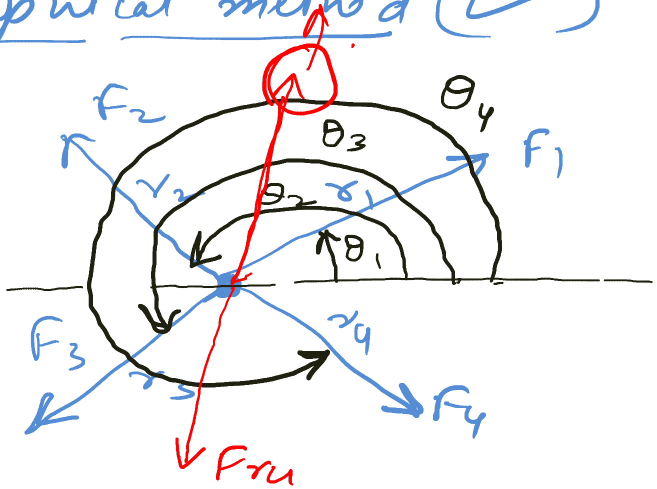
Graphical method (✓)



$10N = F_1 = m_1 r_1 \omega^2$ ✓

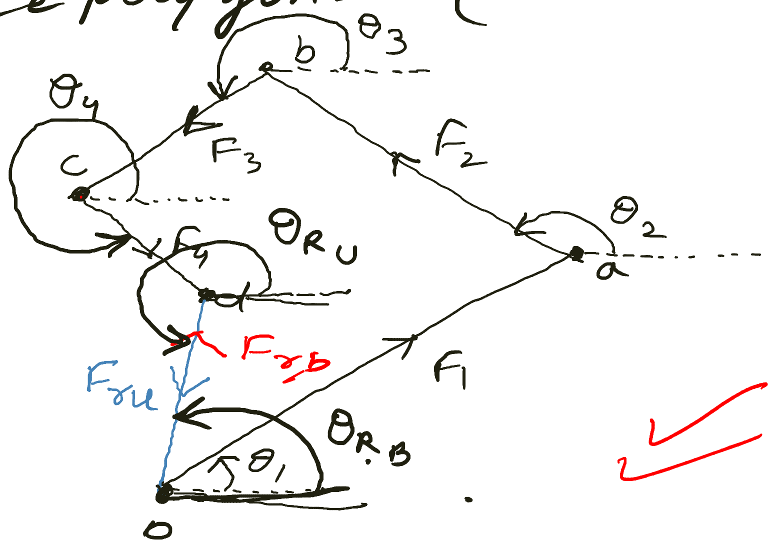
$8N = F_2 = m_2 \cdot r_2 \omega^2$ ✓

$5N = F_3 = m_3 r_3 \omega^2$ ✓

$2N = F_4 = m_4 r_4 \omega^2$ ✓

Vectors
- magnitude
- direction

Force polygon:- (Scale:- 1N = 1cm)



