Internal Assessment Test I – Sept. 2018

Sub:	Dynamics of Machinery							**Code:**	15ME52
Date**:**	07/ 09 / 2018	Duration:	90 mins	Max Marks:	50	**Sem:**	V	**Branch:**	MECH

Note: Answer any **five** questions.

		Marks	OBE CO	OBE RBT
	Note: Answer all **four** questions			
1	a) Define the following i)Sensitiveness (ii) Isochronism (iii)Hunting of governor (iv)Effort of governor	**12.5**	CO3	L1
	b) Derive an expression for equilibrium speed of governor			L2
2	The mass of each ball of a Hartnell type governor is 1.4 kg. The length of ball arm of the bell-crank lever is 100 mm where as the lengths of arm towards sleeve is 50 mm. The distance of the fulcrum of bell-crank lever from the axis of rotation is 80 mm. the extreme radii of rotation of the balls are 75 mm and 112.5 mm. The maximum equilibrium speed is 6% greater than the minimum equilibrium speed which is 300 rev/min. determine i) Stiffness of the spring and ii) Equilibrium speed when the radius of rotation of the ball is 90 mm.	**12.5**	CO3	L2
3	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.	**12.5**	CO2	L2
4	A shaft carries four rotating masses P, Q, R & S in order, along with the axis. The mass center is at 160mm, 180mm, 200mm & 120mm respectively for P, Q, R & S from axis. The masses Q, R & S are 40kg, 30kg & 50kg respectively. The planes contain Q & R are 300mm apart. The angular position of R & S are 90° and 120°respectively, w.r.t. Q measured in same sense. If the shaft and masses are to be in complete dynamic balance. Determine: i) mass and angular position of P ii)positions of P & S.	**12.5**	CO2	L2

Solution for Internal Assessment Test I - Sep. 2018

DYNAMICS OF MACHINERY (15ME52)

1a i) Sensitiveness :- It is defined as the ratio of the difference between the maximum & minimum speed to the mean speed.

$$S = \frac{N_2 - N_1}{\frac{N_1 + N_2}{2}} = \frac{2[N_2 - N_1]}{N_1 + N_2}$$

ii) 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 balls within the working range, neglecting friction.

iii) Hunting of governor :- A governor is said to be hunt if the speed of the engine fluctuates continuously above & below the mean speed.

iv) Effort :- It is the mean force exerted at the sleeve for a given percentage change of speed.

1.b. Equilibrium Speed of governor

Consider the forces acting on governor as shown.

