Internal Assessment Test I – Sept. 2019

Sub: Dynamics of Machinery **Code:** 17ME52

Date: 06/ 09 / 2019 Duration: 90 mins Max Marks: 50 **Sem:** V **Branch:** MECH

Note: Answer **all** questions from PART A and **One** question from PART B

		Marks	OBE	
	PART A		CO	RBT
1.a	Define the following i)Sensitiveness (ii) Isochronism (iii)Hunting of governor (iv)Effort of governor	**4**	CO3	L1
1. b	Derive an expression for equilibrium speed of governor	**6**		L2
1. c	In a porter governor, the upper and lower arms are 200 mm and 250 mm respectively and pivoted on the axis of rotation. The mass of central load is 15 kg, the mass of each ball is 2 kg and friction of the sleeve together with the resistance of the operating gear is equal to a load of 24 N at the sleeve. If the limiting inclinations of the upper arms to the verticals are 30° and 40°. Find the range of speed taking friction in to account.	**10**	CO3	L2
2	A shaft carries four masses A. B. C. and D of magnitude 200kg. 300kg. 400kg and 200kg respectively and revolving at radii 80mm, 70mm. 60mm and 80mm in planes measured from A at 300mm. 400mm and 700 mm. The angle between the crank measured anticlockwise are A to B 45°. B to C 70° and C to D 120° the balancing masses are to be placed in planes X and Y. The distance between the planes A and X is 100mm between X and Y is 400mm and between Y and D is 200mm. If the balancing planes revolved at a radius of 100mm find their magnitudes and angular position.	**20**	CO2	L2
	PART B			
3	In a spring loaded Hartnell type governor, the extreme radii of rotation of the balls are 80mm and 120mm. The ball and sleeve arms of the bell crank lever are equal in length. The mass of each ball is 2kg. If the speeds at the two extreme positions are 400 and 420rpm. Find: i) Stiffness of the spring; ii) Initial compression of the spring.	**10**	CO3	L3
	OR			
4	Four masses 150, 250, 200 & 300kg are rotating in same plane at radii of 0.25m, 0.2m, 0.3m and 0.35m respectively. These angular locations are 40°, 120° & 250° from mass 150kg respectively measured in counter clockwise direction. Find the position and magnitude of balance mass required, if its radius of rotation is 0.25m.	**10**	CO2	L3

Solution for Internal Assessment Test I -Sept. 2019

1. a

SENSITIVENESS

It is defined as the ratio of the difference between the maximum & minimum equilibrium speeds to the mean equilibrium speed.

Mean Speed $N = \frac{N_1 + N_2}{2}$

$$\therefore \text{Sensitiveness} = \frac{N_2 - N_1}{N} = \frac{N_2 - N_1}{\frac{N_1 + N_2}{2}} = \frac{2(N_2 - N_1)}{N_1 + N_2}$$

$$= \frac{2(\omega_2 - \omega_1)}{\omega_1 + \omega_2}$$

ISOCHRONOUS GOVERNOR

A governor is said to be isochronous when the equilibrium speed is constant (i.e range of speed is zero) for all radii of rotation of the balls within the working range, neglecting friction.

HUNTING

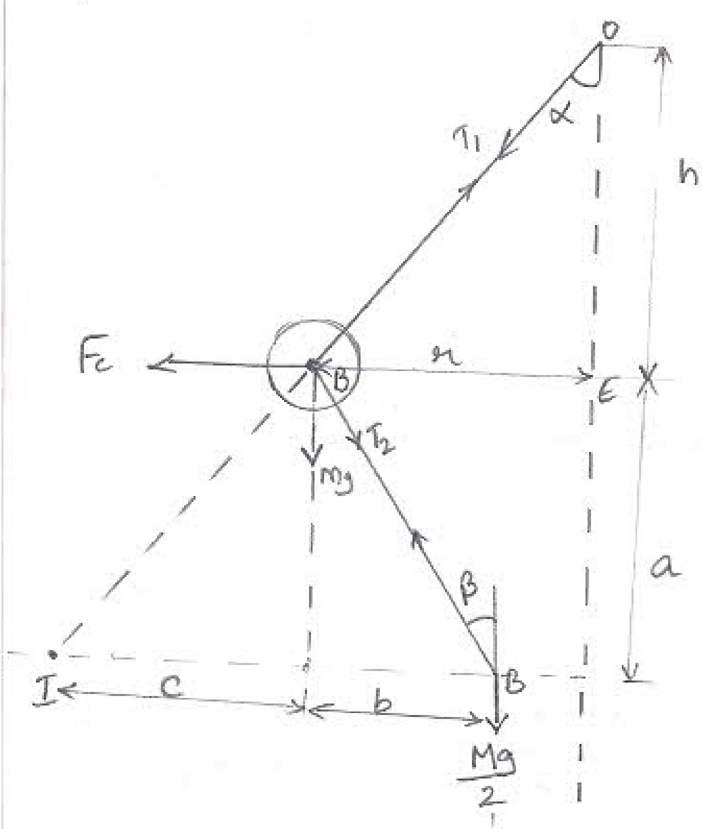
A governor is said to be hunt if the speed of the engine fluctuates continuously above & below the mean speed. This is caused by a sensitive governor. In actual practice hunting is impossible in an isochronous governor because of friction of mechanism.