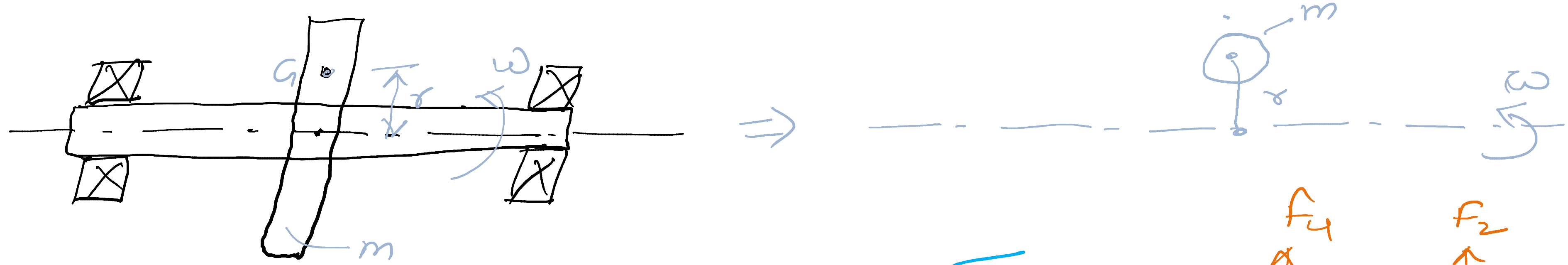
o → start
d → end

] System is Unbalanced

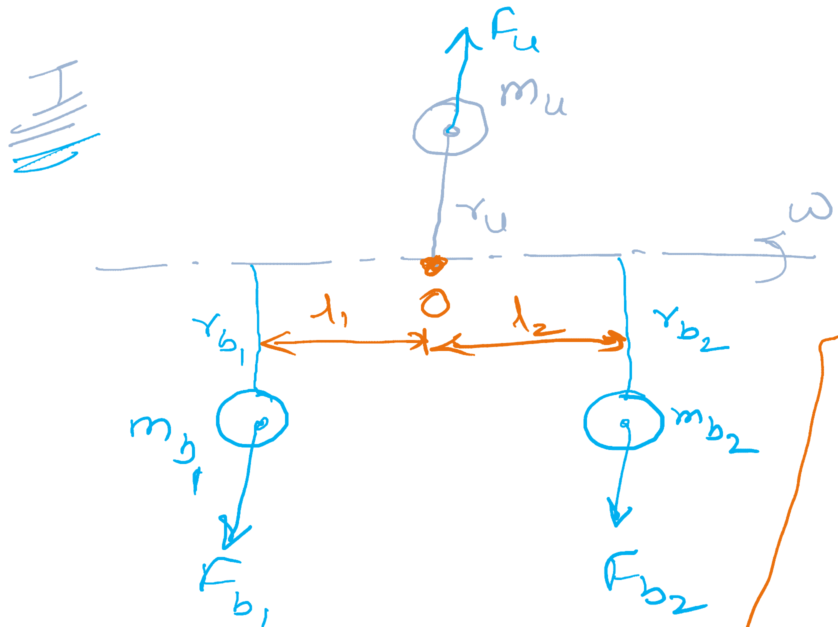
$F_{ru} = m \cdot r$

Single Plane

External Balancing:-



I



$$F_u = F_{b_1} + F_{b_2} \quad \text{— (1)}$$

$$m_u r_u \omega^2 = m_{b_1} \cdot r_{b_1} \cdot \omega^2 + m_{b_2} \cdot r_{b_2} \cdot \omega^2$$

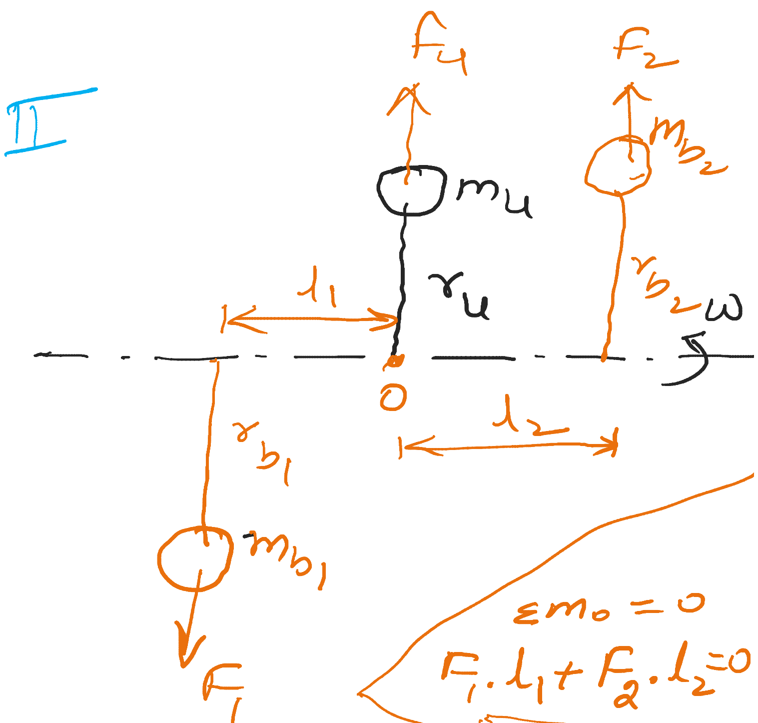
$$m_u r_u = m_{b_1} r_{b_1} + m_{b_2} r_{b_2}$$

