Balancing of Masses (Reciprocating Balancing) ①

By Er. Sandeep Gupta

Balancing: Balancing is the process of designing or modifying machinery so that the unbalanced is reduced to an acceptable level and if possible is eliminated entirely.

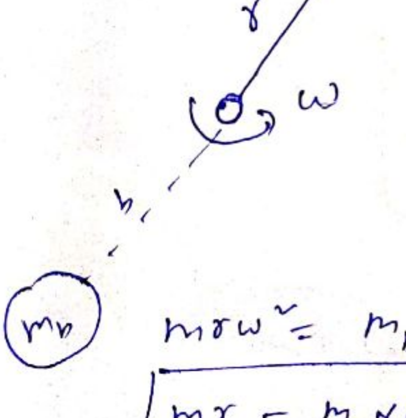
* It is the process of correcting or eliminating either partially or completely the effect of dynamic force and couples on machine part.

① **Static Balancing:** (fig(i))

* centre of mass lies on axis of rotation
* Resultant of dynamic force = 0

② **Dynamic Balancing:** (fig ii)

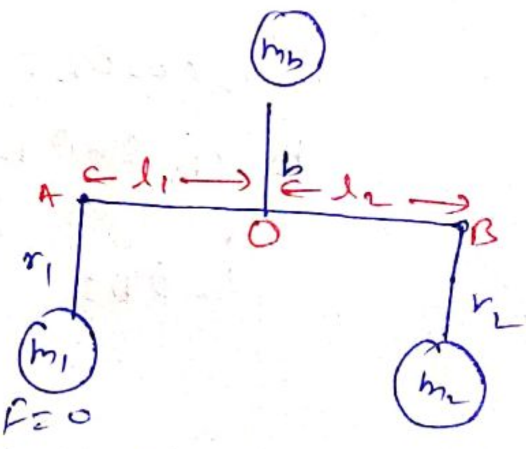
* Resultant of dynamic force = 0
* Resultant couples due to all dynamic forces = 0



$$m r \omega^2 = m_b \times b \times \omega^2$$

$$\boxed{m r = m_b \times b}$$

fig (i)



$\Sigma F = 0$

$$m_b \times b \times \omega^2 = m_1 r_1 \omega^2 + m_2 r_2 \omega^2$$

$$\boxed{m_b \times b = m_1 r_1 + m_2 r_2}$$

$\Sigma M_0 = 0$

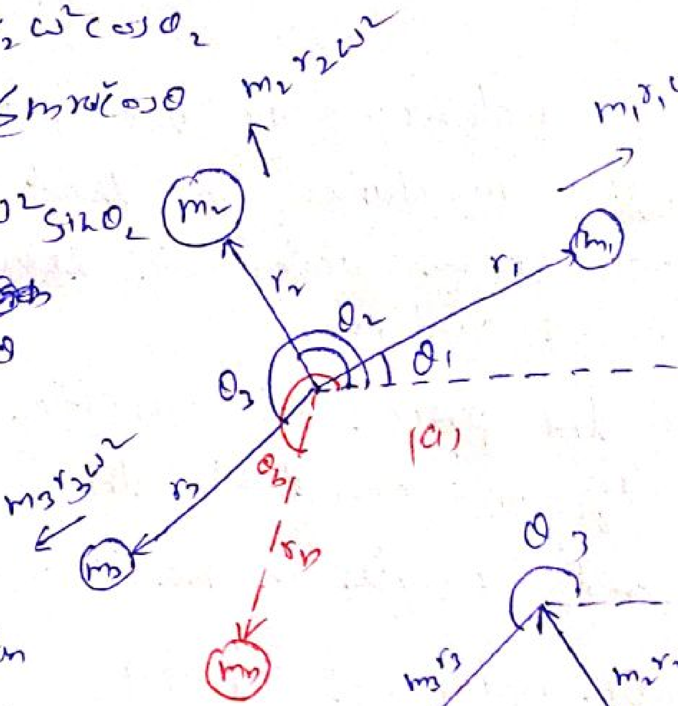
~~$m_b \times b \times l$~~ $\boxed{m_1 r_1 l_1 = m_2 r_2 \times l_2}$

fig (ii)