EFFORT & POWER OF A GOVERNOR

The effort of a governor is the mean force exerted at the sleeve for a given percentage change of speed.

1. b. Instantaneous Centre method.

In this method, equilibrium of forces acting on link AB is considered.



For equilibrium $\Sigma F = 0$; $\Sigma M = 0$

Taking moment about I.

$$F_c . a = mg . c + \frac{Mg}{2}[c + b] \rightarrow (1)$$

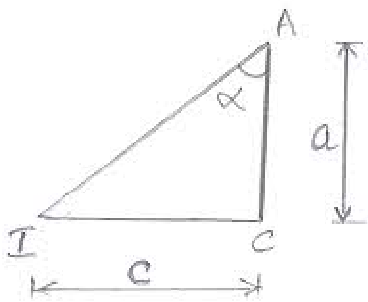
Centrifugal force $F_c = m\omega^2 r$

Substituting this in eqn (1)

$$m\omega^2 r . a = mg . c + \frac{Mg}{2}[c + b]$$

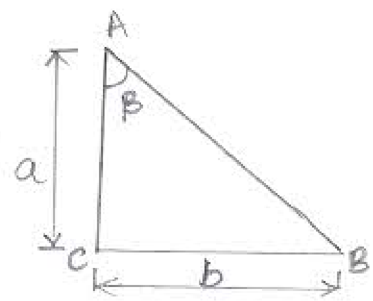
$$m\omega^2 r = mg . \frac{c}{a} + \frac{Mg}{2}\left[\frac{c}{a} + \frac{b}{a}\right] \rightarrow (2)$$

Consider Δ^{le} ACI



$$\tan\alpha = \frac{c}{a} \rightarrow (A)$$

Consider Δ^{le} ACB



$$\tan\beta = \frac{b}{a} \rightarrow (B)$$

Substituting (A) & (B) in eqn (2) we get

$$m\omega^2 r = mg.\tan\alpha + \frac{Mg}{2}\left[\tan\alpha + \tan\beta\right]$$

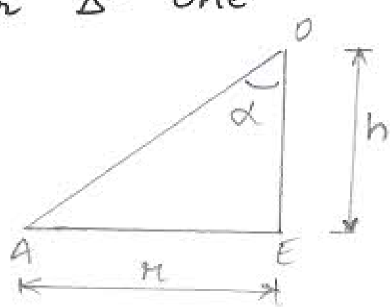
$$m\omega^2 r = \tan\alpha\left[mg + \frac{Mg}{2}\left(1 + \frac{\tan\beta}{\tan\alpha}\right)\right] \rightarrow (3)$$