(2)

$$\Sigma M_O = 0$$

$$F_{b_1} \cdot l_1 = F_{b_2} \cdot l_2$$

II



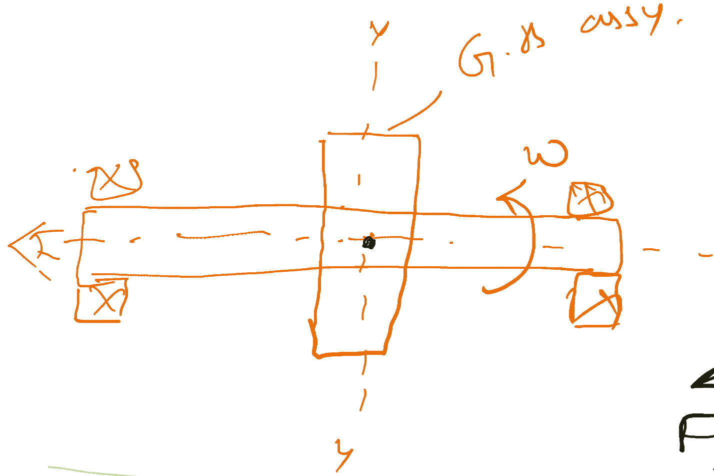
$$F_u + F_2 = F_1 \quad \text{— (1)}$$

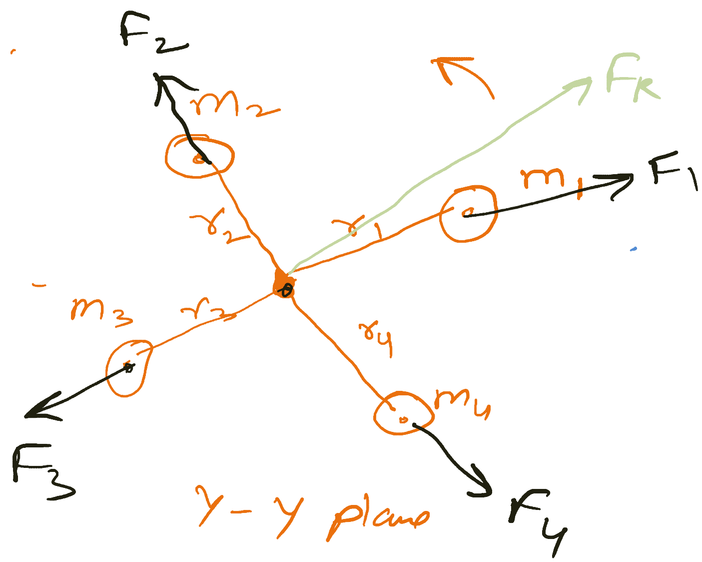
$$m_u r_u + m_{b_2} \cdot r_{b_2} = m_{b_1} \cdot r_{b_1}$$