Balancing of several mass in same rotating plane:

$\Sigma F_H = m_1 r_1 \omega^2 \cos\theta_1 + m_2 r_2 \omega^2 \cos\theta_2$
$\quad + m_3 r_3 \omega^2 \cos\theta_3 = \Sigma m r \omega^2 \cos\theta$

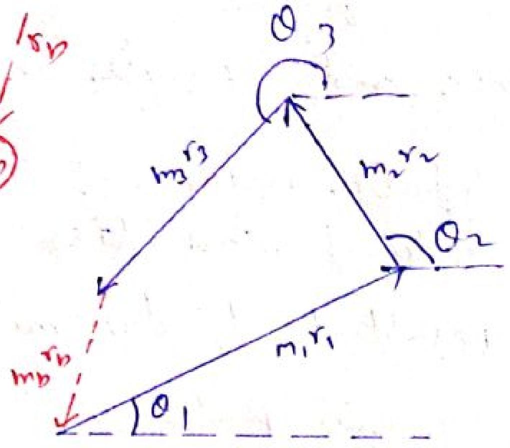
$\Sigma F_V = m_1 r_1 \omega^2 \sin\theta_1 + m_2 r_2 \omega^2 \sin\theta_2$
$\quad + m_3 r_3 \omega^2 \sin\theta_3$
$\quad = \Sigma m r \omega^2 \sin\theta$



(a)

if $\Sigma F_H \neq 0$
$\Sigma F_V \neq 0$

then apply a Balancing mass m_b in θ_b direction to balance this force



(b)

$\cancel{\Sigma F_H = m_b r_b \omega^2 \cos\theta_b}$

$\cancel{\Sigma F_V = m_b r_b \omega \sin\theta_b}$

$\therefore$ now $\Sigma F_H = 0$

$\therefore \Sigma m r \omega^2 \cos\theta + m_b r_b \omega^2 \cos\theta_b = 0$

$\Sigma m r \omega^2 \sin\theta + m_b r_b \omega^2 \sin\theta_b = 0$

$m_b r_b \cos\theta_b = -\Sigma m r \cos\theta$

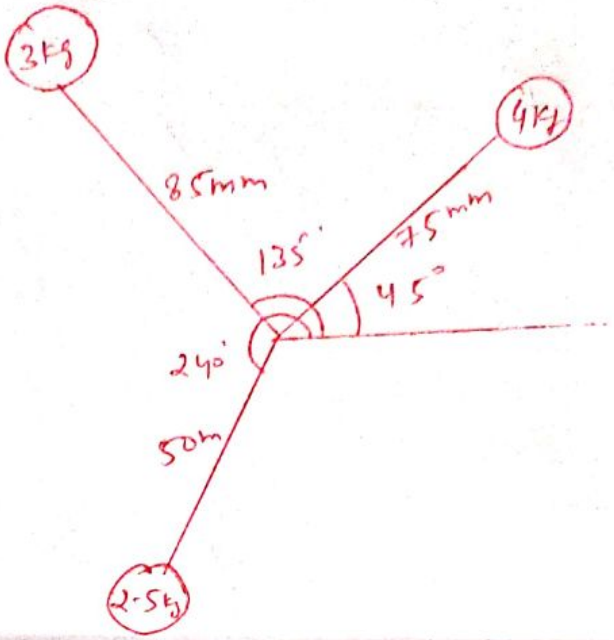
$m_b r_b \sin\theta_b = -\Sigma m r \sin\theta$

$$\therefore \boxed{\tan\theta_b = \frac{-\Sigma m r \sin\theta}{-\Sigma m r \cos\theta}}$$

$$\boxed{m_b r_b = \sqrt{(\Sigma m r \cos\theta)^2 + (\Sigma m r \sin\theta)^2}}$$

Q!.

