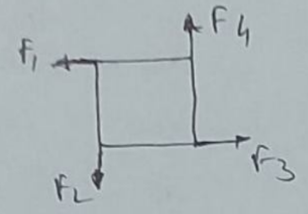


* **Concurrent force system:-**
Line of action of all forces are passes or meet at common pt.



* Non concurrent force system :-

when all the forces or line of action of all forces passing thro' different pt. then the force system is called non-concurrent force system.



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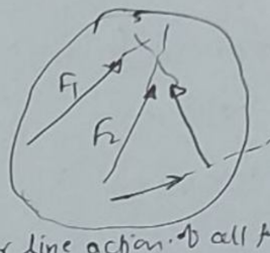

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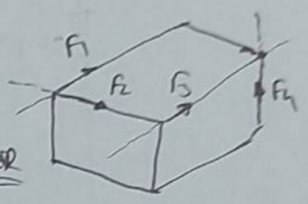
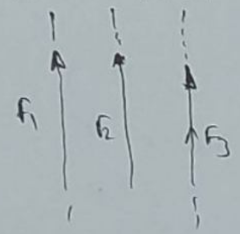


* Parallel force system :-

when all the forces or line action of all forces are parallel to each other then that force system is called parallel force system



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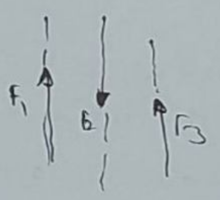

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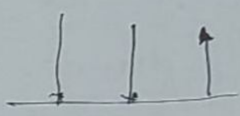
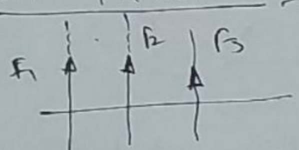
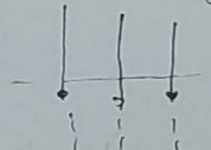


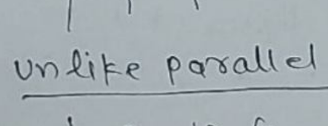
like parallel :-



F1 F2 F3.



unlike parallel - parallel to each other but opposite in directn.



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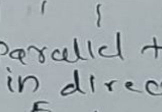
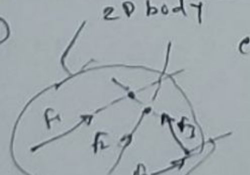


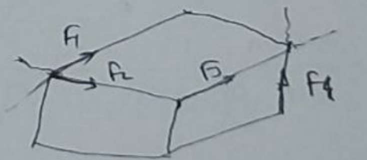
Some of force system :-

① 2D body

coplanner Non current F.S.

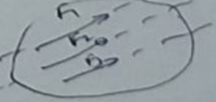


②



Non-Coplanner Non current F-S.

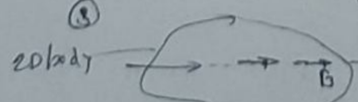
④



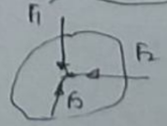
Coplanner Parallel

③ coplanner collinear.

2D body



⑥

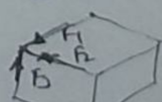


coplanner concurrent

⑤

Non coplanner Parallel

⑦

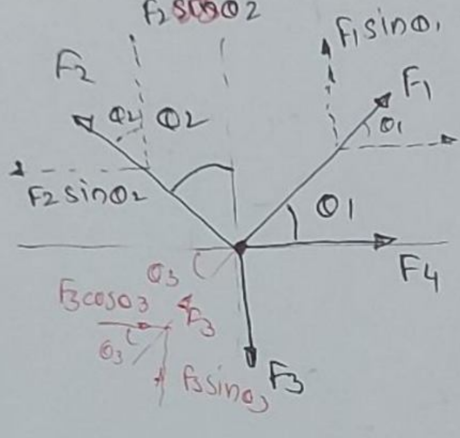


Non coplanner ~~curr~~ concurrent

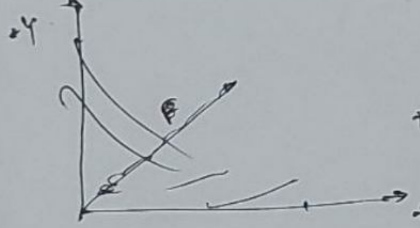
* Resolution of forces :-

→ It is process of resolving the given concurrent forces into number of components without changing its effect on a body.

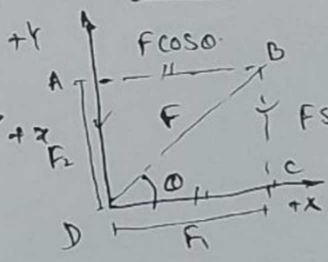
→ A force is resolved in two mutually ⊥ler direction or in two rectangular components.



Let F is force resolve into two component say F_1 (x-axis) & F_2 - (y-axis) & F lies in I^{st} quadrant.



Case I -

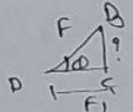


① plot F_1 & F_2 along x & y respectivly

② draw adjacent of F_1 & F_2 to form Parallogram or rectangle

③ draw diagonal (DB) which represent the magnitude of Resultant (F)

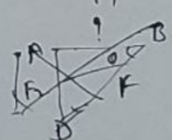
④ F is making angle θ with x-axis.

⑤ 

$\frac{BC}{BF} = \sin\theta$.

$BC = F\sin\theta$.

$BC = F_2 = F\sin\theta = AD$

⑥ 

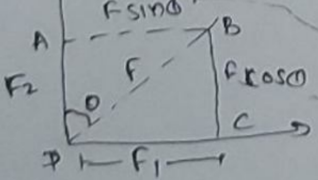
~~AB/ABF = cos θ~~ ΔBDC $\cos\theta = \frac{DC}{F}$

$DC = F\cos\theta$

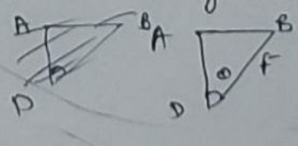
~~AB = Fcos θ~~. $= F_1$

~~AB = AD Fcos θ = CD~~ → F_1

case II :-



① F making an angle θ with y-axis

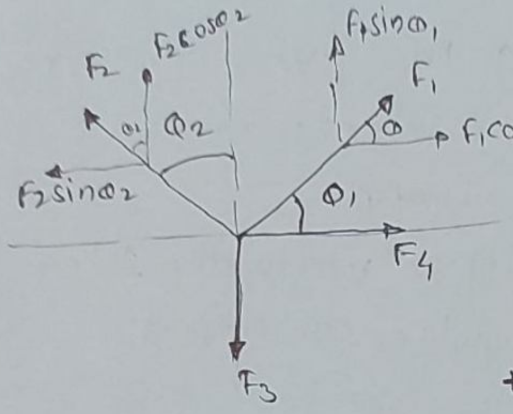


$\sin\theta = \frac{AB}{F}$

$\therefore AB = F\sin\theta = DC = F_1$

$\cos\theta = \frac{AD}{F}$

$AD = F\cos\theta = F_2$



Find R.