$$\Sigma M_o = 0$$

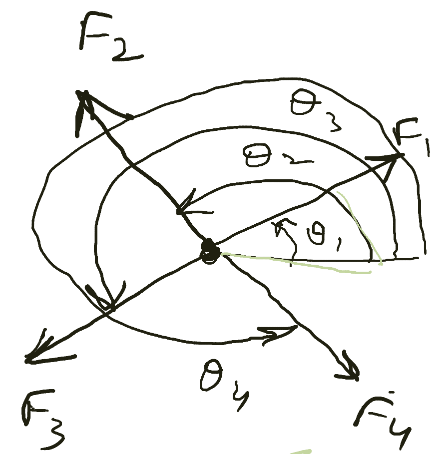
$$F_1 \cdot l_1 + F_2 \cdot l_2 = 0$$

$$m_{b_1} r_{b_1} l_1 + m_{b_2} r_{b_2} l_2 = 0$$

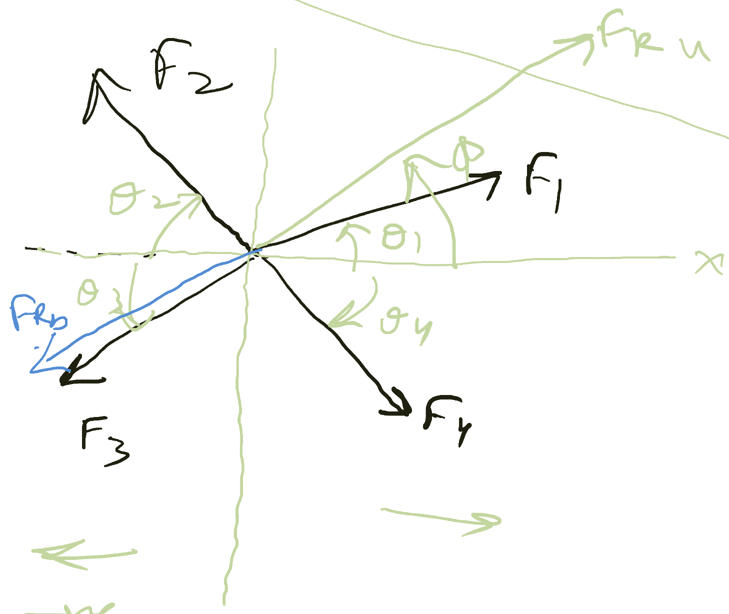




Analytical



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



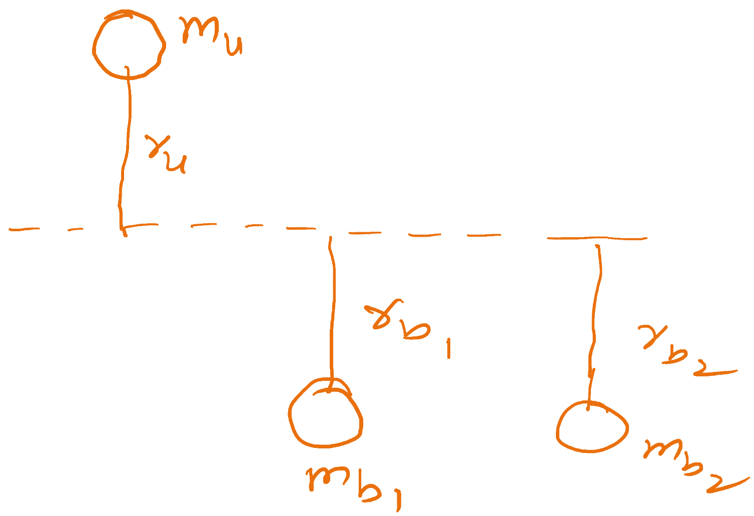
$$\Sigma F_x \neq 0$$

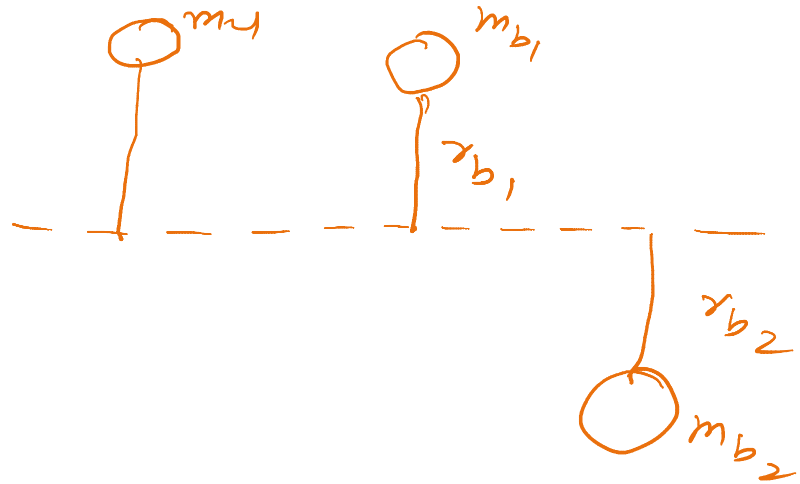
$$\Sigma F_{x_R} = F_1\cos\theta_1 + F_2\cos\theta_2 + F_3\cos\theta_3 + F_4\cos\theta_4$$

$$\Sigma F_{y_R} = F_1\sin\theta_1 + F_2\sin\theta_2 + F_3\sin\theta_3 + F_4\sin\theta_4$$

$$F_R = \sqrt{(\Sigma F_{x_R})^2 + (\Sigma F_{y_R})^2}$$

$$\Sigma f_x = F_1\cos\theta_1 - F_2\cos\theta_2$$



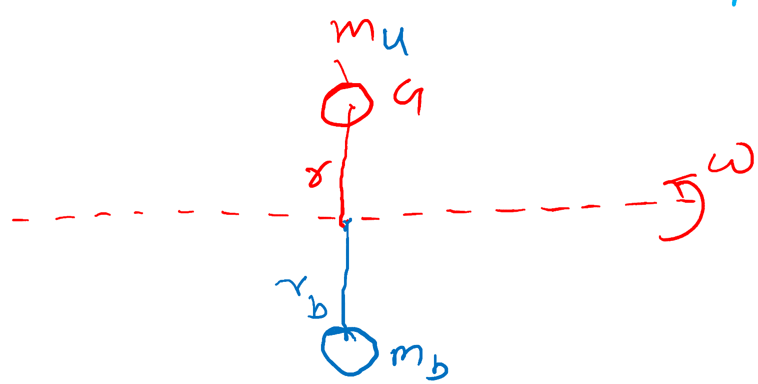


① Force equation →
② Couple equation →
] ← External Balancing.