Determine the amount of balanced mass at a radial distance 75mm required for static balancing.



m	r	mr	θ
4	75	300	
3	85	255	
2.5	50	125	

$m_b r_b \cos\theta_b = -\Sigma m r \cos\theta$

$= -[300\cos 45 + 255\cos 135 + 125\cos 240]$

$m_b r_b \cos\theta_b = +30.68$

$m_b r_b \sin\theta_b = -[300\sin 45 + 255\sin 135 + 125\sin 240]$

$m_b r_b \sin\theta_b = -284.2$

$\tan\theta_b = \dfrac{-284.2}{30.68}$ } fourth co-ordinate since (− sin, + cos)

$\tan\theta_b = -9.26$

$\theta_b = 83^\circ$ $\therefore \theta_b = 360 - 83$

$\theta_b = \cancel{83 + 270} = \boxed{\theta_b = 277^\circ}$ R

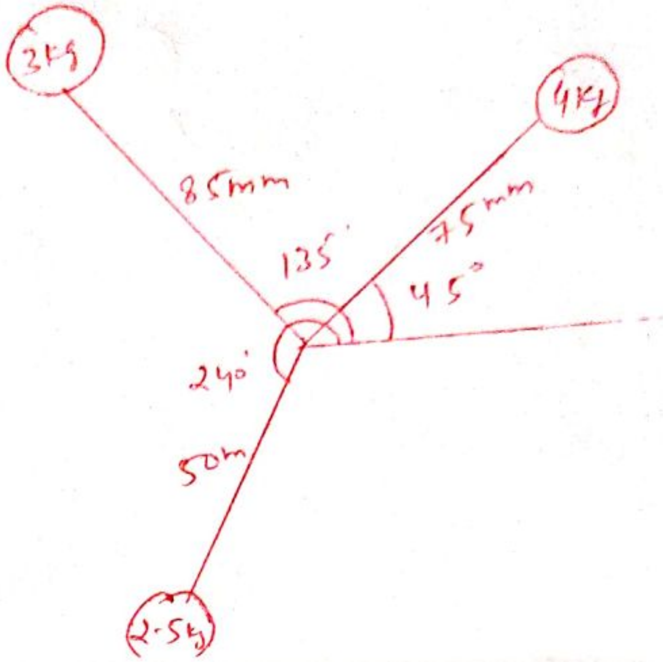
$m_b r_b = \sqrt{(-30.68)^2 + (284.2)^2}$

$m_b \times 75 = 285.8$ kg.mm

$\boxed{m_b = 3.81 \text{ kg}}$ R

Q1:

Determine the amount of balanced mass at a radial distance 75mm required for static balancing.