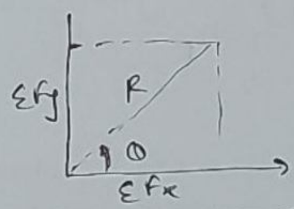
ΣF_x resultant force in x-direcⁿ

$$+F_1\cos\theta_1 - F_2\sin\theta_2 - F_4 = \Sigma F_x$$

ΣF_y - resultant force in y-direcⁿ

$$+F_1\sin\theta_1 + F_2\cos\theta_2 - F_3 = \Sigma F_y$$

* if $\Sigma F_x = +ve$
$\Sigma F_y = +ve$ } I^{st} quad

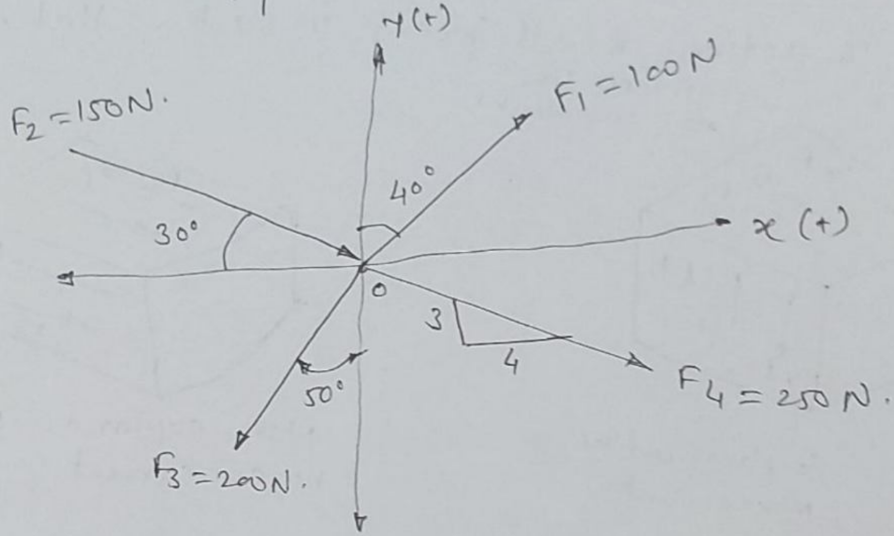


$$R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$$

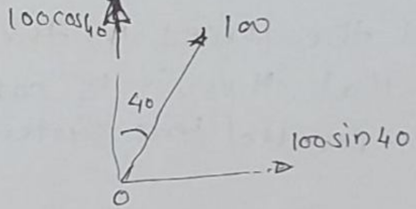
$$\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right)$$

<u>Case II</u> *

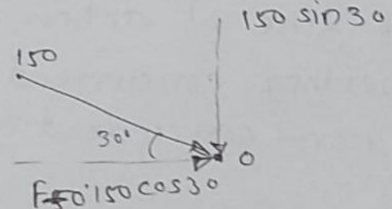
* (a) Det. the x & y component of force. (b) Σf_x (c) Σf_y



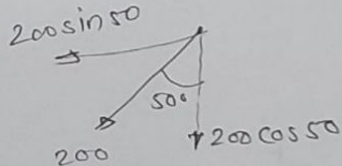
* Force F_1



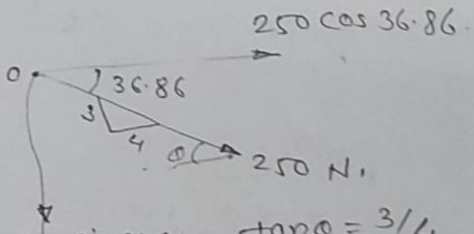
* Force F_2



* Force F_3



* Force F_4



$\tan\theta = 3/4$

$\tan\theta = 0.75$

$\theta = 36.86.$

$\xleftarrow{-ve}\ \xrightarrow{+ve}$

$\Sigma f_x = f_1 + f_2 + f_3 + f_4$

$= 100\sin 40 + 150\cos 30 - 200\sin 50 + 250\cos 36.86.$

$= 240.97\,N\ (\rightarrow)$

$-ve \downarrow \ \uparrow +ve$

$\Sigma f_y = f_1 + f_2 + f_3 + f_4$

$= 100\cos 40 - 150\sin 30 - 200\cos 50 - 250\sin 36.86.$

$\Sigma f_y = -276.95\,N.$

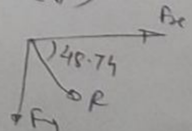
$= 276.95\,N\ (\downarrow)$

$R = \sqrt{\Sigma f_x^2 + \Sigma f_y^2}$

$R = 76.942\,N.$

$\theta = \tan^{-1}\dfrac{\Sigma f_y}{\Sigma f_x}.$

$\theta = 48.74.$



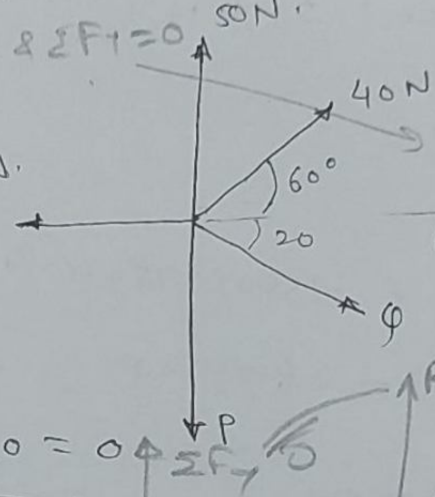
Jan. 10

(8)

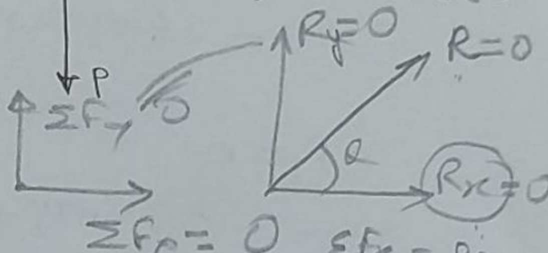
* Find the forces P & Q such that the resultant of the five forces is zero.

→ if R is zero ∴ ΣF_x & $\Sigma F_y = 0$

(1)



$R_y = R\sin\theta$. R_y is component of R in y dir. R_x is component of R in x dir. $R_x = R\cos\theta$



$\Sigma F_x = 0$

$40\cos 60 + Q\cos 20 - 30 = 0$

$$\boxed{Q = 10.642\ N.}$$

$\Sigma F_x = R_x = R\cos\theta$ ∴ if R = 0 ∴ $\Sigma F_x = 0$

$\Sigma F_y = 0$

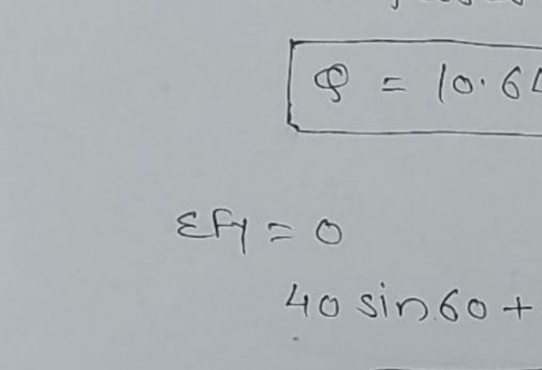
$40\sin 60 + 50 - Q\sin 20 - P = 0$

$$\boxed{P = 81\ N.}$$

$\Sigma F_y = R_y = R\sin\theta$, if R = 0, $\Sigma F_y = R\sin\theta = 0$

Resultant force acting is zero. therefore Resultant force acting will not act along x & y direction.

∴ $\Sigma F_x = 0$, $\Sigma F_y = 0$ if Resultant is zero

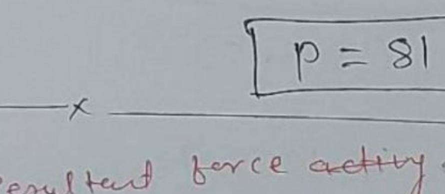


↻ +ve ↺ -ve

Find moment @ A.