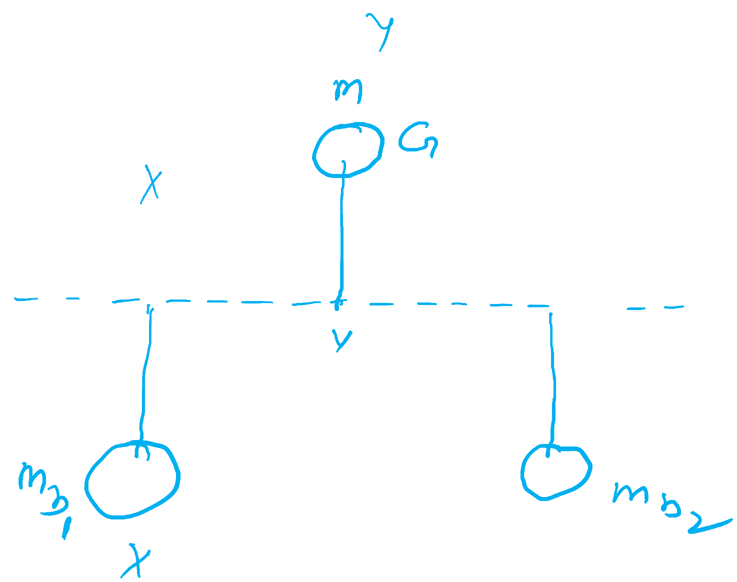
Balancing
- → Rotating masses
  - → Single Plane Balancing
  - → Multiplane Balancing
- → Reciprocating

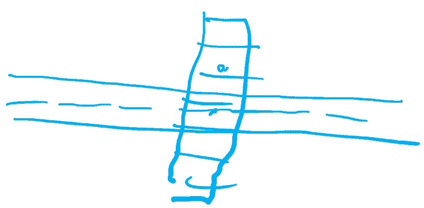
Single Plane Balancing :-

- Internal Balancing (In same plane) — centrifugal forces
- External Balancing (In different plane) — centrifugal forces + Couples.



$F_c = m \cdot r \cdot \omega^2$





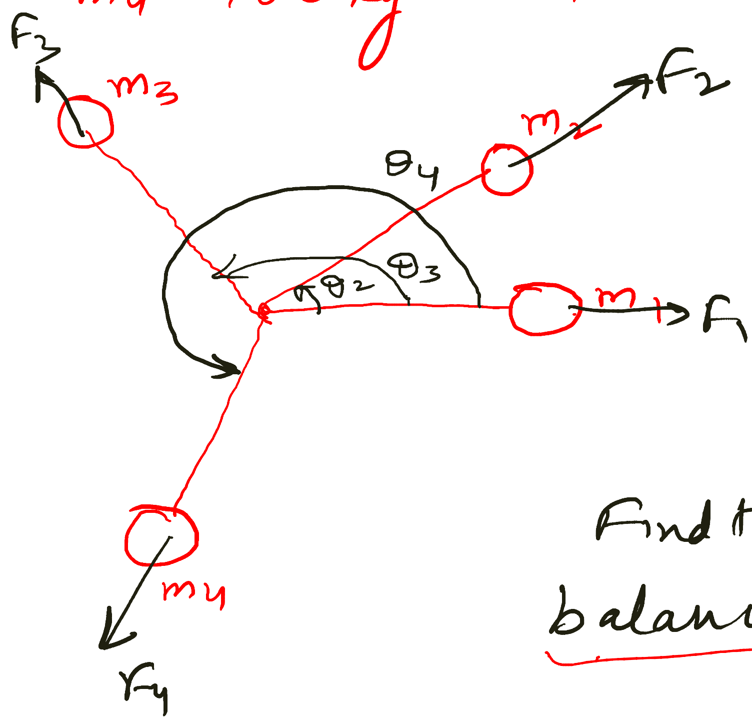
$m_1 = 200\,kg$ $r_1 = 100\,mm = 0.1\,m$ $F_c = m r \omega^2$