Denote $\frac{\tan\beta}{\tan\alpha} = K$

Equation (3) becomes

$$m\omega^2 r = \tan\alpha\left[mg + \frac{Mg}{2}(1+K)\right] \rightarrow (4)$$

Consider Δ^{le} OAE



$$\tan\alpha = \frac{r}{h} \rightarrow (C)$$

Substitute (C) in eqn (4) we get

$$m\omega^2 r = \frac{r}{h}\left[mg + \frac{Mg}{2}(1+K)\right]$$

$$\omega^2 = \frac{r}{mrh}\left[mg + \frac{Mg}{2}(1+K)\right]$$

$$= \frac{1}{mh}\left[mg + \frac{Mg}{2}(1+K)\right]$$

$$\left(\frac{2\pi N}{60}\right)^2 = \frac{1}{mh}\left[mg + \frac{Mg}{2}(1+K)\right]$$

$$= \frac{g}{h}\left[\frac{m + \frac{M}{2}(1+K)}{m}\right]$$

$$\boxed{N^2 = \frac{895}{h}\left[\frac{m + \frac{M}{2}(1+K)}{m}\right]}$$

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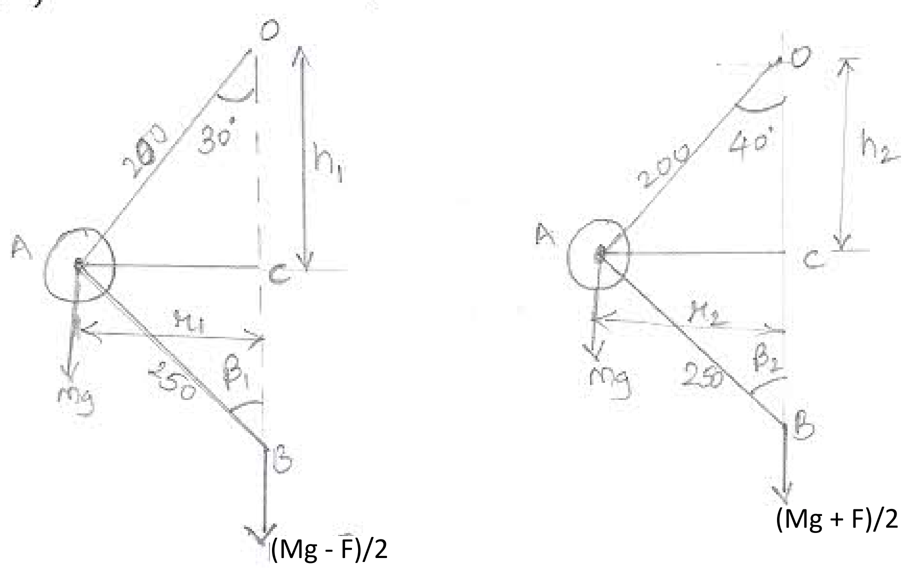
1. c. In an engine governor of the Porter type, the upper & lower arms are 200mm & 250 mm respectively & pivoted on the axis of rotation. The mass of the Central load is 15 Kg, the mass of each ball is 2kg & friction of the sleeve together with the resistance of the operating gear is equal to a load of 24N at the sleeve. If the limiting inclinations of the upper arms to the vertical are 30° & 40°, find, taking friction into account, range of speed of the governor.

Sol :



Given :- $OA = 200\ mm = 0.2m$; $AB = 0.25m$, $M = 15\ Kg$,

$m = 2\ Kg$; $F = 24N$; $\alpha_1 = 30°$, $\alpha_2 = 40°$

From fig. a. $r_1 = 0.2 \sin 30° = 0.2 \times 0.5 = 0.1m$

Height of governor,

$$h_1 = 0.2 \cos 30° = 0.2 \times 0.866 = 0.1732\ m$$

$$BC = \sqrt{0.25^2 - 0.1^2} = 0.23m.$$

$$\tan \beta_1 = \frac{0.1}{0.23} = 0.4348$$

$$\tan \alpha_1 = \tan 30^\circ = 0.5774.$$

$$K_1 = \frac{\tan \beta_1}{\tan \alpha_1} = \frac{0.4348}{0.5774} = 0.753$$

$$N_1^2 = \frac{895}{h_1} \cdot \left[\frac{m.g + \frac{M.g - F}{2} (1 + K_1)}{mg} \right]$$

$$= \frac{895}{0.1732} \left[\frac{2 \times 9.81 + \left(\frac{15 \times 9.81 - 24}{2} \right)(1 + 0.753)}{2 \times 9.81} \right]$$