① $M_A^{P_1} = 20 \times 5 = -100$ Nm (↻)

② $M_A^{P_2} = 60 \times 3 = +180$ Nm (↺)

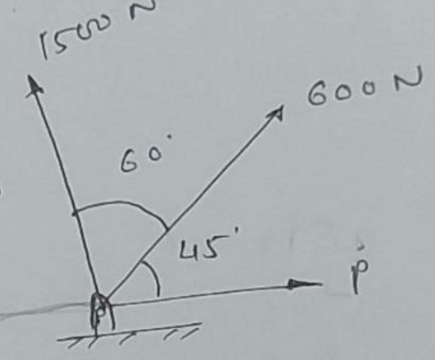


③ $M_A^{P_3} = -50\sin 30 + 50\cos 30$

④ $M_A^{P_4} = 0$ P_4 passes thro' A, no ⊥lar dist.

* Det. the range of values for magnitude P so that the magnitude of the resultant force doesn't exceed 2500 N.

→



$\Sigma F_x = -1500\cos 75 + 600\cos 45 + P$

$= 36.035 + P$ — (1)

$\Sigma F_y = \cancel{0}$

$= 1500\sin 75 + 600\sin 45$

$\Sigma F_y = 1873.15$ — (2)

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

$$(2500)^2 = \sqrt{(36.035+P)^2 + (1873.15)^2}$$

$$(36.035 + P) = \pm 1655.7$$

$$P = 1655.7 - 36.035 \text{ or } -1655.7 - 36.035$$

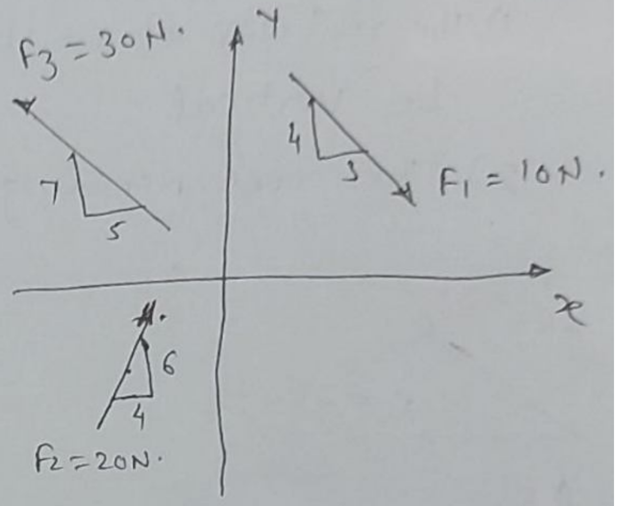
$$P = 1619.7\ N \text{ or } -1684.04\ N.$$

P lies betn -1684 & 1619 the resultant will be less than 2500 N. But -1684 N is directed towards left. As the directn shown towards right, the minm value of P will be zero.

$$0 \leq P \leq 1619.7\ N.$$

* ① Find x & y component of forces : ⑦ ⑧

ⓑ ΣF_x ⓒ ΣF_y = ?



$\theta_1 = \tan^{-1} 4/3$

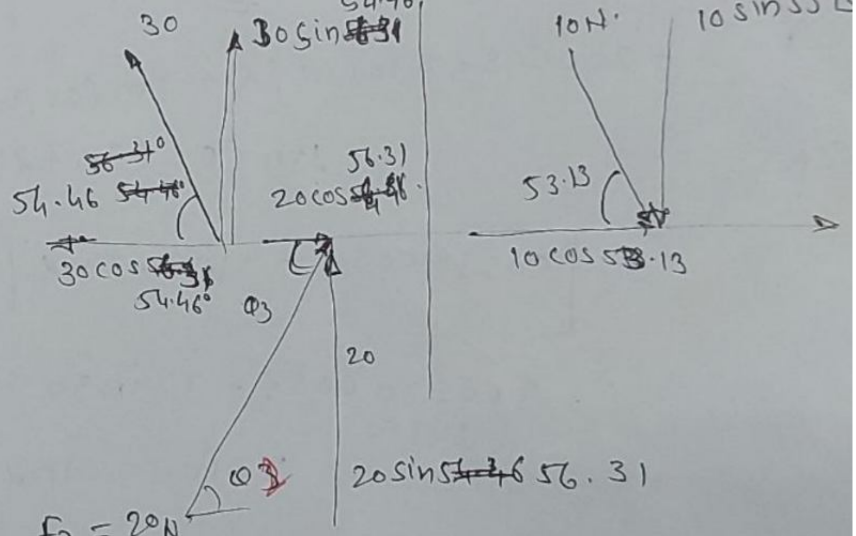
$\theta_1 = 53.13$

$\theta_2 = \tan^{-1}(6/4)$

$\theta_2 = 56.31°$

$\theta_3 = \tan^{-1}(7/5)$

$\theta_3 = 54.46°$



$\Sigma F_x = 10\cos 53.13 - 30\cos 54.46 + 20\cos 56.31$

$= 6 - 17.44 + 11.09$

$= -0.35\ N$

$= 0.35\ N\ (\leftarrow)$

$\Sigma F_y = -10\sin 53.13 + 20\sin 56.31 + 30\sin 54.46$

$= -8 + 16.64 + 24.41$

$= 33.05\ N\ (\uparrow)$

Dec - 08

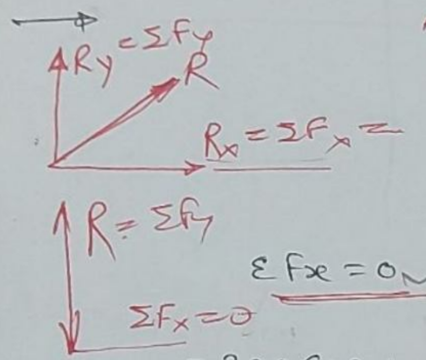
* Determine

1) The req^d value of α if resultant of three forces is to be vertical.

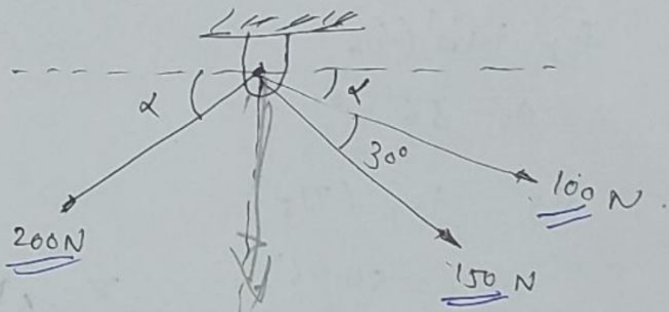
2) The corresponding magnitude of resultant.

① if resultant is vertical then (3)

$\Sigma F_x = 0$ & $\Sigma F_y = R$.