m	r	mr	θ
4	75	300	
3	85	255	
2.5	50	125	

Let 1 cm = 50 units

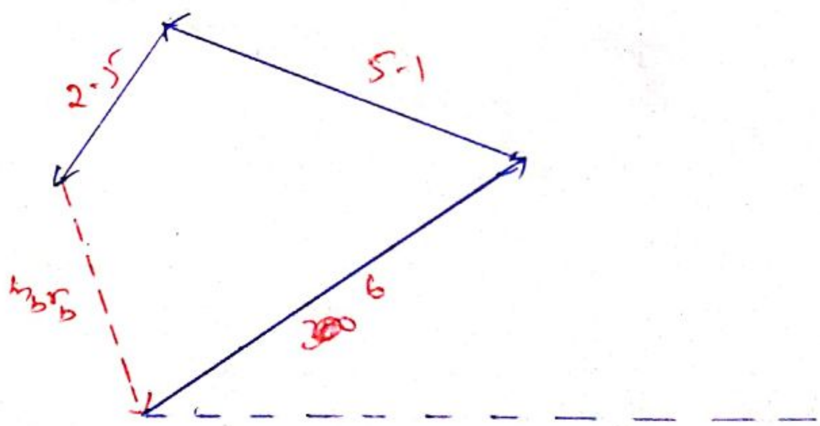
Graphical method:-

$\boxed{\theta_b = 277^\circ}$

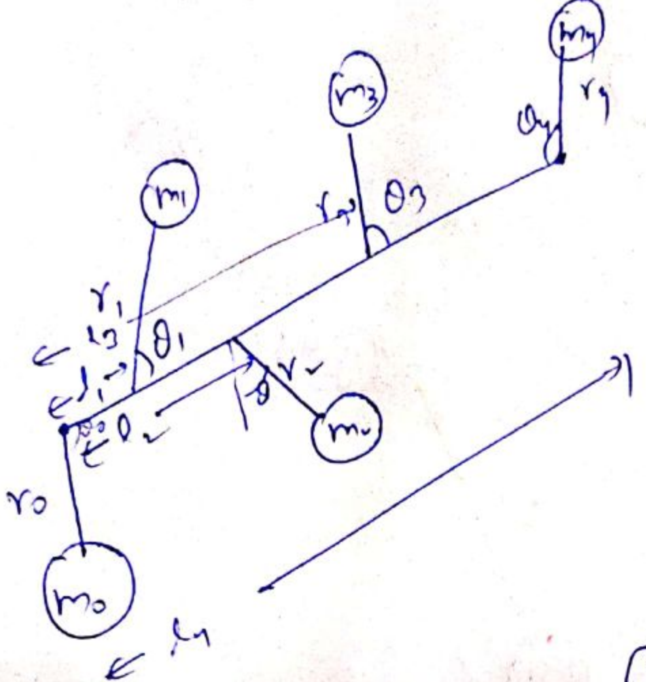
$m_b r_b = 250$

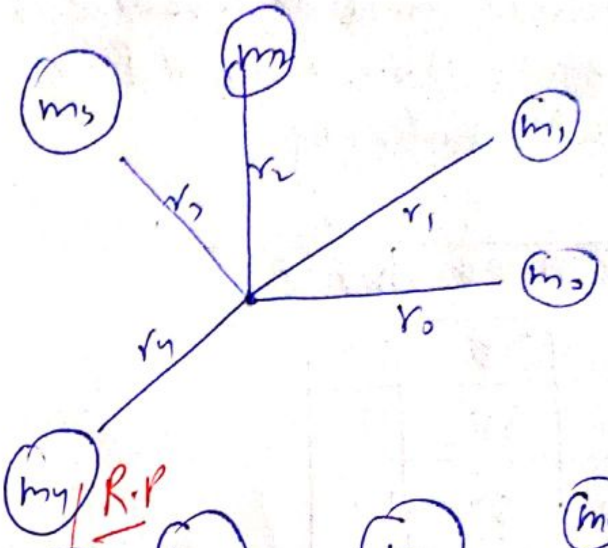
$m_b \times 75 = 250$

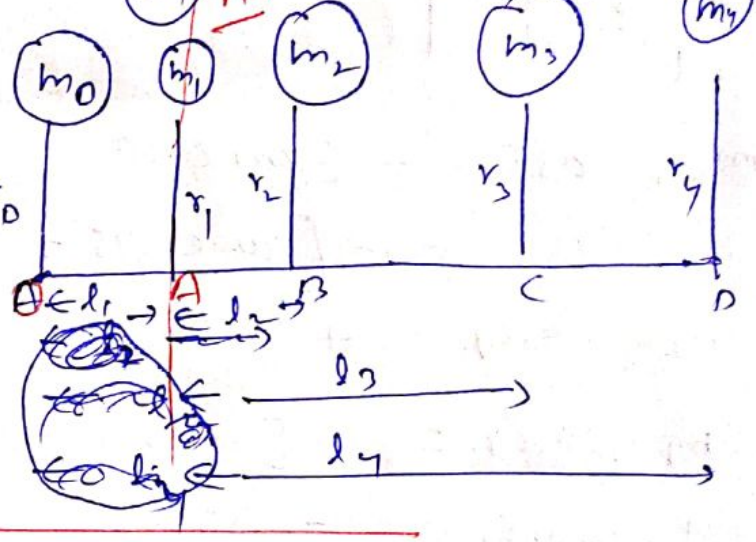
$\boxed{m_b = 3.33 \text{ kg}}$



Balancing of several masses in different planes: (4)