$$= 33596.$$

$$N_1 = \sqrt{33596} = 183.3 \text{ rpm}$$

$$\boxed{N_1 = 183.3 \text{ rpm}}$$

From fig. b. $r_2 = 0.2 \sin 40^\circ = 0.2 \times 0.643 = 0.1268$ m

Height of governor,

$$h_2 = 0.2 \cos 40^\circ = 0.2 \times 0.766 = 0.1532 \text{ m}$$

$$Bc = \sqrt{0.25^2 - 0.1268^2} = 0.2154 \text{ m}$$

$$\tan \beta_2 = \frac{0.1268}{0.2154} = 0.59.$$

$$\tan \alpha_2 = \tan 40^\circ = 0.839$$

$$K_2 = \frac{\tan \beta_2}{\tan \alpha_2} = \frac{0.59}{0.839} = 0.703$$

$$N_2^2 = \frac{895}{h_2}\left[\frac{mg + \frac{Mg+F}{2}(1+k_2)}{mg}\right]$$

$$= \frac{895}{0.1532}\left[\frac{2\times 9.81 + \frac{15\times 9.81+24}{2}(1+0.703)}{2\times 9.81}\right]$$

$$= 49,236$$

$$N_2 = \sqrt{49236} = 222 \text{ rpm}$$

$$\boxed{N_2 = 222 \text{ rpm}}$$

Range of Speed

$$= N_2 - N_1$$

$$= 222 - 183.3$$

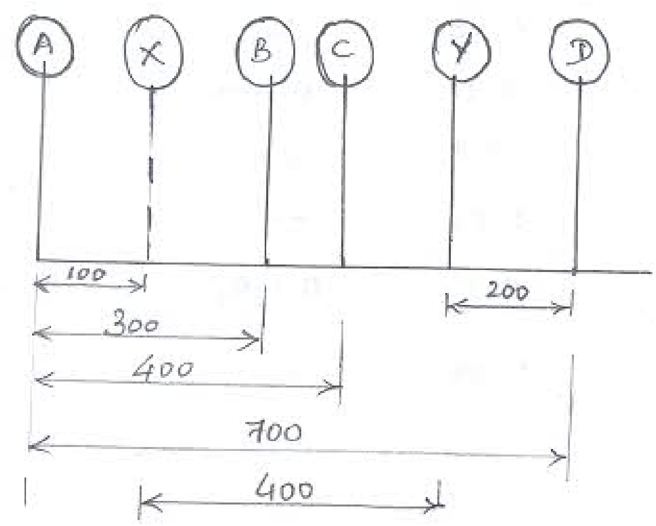
$$= 38.7 \text{ rpm}$$

2. A Shaft Carries four masses A, B, C & D of Magnitude 200kg, 300kg, 400kg & 200 kg respectively and revolving at radii 80 mm, 70 mm, 60 mm & 80 mm in planes measured from A at 300mm, 400 mm & 700 mm. The angles between the cranks measured anticlockwise are A to B 45°, B to C 70° & C to D 120°. The balancing masses are to be placed in planes X & Y. The distance b/w the planes A & X is 100 mm, between X & Y is 400 mm and b/w Y & D is 200mm. If the balancing masses revolve at a radius of 100mm, find their magnitudes & angular positions.

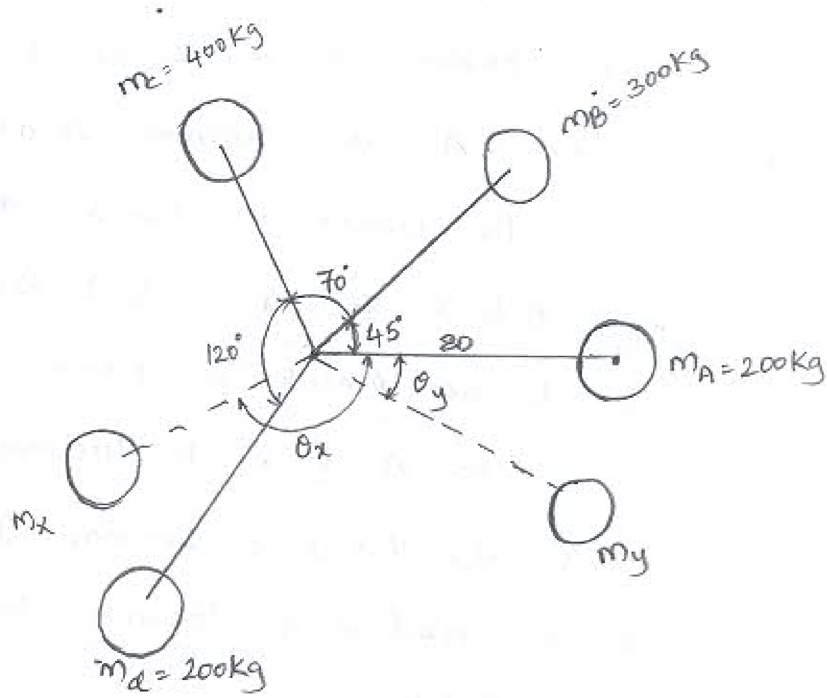
Sol:

Position of planes

All dimensions in mm.



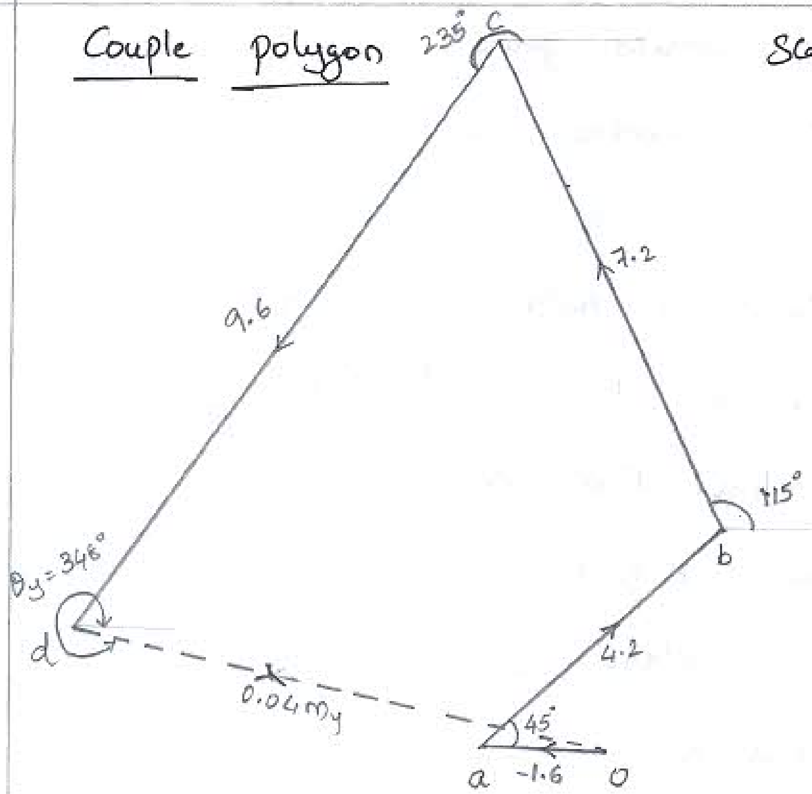
Space diagram   Scale 1cm = 20mm



Planes	Masses (m) Kg	Radius (r) m	Cent. force ÷ ω^2 (mr) Kg-m	Distance from R.P (l) m	Couple ÷ ω^2 (mrl) Kg-m²
A	200	0.08	16	-0.1	-1.6
x	m_x	0.1	$0.1m_x$	0	0
B	300	0.07	21	0.2	4.2
C	400	0.06	24	0.3	7.2
Y	m_y	0.1	$0.1m_y$	0.4	$0.04\,m_y$
D	200	0.08	16	0.6	9.6