$\uparrow R$



$\Sigma Fx = 0$

$$-200\cos\alpha + 100\cos\alpha + 150\cos(30+\alpha) = 0$$

$R = \Sigma F_y =$

$$\frac{150}{3}\cos(30+\alpha) = \frac{100}{2}\cos\alpha.$$

$$3\left[\cos 30\cos\alpha - \sin 30 \sin\alpha\right] = 2\cos\alpha.$$

$$\underbrace{3\cos 30\cos\alpha}_{2.59\cos\alpha} - 3\sin 30 \sin\alpha = 2\cos\alpha$$

$$3\sin 30 \sin\alpha = (-2\cos\alpha + 2.59\cos\alpha)$$

$$1.5\sin\alpha = 0.59\cos\alpha.$$

Resultant may be vertical upward or downward

~~$\Sigma F_y = R$~~

if R comes +ve ↑ (vertically upward), −ve ↓ (down)

$$\tan\alpha = 0.393$$

$$\boxed{\alpha = 21.74°}$$

~~$\Sigma F_y = \uparrow R$~~

Hence R is downward direct.

$$\Sigma F_y = -200\sin\alpha - 150\sin(30+\alpha) - 100\sin\alpha = \cancel{R} \; -228.9\text{ N}$$

$\therefore$ We know

$\Sigma F_y = R$

$\therefore R = -228.9$

$$\boxed{R = 228.9 \text{ N}}$$

~~case~~

$\sin 30$

$$\boxed{\Sigma F_y = R}$$

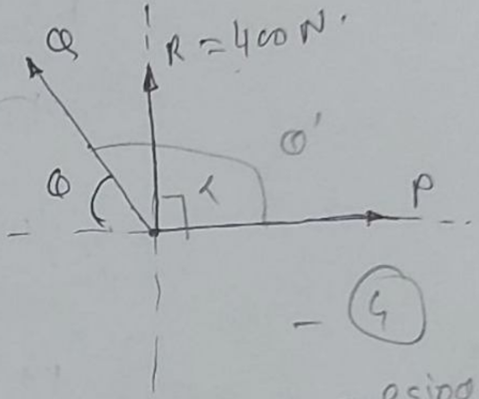
$\Sigma F_y =$

150 / 181+2α = (360 f2α − 210)

because ① system is not in eq^m due to Resultant is vertical due to Reac^n at hinge

② two Reac^n at hinge means total forces on system will be +ive.

* The sum of two concurrent P & Q is 500 N & their resultant is 400 N. If the resultant is ⊥ler to P. find P, Q & angle betn P & Q.



$\Sigma F_x = 0$

$P - Q\cos\theta = 0$

$\therefore \frac{P}{Q} = \cos\theta$ — ①

$\Sigma F_y = R_y \quad Q\sin\theta = 400$

$\cancel{Q\sin\theta = 400}$ — ②

$\Sigma F_y = R_y = R\sin\theta$

$P + Q = 500$ — ③ - Given

we know

$\cos\theta = \frac{P}{Q}$

$\sin^2\theta + \cos^2\theta = 1$

$\sin\theta = \sqrt{1 - \cos^2\theta}$

$\sin\theta = \sqrt{1 - P^2/Q^2}$ — ④

put $\sin\theta$ in eqn ②

$400 = \sqrt{1 - P^2/Q^2} \cdot Q$

$400^2 = (1 - P^2/Q^2)\, Q^2$

$Q^2 - P^2 = 400^2$

$(Q-P)(Q+P) = 1600$

$(Q-P)\, 500 = 1600$

$Q - P = 320$ — ④

Solving eqn ③ & ④

$Q = 90\text{ N}, \quad P = 410\text{ N}.$

$\cos\theta = \frac{P}{Q} = \frac{90}{410}$

$\boxed{\theta = 77.32^\circ}$

Angle betn P & Q
$= 180 - 77.32$
$= 102.68^\circ$

or — Parallelogram.

$P + Q = 500$ — Given. — (A)

$R = 400\,N$ & $\alpha = 90°$.

$$\tan\alpha = \frac{Q\sin\theta'}{P + Q\cos\theta'}$$

$$\tan 90 = \frac{Q\sin\theta'}{P + Q\cos\theta'}$$

$$\infty = \frac{Q\sin\theta'}{P + Q\cos\theta'}$$

$$\infty = \frac{1}{0} = \frac{Q\sin\theta}{P + Q\cos\theta}$$

$(P + Q\cos\theta) = 0 \times Q\sin$

$P + Q\cos\theta' = 0$

$\therefore Q\cos\theta' = -P$ — (C)

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

$400^2 = P^2 + Q^2 + 2P(-P)$

$400^2 = P^2 + Q^2 - 2P^2$

$= Q^2 - P^2$

$1600 = (Q+P)(Q-P)$

$1600 = 500\,(Q-P)$

$Q - P = 320$ — (B)

solving (A) & (B)

$P = 90\,N$

$Q = 410\,N$.

$\therefore Q\cos\theta' = -P$

$410\cos\theta' = -90$

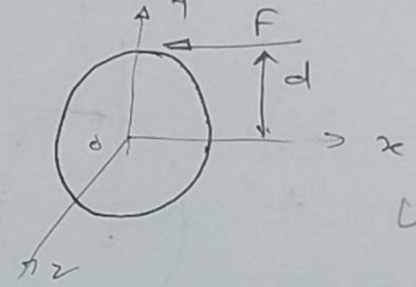
$\cos\theta' = -0.219$

$$\boxed{\theta' = 102.65°}$$

* moment of force :-

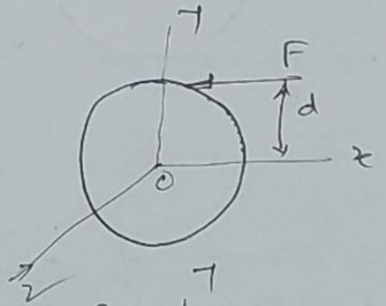
The rotational effect produced by force is known as moment of force. (i.e. Force × ⊥lar dist.)

$M_0 = F \times d$



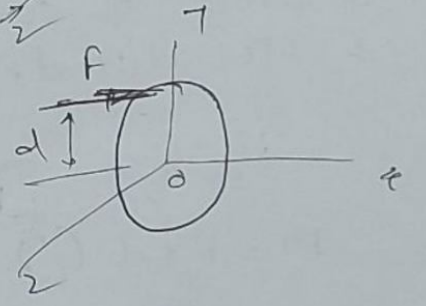
sign convention

1.



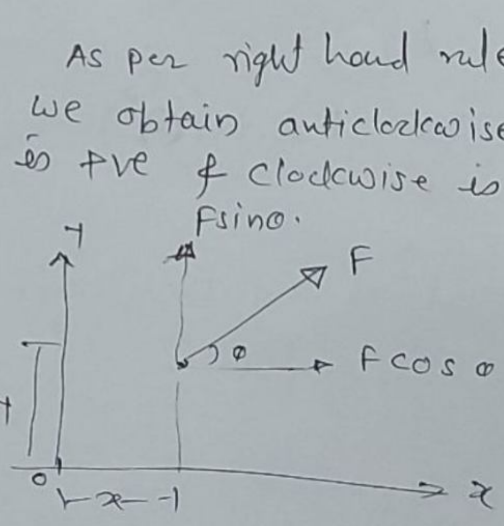
$M_o = F \times d$ (↺) (+ve)

2.



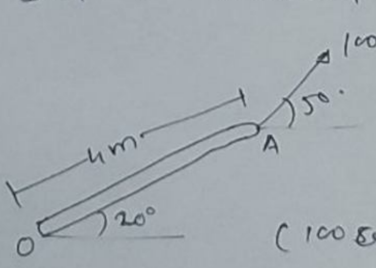
$M_o = -F \times d$ (↻) (-ve)

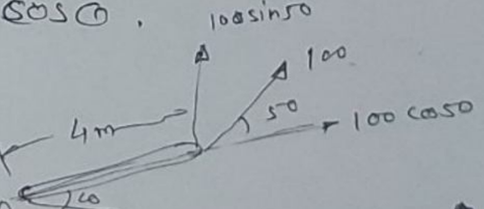
As per right hand rule we obtain anticlockwise moment is +ve & clockwise is +ve.