$m_2 = 250\,kg$ $r_2 = 120\,mm = 0.12\,m$

$m_3 = 150\,kg$ $r_3 = 250\,mm = 0.25\,m$

$m_4 = 100\,kg$ $r_4 = 300\,mm = 0.3\,m$

Graphical method



$\theta_1 = 0°$

$\theta_2 = 45°$

$\theta_3 = 115°$

$\theta_4 = 255°$

$F_1 = m_1 r_1 \omega^2$

$F_2 =$

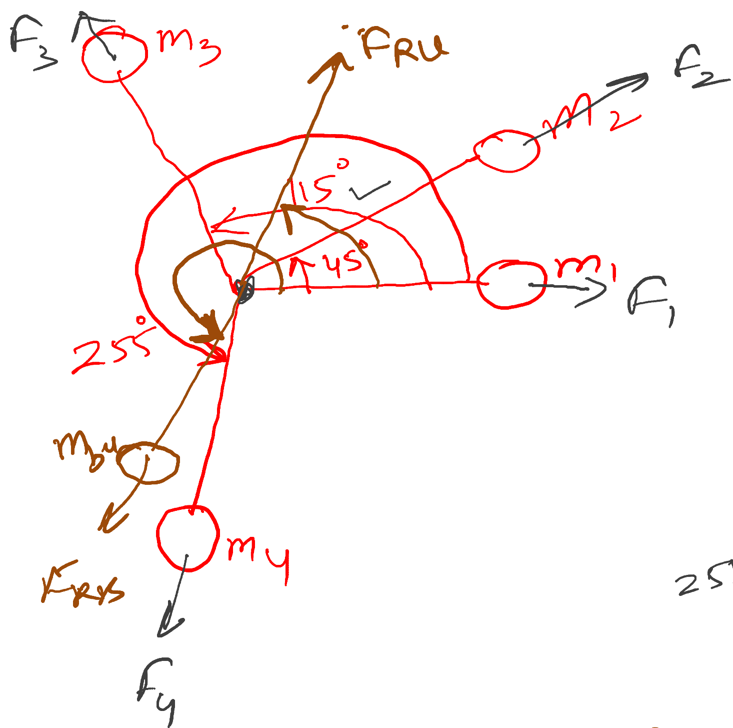
$F_3 =$

$F_4 =$

Find the position and magnitude of the balancing mass required if radius of rotation is 350 mm.

$F_{br} = m_b r_b \omega^2$ $r_b = 0.35\,m$

$m_b = ?$



$m_1 = 200\ kg$

$m_2 = 250\ kg$

$m_3 = 750\ kg$

$m_4 = 100\ kg$

$r_1 = 0.1\ m$

$r_2 = 0.12\ m$

$r_3 = 0.25\ m$

$r_4 = 0.3\ m$

ω is not given

$F_1 = m_1 r_1 \omega^2 = m_1 r_1 = 20\ kg\text{-}m$

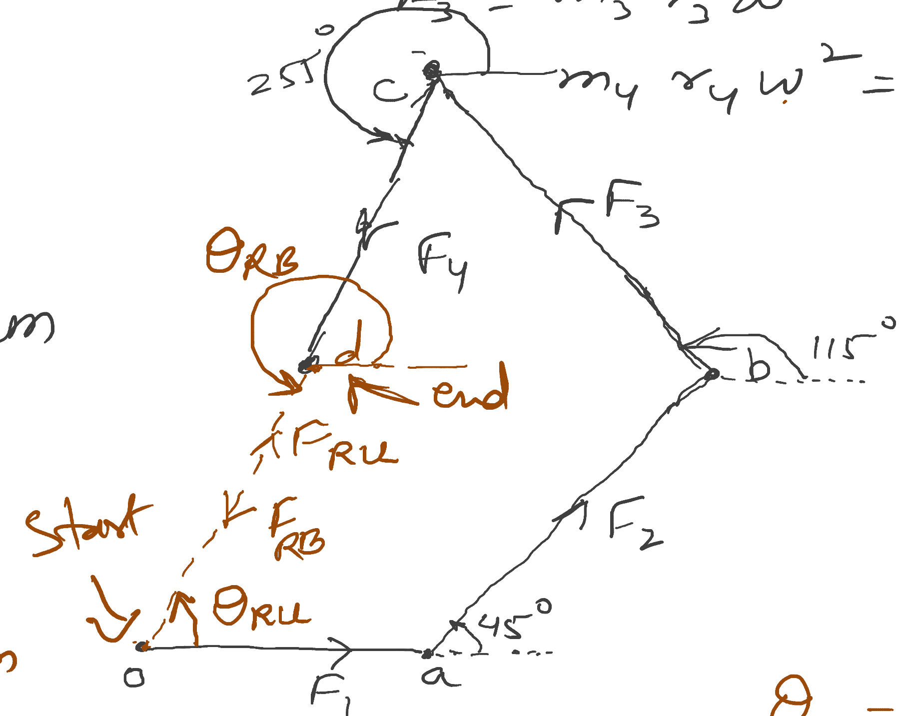
$F_2 = m_2 r_2 \omega^2 = m_2 r_2 = 30\ kg\text{-}m$