Couple polygon

Scale 1 cm = 1 kg-m^2



$0.04\, m_y = od$

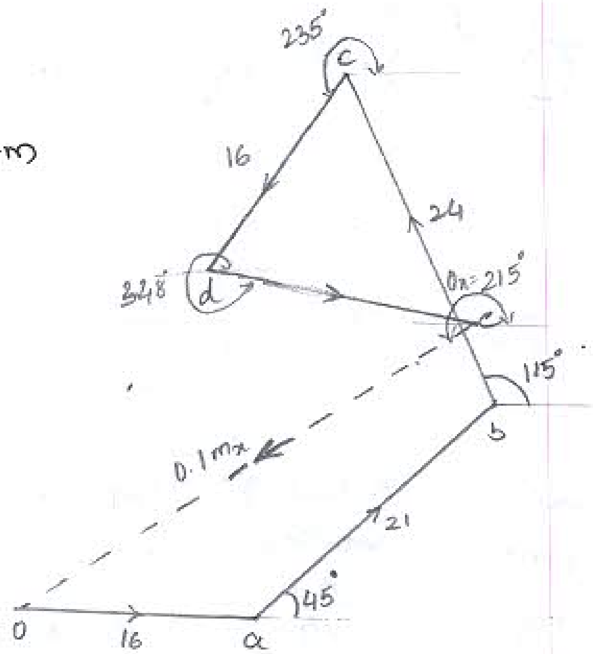
$0.04\, m_y = 7.3$ kg-m^2

$m_y = 182.5$ kg.

$\theta_y = 348°$

Force polygon

Scale 2 cm = 1 kg-m



$oe = \frac{7.1}{2} = 3.55$

$0.1\, m_x = 35.5$ kg-m

$m_x = 355$ kg

$\theta_x = 215°$

3 In a Spring loaded Hartnell type governer, the extreme radii of rotation of the balls are 80mm & 120mm. The ball arm & the Sleeve arm of the bell crank lever are equal in length. The mass of each ball is 2Kg. If the Speeds at the two extreme positions are 400 & 420 rpm. find.

1 The initial Compression of the Central Spring.

2. the Spring Constant.

Sol Given: $r_1 = 80mm = 0.080\ m$, $r_2 = 120mm = 0.12m$; $x = y$.

$m = 2\ kg$; $N_1 = 400\ rpm$; $N_2 = 420\ rpm$

$\omega_1 = \frac{2\pi N_1}{60}$; $\omega_2 = \frac{2\pi N_2}{60}$

$= \frac{2\pi(400)}{60}$; $= \frac{2\pi(420)}{60}$

$\omega_1 = 41.9\ rad/sec$; $\omega_2 = 44\ rad/sec$.

Centrifugal force.

$$F_{c_1} = m\omega_1^2 r_1 = 2(41.9)^2\ 0.08 = 281N.$$

$$F_{c_2} = m\omega_2^2 r_2 = 2(44)^2\ 0.12 = 465N.$$

Let S_1 = Spring force at minimum speed

S_2 = Spring force at maximum speed

For minimum position

$$M.g + S_1 = 2F_{c_1} \times \frac{x}{y}$$

$$S_1 = 2F_{c_1} = 2 \times 281 = 562N$$

$$\boxed{S_1 = 562\ N}$$

For Maximum position

$$M.g + S_2 = 2 F_{c_2} \times \frac{x}{y}$$

$$S_2 = 2 F_{c_2} = 2 \times 465 = 930 \text{ N}$$

$$\boxed{S_2 = 930 \text{ N}}$$

Lift of the Sleeve

$$h = (r_2 - r_1) \frac{y}{x} = r_2 - r_1 = 0.12 - 0.08 = 0.04 \text{ m}$$

$$\boxed{h = 0.04 \text{ m}}$$

Stiffness of Spring / spring constant

$$S = \frac{S_2 - S_1}{h} = \frac{930 - 562}{0.04} = 9200 \text{ N/m}$$

Initial Compression of Central Spring

$$= \frac{S_1}{S} = \frac{562}{9200} = 0.061 \text{ m}$$

4 Four masses 150, 250, 200 & 300 kg are rotating in Same plane at radii of 0.25 m, 0.2 m, 0.3 m & 0.35 m resp. There angular locations are $40°$, $120°$ & $250°$ from mass 150 kg respectively measured in Counter clockwise direction. Find the position & magnitude of balance mass required, if its radius of rotation is 0.25 m.

Masses m (Kg)	Radius of rotation r (m)	Centrifugal force $\div \omega^2$ mr (kg-m)	Angular positions θ (deg)	Horizontal Components H ($mr\cos\theta$) kg-m	Vertical Components V ($mr\sin\theta$) kg-m
150	0.25	37.5	0	37.5	0
250	0.2	50	40	38.3	32.14
200	0.3	60	120	−30	51.96
300	0.35	105	250	−35.9	−98.67
				$\Sigma H = 9.9$	$\Sigma V = -14.57$