$M_o = x \times F\sin\theta - y F\cos\theta$.

* Det. the moment.



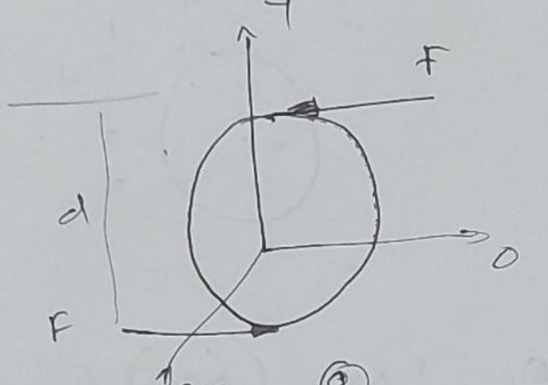


$M_o = 4 \times 100 \sin 50 = 200$ Nm ↻

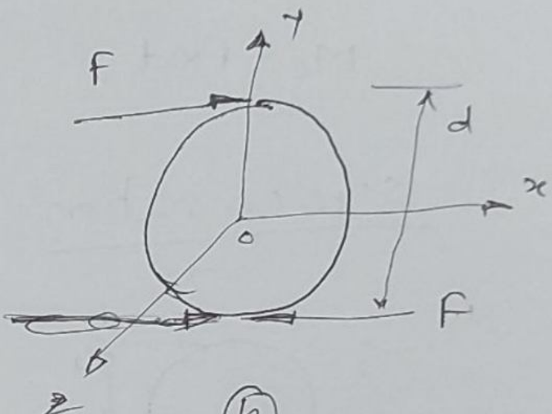
$(100\cos 50)$ line of action of component parallel to the rod passes thro' o

* couple :-

Two non collinear forces of equal magni. & in oppsite directⁿ forms a couple.



(a)



(b)

moment of couple - is the prodt of common magnitude of two force F & their dist. d.

fig. a

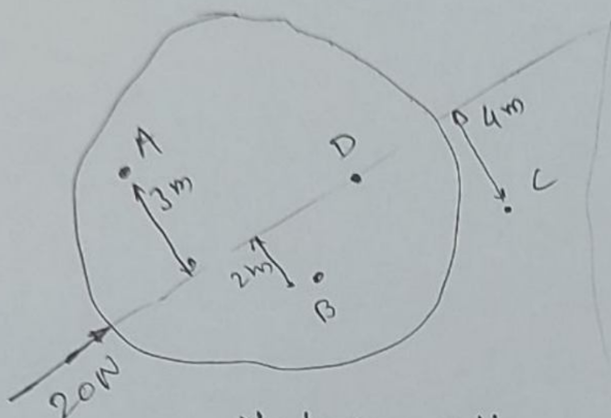
$M = F \times d$ ( )

fig. b

$M = F \times d$ ( )

* Moment is static force & torque is movement force.

① Find the moment at different points.



$\Sigma M_A = 20 \times 3 = 60\ Nm$

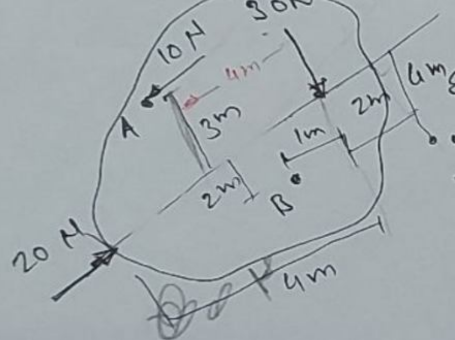
$M_B = -20 \times 2 = -40\ Nm$

$M_C = -20 \times 4 = -80\ Nm$

$M_D = 20 \times 0 = 0\ N \cdot m$ No sense.

Note :- When we take moment of force at different points, its magnitude & sense of rotation also different.

②



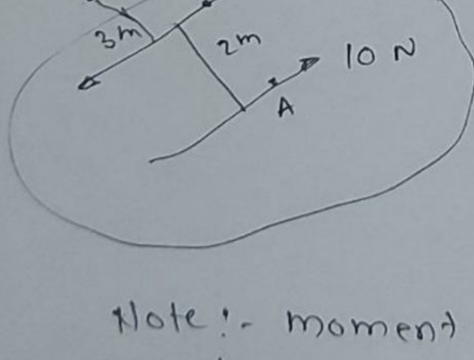
$\Sigma M_A = 10 \times 0 + 20 \times 3 - 30 \times 4 = -60\ Nm$

$\Sigma M_B = -20 \times 2 + 10 \times 5 - 30 \times 1 = -20\ Nm$

$\Sigma M_C = +20 \times 4 + 10 \times 7 + 30 \times 2 = +50\ Nm$

③ find moment of couple.

Rigid body



anticlockwise

$\Sigma M_A = 10 \times 0 + 10 \times 2 = 20\ Nm$

$\Sigma M_B = 10 \times 0 + 10 \times 2 = 20\ Nm$

$\Sigma M_C = -10 \times 3 + 10 \times 5 = 20\ Nm$

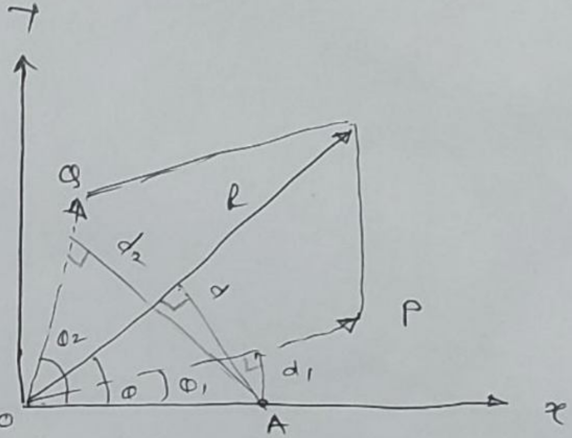
Note :- moment of couple at different pts would be same in magnitude as well as in sense of direction.

(11) (4)

* Varignon's Theorem:-

It states that the moment of resultant of all the forces in a plane @ any pt. is equal to the algebric sum of moment of all the forces @ the same pt.

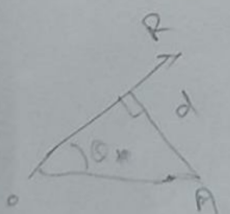
$$R \times d = P \times d_1 + Q \times d_2$$



since R is resultant of P & Q. it follows that the sum $P_Y + Q_Y$ of Y-component of two forces P & Q is equal to Y component R_Y of their resultant R.

i.e. $R_Y = P_Y + Q_Y$ - (1) $\quad \Sigma F_y = R_y$

$R_Y = R\sin\theta$, $P_Y = P\sin\theta_1$, $Q_Y = Q\sin\theta_2$



$R\sin\theta = P\sin\theta_1 + Q\sin\theta_2$

Multiply by length OA.