$l \rightarrow$ Distance from Reference plane (R.P)

Plane	mass	radius	mr	l	mrl
O	m_0	r_0	$m_0 r_0$	$-l_1$	$-m_0 r_0 l_1$
A	m_1	r_1	$m_1 r_1$	0	0
B	m_2	r_2	$m_2 r_2$	l_2	$m_2 r_2 l_2$
C	m_3	r_3	$m_3 r_3$	l_3	$m_3 r_3 l_3$
D	m_4	r_4	$m_4 r_4$	l_4	$m_4 r_4 l_4$

Q-2 four masses A, B, C, D are completely balanced. Masses C and D make angles of 90° and 195° respectively with B in same sense. (5)

$m_B = 25\,kg$, $m_C = 40\,kg$, $m_D = 35\,kg$, $m_a = ?$

$r_a = 150\,mm$, $r_b = 200\,mm$, $r_c = 100\,mm$, $r_d = 180\,mm$

find (i) m_a, θ_A

(ii) Position of plane of A C D

Soln:

A	m_a	150
B	25	200
m_C	40	1000
m_D	35	180

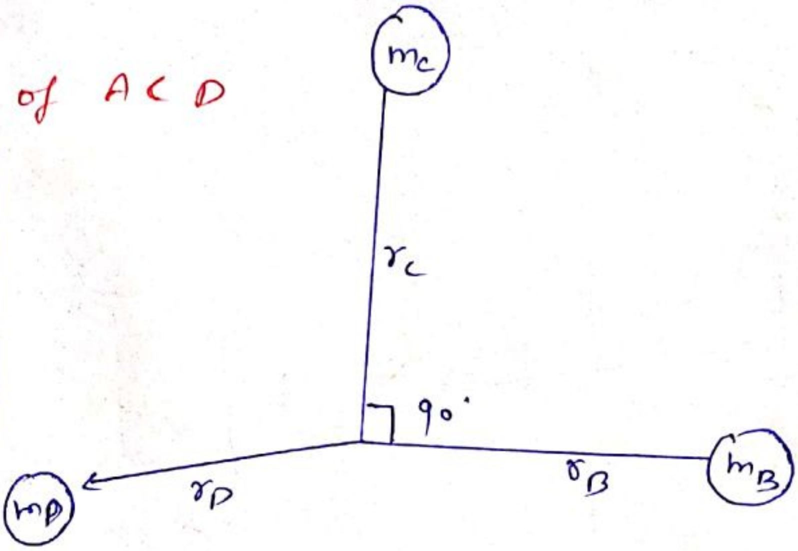
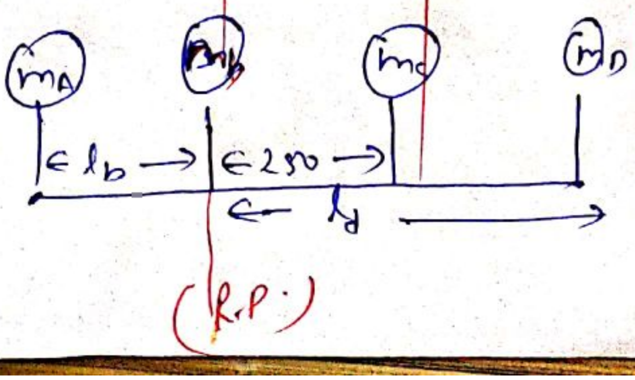


Table:

Plane	mass	Radius	Distance mr	(l)	mrl
A	m_a	150	$150\,m_a$	$-l_b$	$-150\,m_a \times l_b$
B	25	200	5000	0	0
C	40	100	4000	250	$4000 \times 250 = 1000000$
D	35	180	6300	$+l_d$	$6300 \times l_d$



Scanned with CamScanner

Q-2 Four masses A, B, C, D are completely balanced. Masses C and D make angles of 90° and 195° respectively with B in same sense.