Let m = Mass of each ball in kg,

M = Mass of central load in kg,

r = Radius of rotation in m,

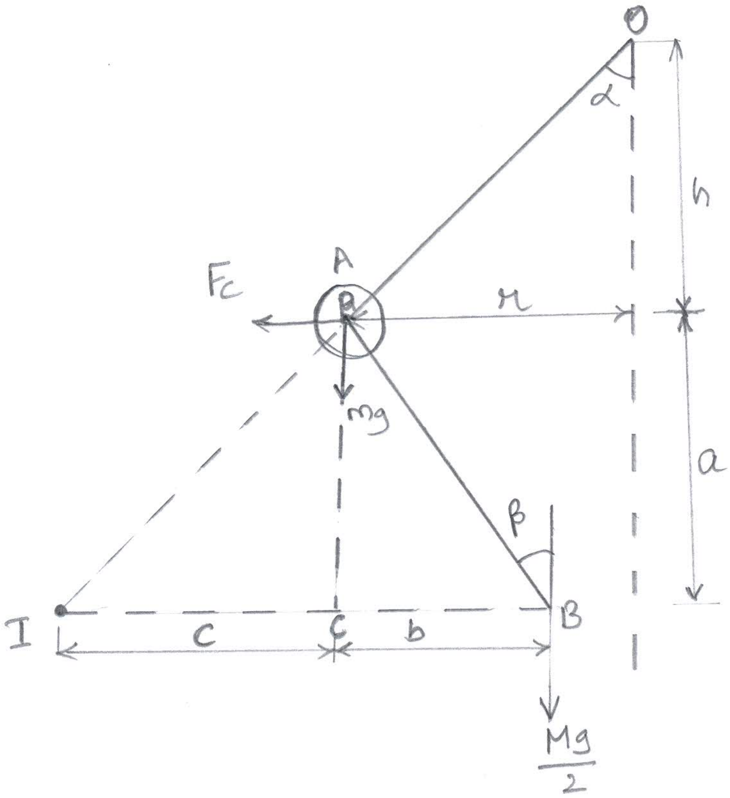
h = height of governor in m,

N = Speed of the balls in rpm,

F_c = Centrifugal force

α = Angle of inclination of upper arm to the vertical

β = Angle of inclination of lower arm to the vertical



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

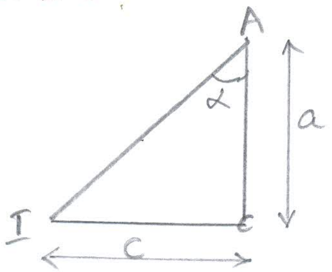
Taking moment about I

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

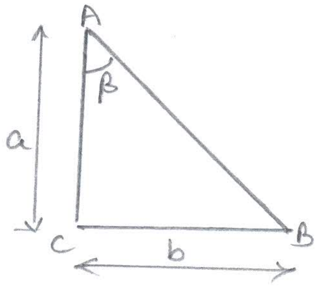
$$F_c = mg . \frac{c}{a} + \frac{Mg}{2}\left[\frac{c}{a} + \frac{b}{a}\right]$$

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

Consider Δ^{le} ACI



Consider Δ^{le} ACB



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

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

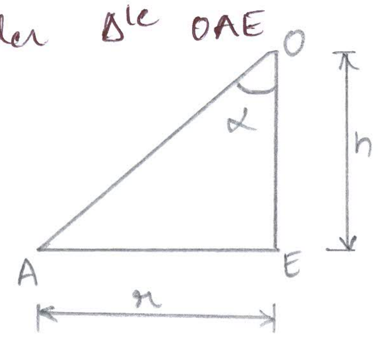
Sub. (A) & (B) in eqn (2) we get.

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

$$= \tan\alpha\left[mg + \frac{Mg}{2}\left(1 + \frac{\tan\beta}{\tan\alpha}\right)\right]$$

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

Consider Δ^{le} OAE



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

Sub. (C) in eqn (4)

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

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

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

$$\left(\frac{2\pi N}{60}\right)^2 = \frac{g}{h}\left[\frac{m + \frac{M}{2}(1+k)}{m}\right]$$

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

2. <u>Given</u>

$m = 1.4\ Kg$; $x = 100mm = 0.1m$; $y = 50mm = 0.05m$

$r_1 = 75mm = 0.075m$;

$r_2 = 112.5mm = 0.1125m$; $r = 0.09m$

$N_1 = 300rpm$; $N_2 = 300 + \frac{6}{100} \times 300 = 318\ rpm.$

$S = ?$; $N = ?$

<u>Angular velocity</u> : $\omega_1 = \frac{2\pi N_1}{60} = \frac{2\pi(300)}{60} = 31.42\ r/s$

<u>Centrifugal force</u>

$$F_{C_1} = m\omega_1^2 r_1^2$$

$$= 1.4\ (31.42)^2\ 0.075$$

$$F_{C_1} = 103.66\ N$$

<u>Angular Velocity</u> :- $\omega_2 = \frac{2\pi N_2}{60} = \frac{2\pi(318)}{60} = 33.3\ r/s$

$$F_{C_2} = m\omega_2^2 r_2 = 1.4\ (33.3)\ 0.1125$$

$$F_{C_2} = 174.65\ N$$

Stiffness of Spring

$$S = 2\left[\frac{F_{C_2}-F_{C_1}}{r_2-r_1}\right]\left[\frac{x}{y}\right]^2$$

$$= 2\left[\frac{174.65-103.66}{0.1125-0.075}\right]\left[\frac{0.1}{0.05}\right]^2$$

$$\boxed{S = 15.14 \times 10^3 \ N/m}$$

Centrifugal force at $r = 0.09m$

$$S = 2\left[\frac{F_{C_2}-F}{r_2-r}\right]\left[\frac{x}{y}\right]^2$$

$$15.14\times10^3 = 2\left[\frac{174.65-F}{0.1125-0.09}\right]\left[\frac{0.1}{0.05}\right]^2$$

$$F = 132.07 \ N$$

Centrifugal force

$$F = m\omega^2 r$$

$$132.07 = 1.4\left(\frac{2\pi N}{60}\right)^2 0.09$$

$$\boxed{N = 309.16 \ rpm}$$

3 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.