$R \times OA\sin\theta = P \times OA\sin\theta_1 + Q \times OA\sin\theta_2$

$OA\sin\theta_1 = d_1$, $OA\sin\theta_2 = d_2$

But $OA\sin\theta = d$

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

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

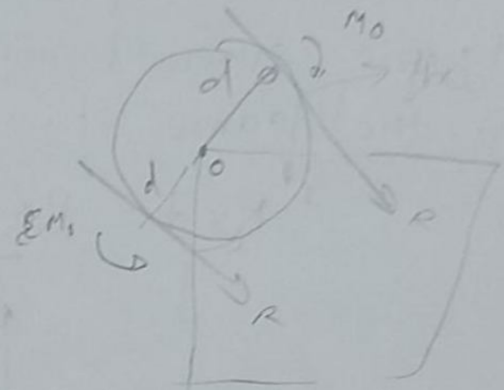
$|\Sigma M| = R \times d$

$\{\Sigma M\} = \Sigma F_y \times x$

$\{\Sigma M\} = \Sigma F_x \times y$

To Locate resultant at any pt

- see ΣM, if +ve

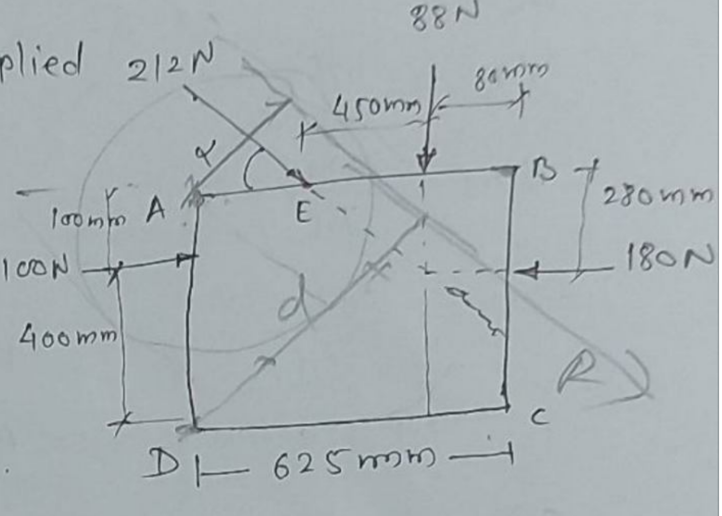


(12)

* A Rectangular block is subjected to forces as shown in fig.

(a) Det. resultant of applied forces.

(b) Locate two pts. where line of action of resultant intersects the edge of the block.

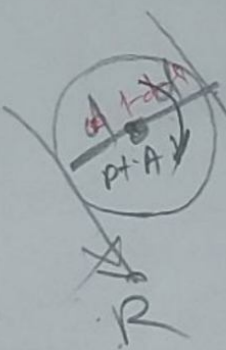


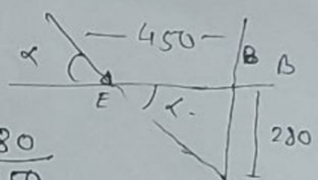
$\rightarrow$

$AE = AB - EB$

$= 625 - (450 + 80)$

$AE = 95\ mm$





$\tan\alpha = \frac{280}{450}$

$\alpha = 31.89°$

$\Sigma fx = -180 + 100 + 212\cos 31.89$

$\approx 100\ N$

$= +99.825\ N\ (\rightarrow)$

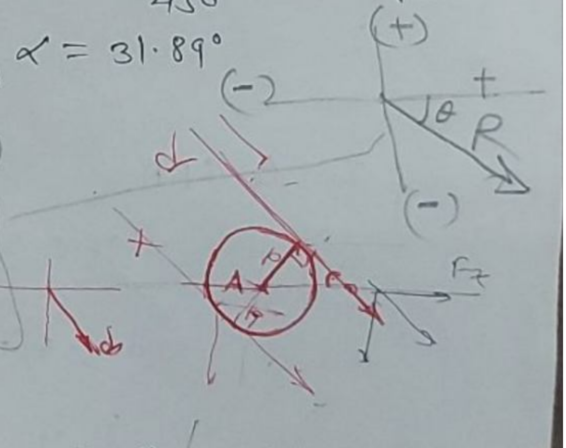
$\Sigma fy = -212\sin 31.89 - 88$

$= -199\ N$

$= \cancel{+199\ N} = 199\ N\ (\downarrow)$

$R = \sqrt{(\Sigma fx)^2 + (\Sigma fy)^2}$

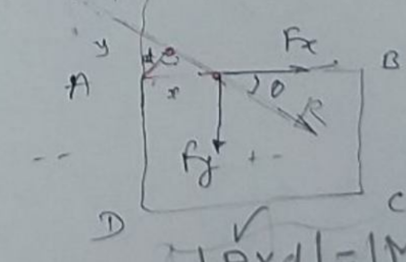
$R = 223.53\ N$



$\Sigma M_A = \pm$

$\tan\theta = \frac{\Sigma fy}{\Sigma fx}$

$\theta = 63.67$



(1) $\Sigma MA = -98999.76\ Nm$

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

$R \times d = 98999.76$

$d = 0.442\ m$

Varignon's thm @ pt. A.

$+100 \times 100 - 212\sin 31.89 \times 95 - 88 \times (480 + 95) - 180 \times 280 = R \times d$

$|\Sigma M| = Rd$

d - +ve

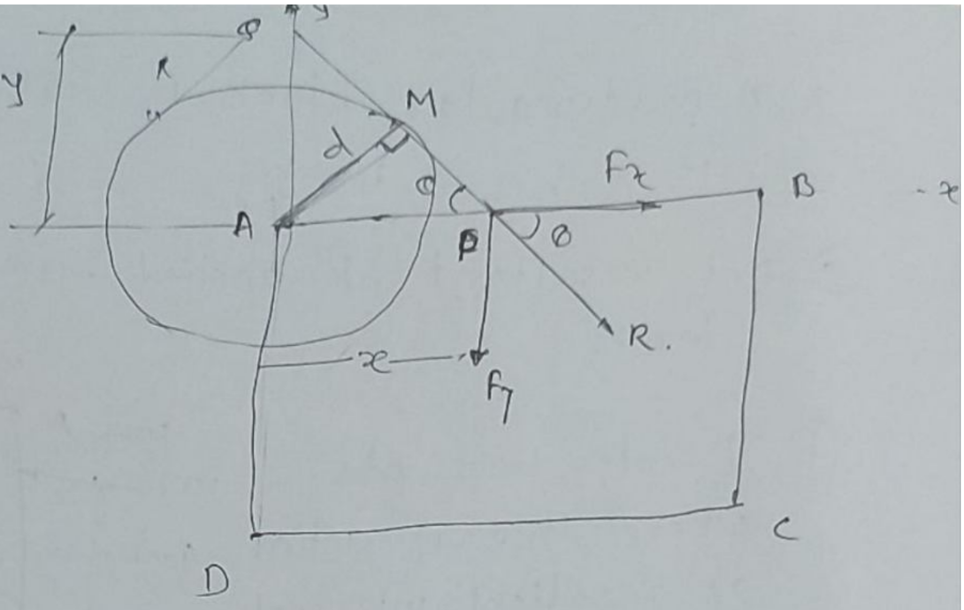
$R d = \underbrace{-98999.76}_{\Sigma Ma}\ N \cdot mm$

$223 \times d = 99\ N \cdot m$

$\boxed{|R \times d| = |M_A|}$

$\Rightarrow d =$

$\boxed{\therefore d = 0.442\ m\ \text{from}\ A}$



Δ AMP

$\angle P = 63.47^\circ$

$$\sin\theta = \frac{AM}{AP}$$

$$\sin 63.47^\circ = \frac{0.442}{AP}$$

$AP = 0.495$ m from A.

or

Applying varignon thm

$$\Sigma M = \Sigma F_y \times x$$

$$99 = 200 \times x$$

$x = 0.495$ From A.