$m_B = 25$ kg $m_C = 40$ kg, $m_D = 35$ kg, $m_a = ?$

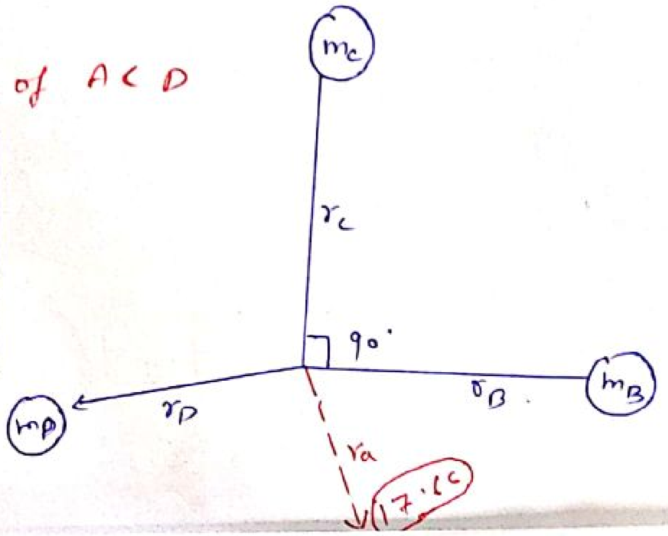
$r_a = 150$ mm $r_b = 200$ mm, $r_c = 100$ mm $r_d = 180$ mm

find (i) m_a , θ_A

(ii) Position of plane of A C D

Sol^n:

A	m_a	150
B	25	200
C	40	1000
D	35	180



Table!