Resultant

$$R = \sqrt{(\Sigma H)^2 + (\Sigma V)^2} = \sqrt{9.9^2 + (-14.57)^2}$$

$$\boxed{R = 17.61 \text{ kg-m.}}$$

$$\tan\theta = \frac{\Sigma V}{\Sigma H} = \frac{-14.57}{9.9} = -1.47172$$

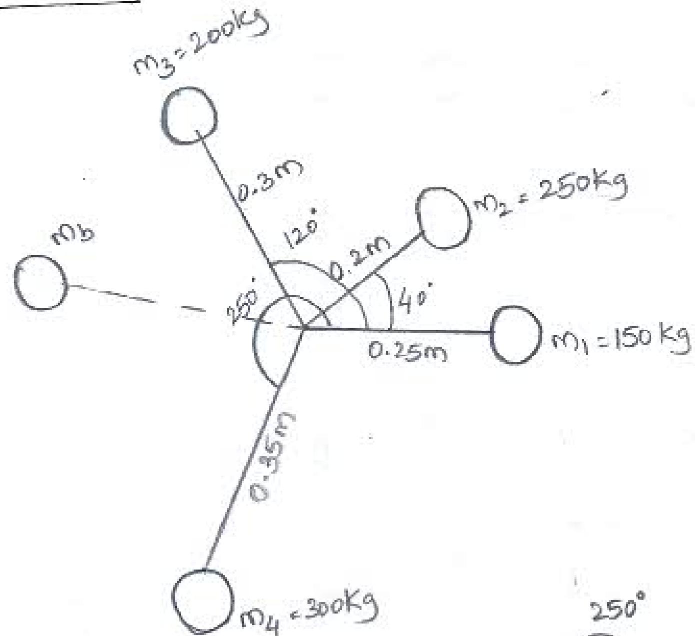
$$\theta = -55.8°$$

$$\theta_b = 180 + \theta = 180 - 55.8$$

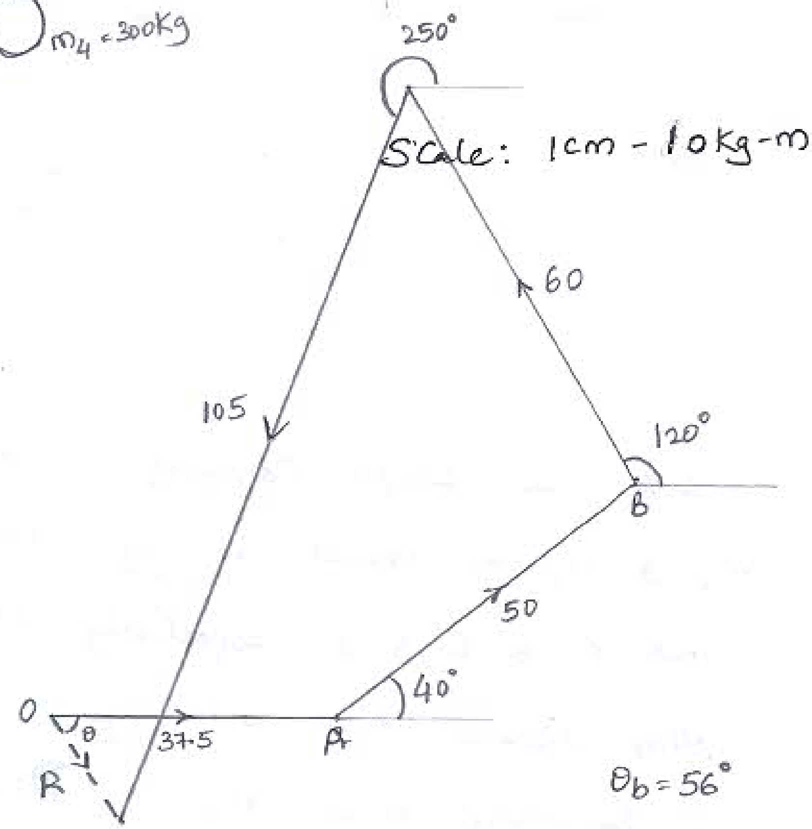
$$\boxed{\theta_b = 124.2°}$$

Graphical Method

Space diagram



Vector diagram :-



$m_b r_b = R = 18$

$m_b . \ 0.25 = 18$

$\boxed{m_b = 72 Kg}$ - Balancing mass.