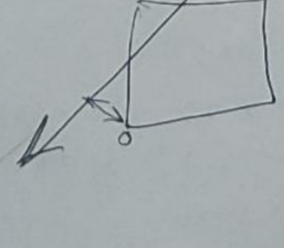
In Δ QPA

$$\tan\theta = \frac{QA}{AP}$$

$$\tan 63.47^\circ = \frac{y}{x}$$

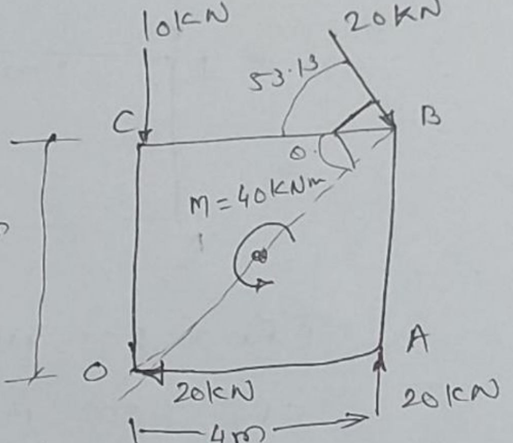
$$\boxed{y = 0.991 \text{ m from A.}}$$

$\Sigma m = 20 \circlearrowleft$



Dec. 10 (13)

* Find the resultant force system acting on body OABC, shown in fig. Also find the pts. where the resultant will cut x & y axis. What is the dist. of resultant from O?



$$OB = \sqrt{3^2+4^2} = 5m$$

ΔOBC

$\tan\theta = 3/4$

$\theta = 36.87$

$\therefore$ The angle made by 20kN with hori $= 90 - \theta = 53.13°$

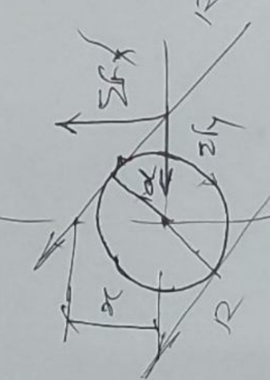
$|\Sigma M| = |R \times d|$

$d =$

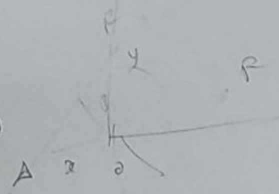
$$\Sigma F_x = -20 + 20\cos 53.13$$
$$= -8kN = 8kN (\leftarrow)$$

$$\Sigma F_y = -10 + 20 - 20\sin 53.13$$
$$= -6kN = 6kN (\downarrow)$$

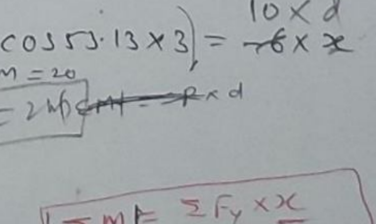
$$R = \sqrt{\Sigma F_x^2 + \Sigma F_y^2} = 10kN.$$



$$\theta = \tan^{-1}\frac{\Sigma F_y}{\Sigma F_x}$$



$$\theta = 36.87$$



using varignon's thm at O

$\cancel{20\times4 - 20\times5 + 40 = 6\times x}$ R

(+ve) (-ve) $\cancel{x = 3.33m}$.

or $\Sigma M = \Sigma R \times d$

$$\left(20\times4 + 40 - 20\sin 53.13\times4 - 20\cos 53.13\times3\right) = \cancel{6}\times x \quad \frac{10\times d}{}$$

$\Sigma M = 20$

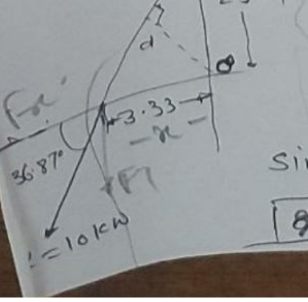
$\boxed{x = \cancel{3.33}\ 3.33\ m}$ $\boxed{d = 2m}$ $\cancel{\Sigma M = R\times d}$

$$\tan 36.87 = \frac{y}{3.33}$$

$\boxed{y = 2.5m}$

$\sin 36.87 = \frac{d}{\cancel{3.33}\,x}$

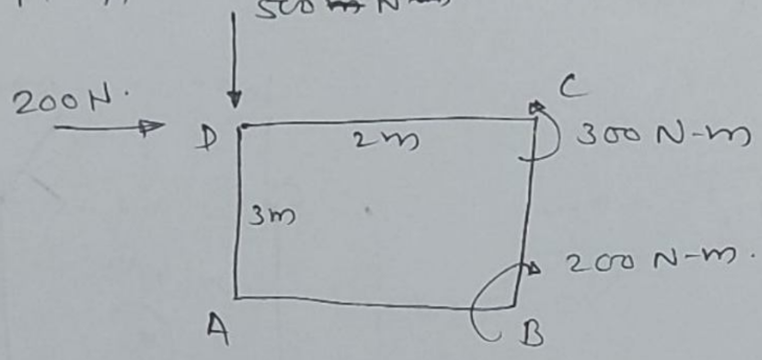
$\boxed{\cancel{x} = \cancel{2m}}$ 3.33



$$\Sigma M_o = \Sigma F_y \times x$$
$$\Sigma M_o = \Sigma F_x \times y$$

May 2010

* For the fig. shown. find resultant force & moment at . pt . A



$\Sigma F_x = 200\ N. (\rightarrow)$

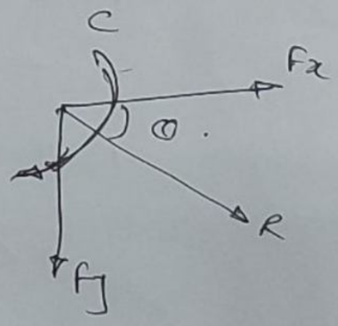
$\Sigma F_y = -500\ N$

$= 500\ N (\downarrow)$

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

$= \sqrt{400 + 250000}$

$R = 538.52\ N.$



$\tan\theta = \frac{\Sigma F_y}{\Sigma F_x}$

$\theta = 68.2^\circ$

$\Sigma M_A = +300 - 200 - 200 \times 3$

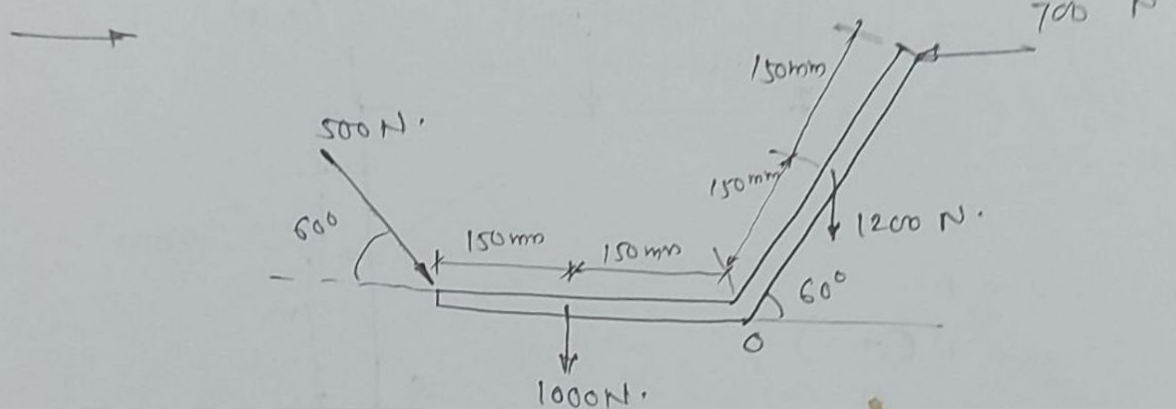
$= -500\ N.m$

$= 500\ Nm$

Dec. 08

(14)