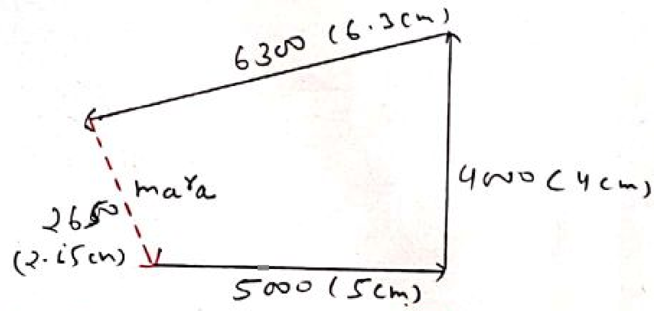
Force Polygon Let 1 cm = 1000 unit

$m_a r_a = 2650$

$m_a \times 150 = 2650$

$\boxed{m_a = 17.66 \text{ kg}}$

Answer



$\boxed{\theta = 295° \text{ by observation}}$ Ans

Moment polygon

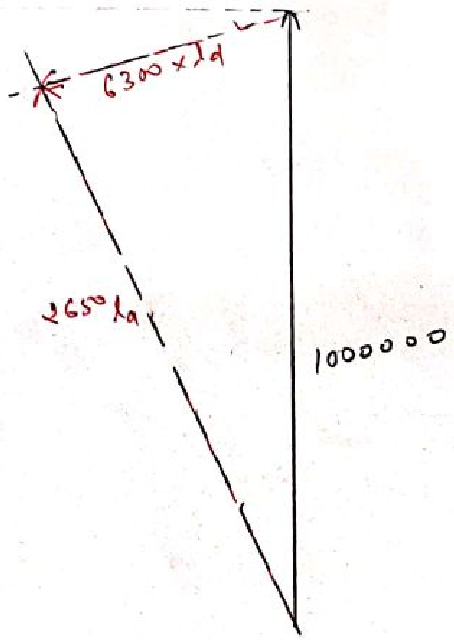
Let 1 cm = 100000 units

$6300 \times l_d = 4.3 \times 100000$

$\boxed{l_d = 68 \text{ mm}}$

$2650\, l_d = 9.8 \times 100000$

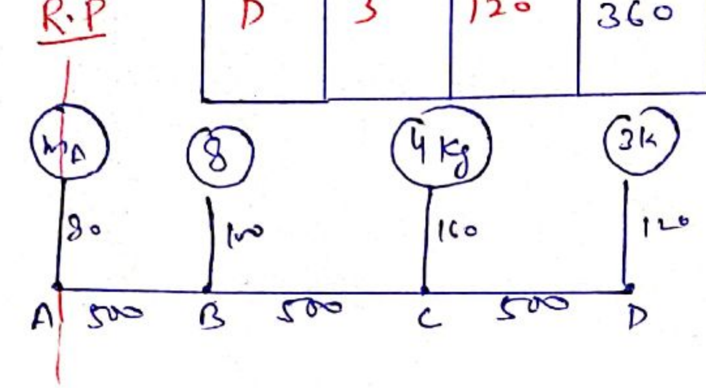
$\boxed{l_a = 369.81 \text{ mm}}$

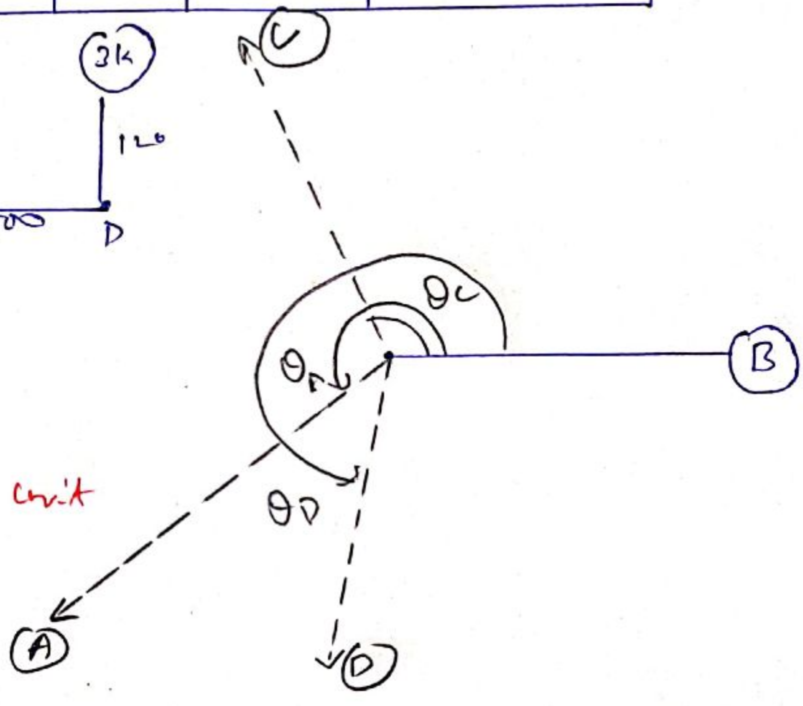


Q1:

A → R.P

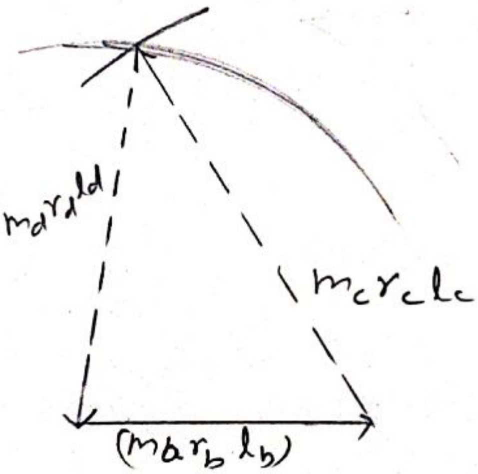
Plane	Mass	Radius (mm)	m×r	l	m r l
A	m_A	80	$80m_A$	0	0
B	8	100	800	500	400,000
C	4	160	640	1000	640000
D	3	120	360	1500	540000





Moment Polygon:

unit 1cm = 1000000 unit



$m_a \times r_a = 520$

$m_a \times 80 = 520$

$\boxed{m_a = 6.5 \text{ kg}}$

Answer

Force Polygon:

Let 1cm = 100 unit