$F_3 = m_3 r_3 \omega^2 = m_3 r_3 = 37.5\ kg\text{-}m$

$m_4 r_4 \omega^2 = m_4 r_4 = 30\ kg\text{-}m$

Scale:–

$1\ kg\text{-}m = \frac{1}{10}\ cm$



Polygon is not closed

$od = 3.1\ cm$

$F_{RB} = 31\ kg\text{-}m$

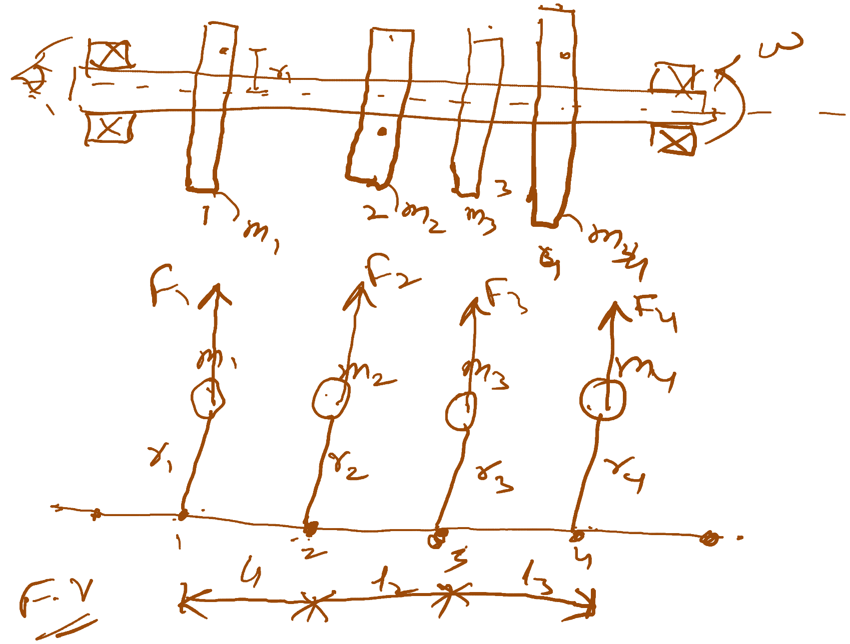
$m_b \cdot r_b = 31$

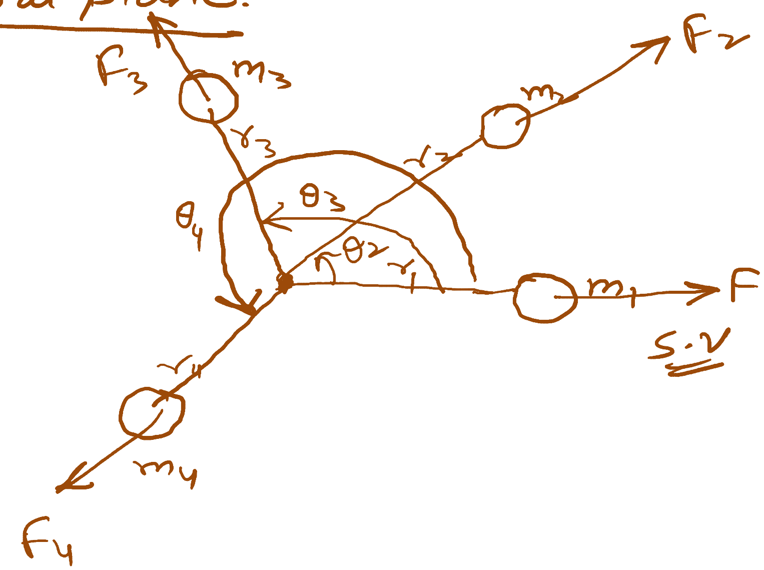
$m_b \times 0.35 = 31$

$m_b = 90.2\ kg$

$\theta_b = 236.11°$

* Balancing of Rotating masses in several plane:-





Force + Couples

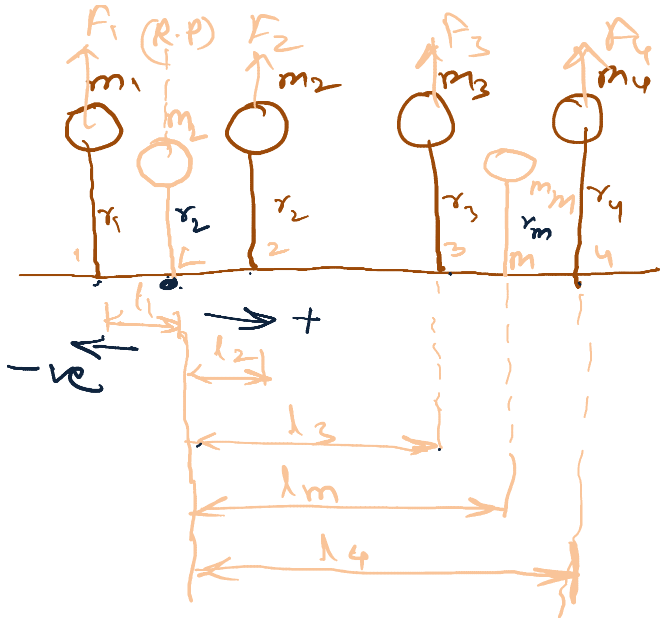
at pt. 2, F_2.

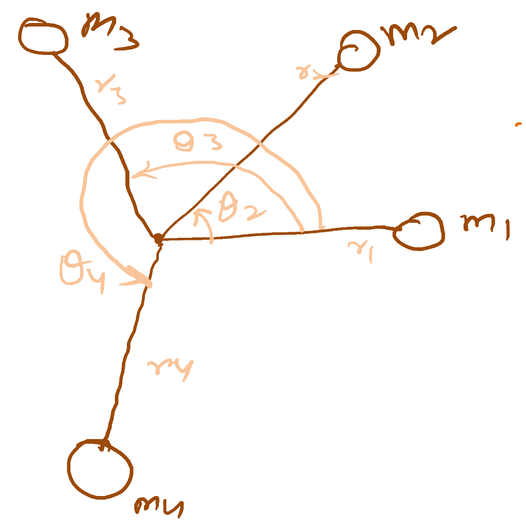
Couple $(F_1 \cdot l_1)$, $(F_3 \cdot l_2)$, $[F_4 \cdot (l_2 + l_3)]$ — couple

at Pt, 3

Force → F_3

Couples → $(F_4 \cdot l_3)$, $(F_2 \cdot l_2)$, $[F_1 (l_1 + l_2)]$





m_m } Bala
m_2

C.F (Polygon closed)

Couple (Polygon closed)

Plane	mass (kg)	Radius (m)	Centrifugal force ÷ ω^2 (kg-m)	Distance from R.P (m)	Couple ÷ ω^2 (kg-m^2)
1	m_1	r_1	$m_1 \cdot r_1$ ✓	$-l_1$	$-m_1 r_1 l_1$ ✓
L (R.P)	m_L (?)	r_L (?)	$m_L \cdot r_L$ (?)	0	0
2	m_2	r_2	$m_2 \cdot r_2$ ✓	l_2	$m_2 r_2 l_2$ ✓
3	m_3	r_3	$m_3 \cdot r_3$ ✓	l_3	$m_3 r_3 l_3$ ✓
m	m_m (?)	r_m (?)	$m_m \cdot r_m$ (?)	L_m	$m_m r_m L_m$ (?)
4	m_4	r_4	$m_4 \cdot r_4$ ✓	l_4	$m_4 r_4 l_4$ ✓