* A system of forces acting on a bell crank as shown in fig. Determine magnitude, directⁿ & pt. of applⁿ of resultant w.r.t. 'o'



$\Sigma f_x = 500\cos 60 - 700 = -450\ N$

$\Sigma f_x = 450\ N\ (\leftarrow)$

$\Sigma f_y = -500\sin 60 - 1000 - 1200$

$= -2633.013\ N$

$= 2633.013\ N\ (\downarrow)$

$R = \sqrt{(\Sigma f_x)^2 + (\Sigma f_y)^2} = 2671.2\ N.$

$\theta = \tan^{-1}\dfrac{\Sigma f_y}{\Sigma f_x} = 80.3^\circ$ (+ve) -ve.

Using varignon's thm

$\Sigma M_O = 1000\times150 + 500\sin30\times300 - 1200\times150\cos60 + 700\times300\sin60$

ΣM +ve. ~~= 2671.2 × d~~.

$\Sigma M = +371831$ (struck out)

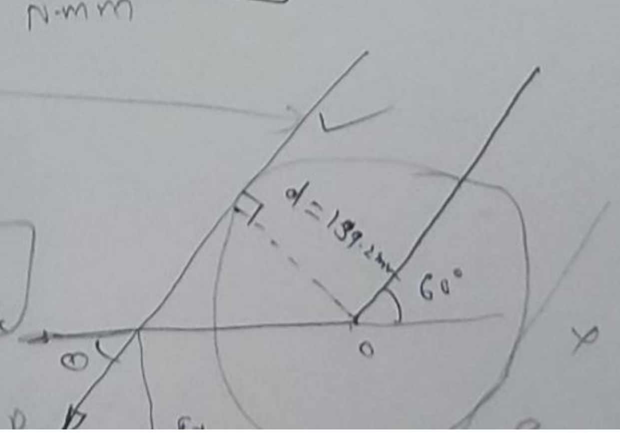
$\boxed{\cancel{d = 139.2\ mm}}$

$\Sigma M_O = +371831$ N·mm

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

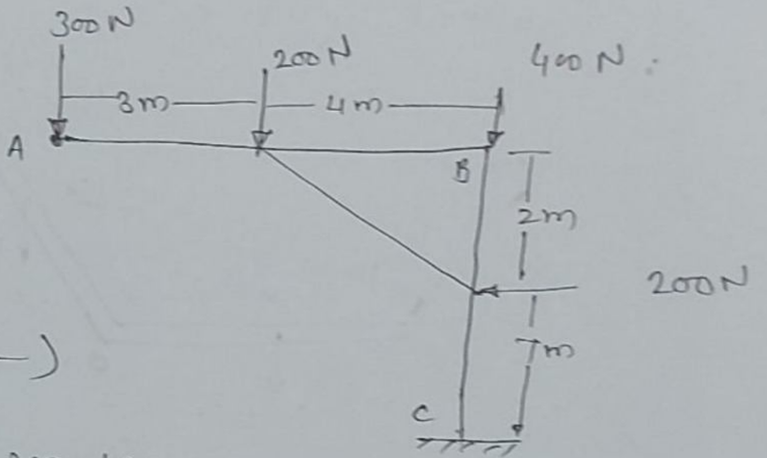
$2671.2\times d = 371831$

$\boxed{d = 139.22\ mm}$



May - 09

* Replace the loading on the frame by a force & moment at. pt. A.



$\Sigma F_x = -200\ N$

$= 200\ N (\leftarrow)$

$\Sigma F_y = -300 - 200 - 400$

$= -900\ N$

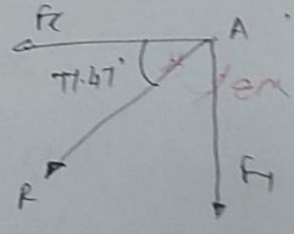
$= 900\ N (\downarrow)$

$R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2} = \sqrt{(200)^2 + (900)^2}$

$R = 921.95\ N.$

$\theta = \tan^{-1}\left(\frac{\Sigma F_y}{\Sigma F_x}\right)$

$\theta = 77.47°$



$\Sigma M_A = -200 \times 3 - 7 \times 400 - 2 \times 200$

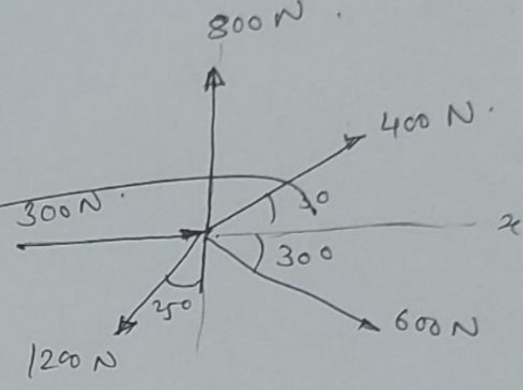
$= -600 - 2800 - 400$

$= -3800\ N$

$= 3800\ Nm$

(12)

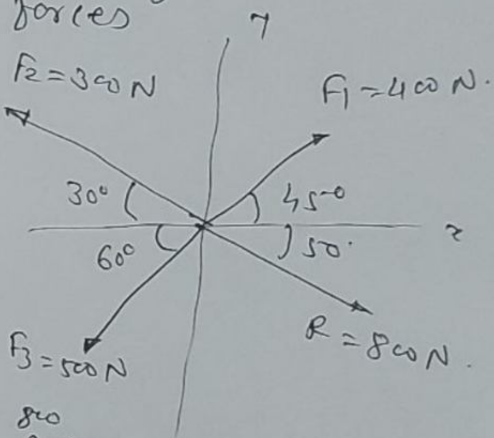
* Det. the resultant of the five co-planner concurrent forces at pt. O



ΣF_x

* Find force F_4 completely so as to give the resultant of the system of forces

→ assume F_4 in I^{st} quad.
with angle θ_4 with x-axis



$\Sigma F_x = R_x$

$$400\cos 45 - 300\cos 30 - 500\cos 60 + F_4\cos\theta_4 = 800\cos 50°$$

$$F_4\cos\theta_4 = 741.19\text{ N } (\rightarrow) \quad -(1)$$

$\Sigma F_y = R_y$

$$400\sin 45 + 300\sin 30 - 500\sin 60 + F_4\sin\theta_4 = -800\sin 50$$

$$F_4\sin\theta_4 = -612.66\text{ N}$$
$$= 612.66\text{ N } (\downarrow) \quad -(2)$$

(2) ÷ (1)

$$\tan\theta_4 = \frac{612.66}{741.19} = \quad \therefore \theta_4 = 39.58°$$

$$\therefore F_4 = \frac{741.19}{\cos(39.58)} = 961.67\text{ N}.$$