Sol

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

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

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

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

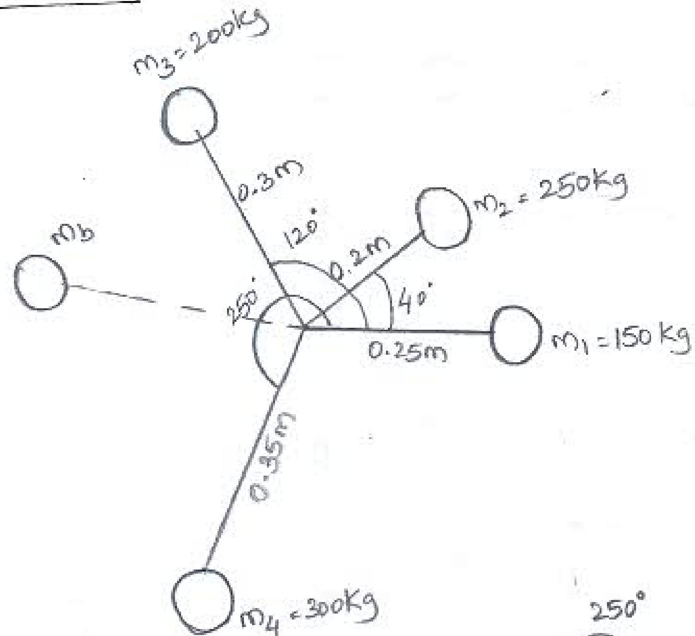
$$\theta = -55.8^\circ$$

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

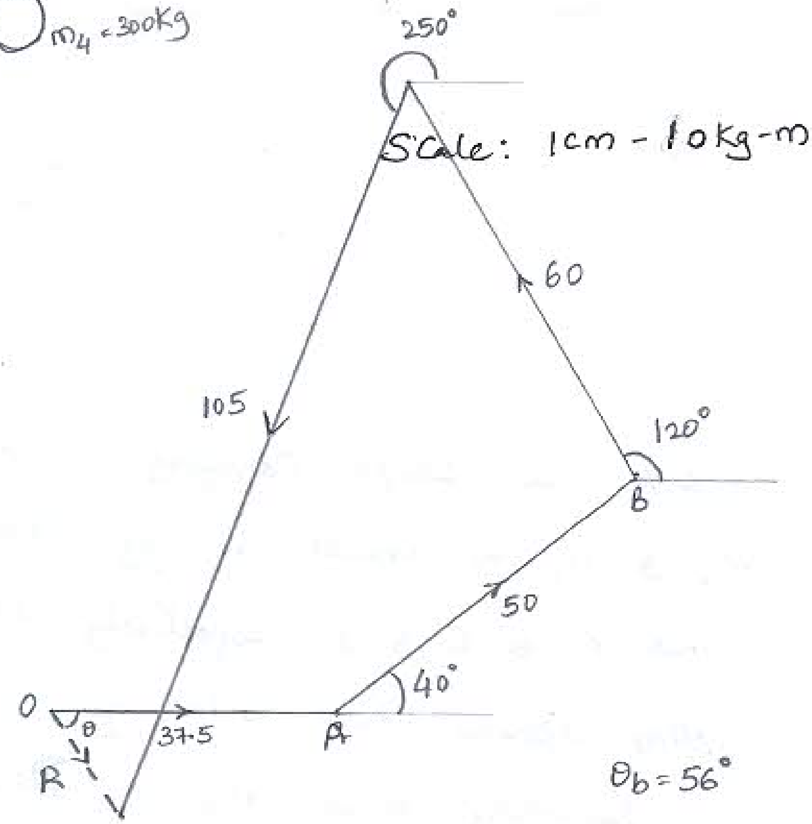
$$\boxed{\theta_b = 124.2^\circ}$$

Graphical Method

Space diagram



Vector diagram :-



$m_b r_b = R = 18$

$m_b . \ 0.25 = 18$

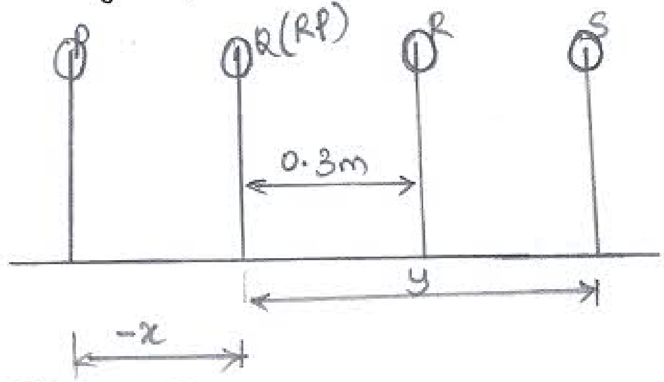
$\boxed{m_b = 72 Kg}$ - Balancing mass.

4 A Shaft carries four rotating masses P, Q, R & S in order along the axis. The mass centre is at 160 mm, 180 mm, 200 mm & 120 mm respectively for P, Q, R, S from axis. The masses Q, R & S are 40 kg, 30 kg & 50 kg resp. The planes containing Q & R are 300 mm apart. The angular positions of R & S are 90° & 210° respectively w.r.t Q measured in same sense. If the shaft & masses are to be in complete dynamic balance. Determine

i) Mass & angular position of P

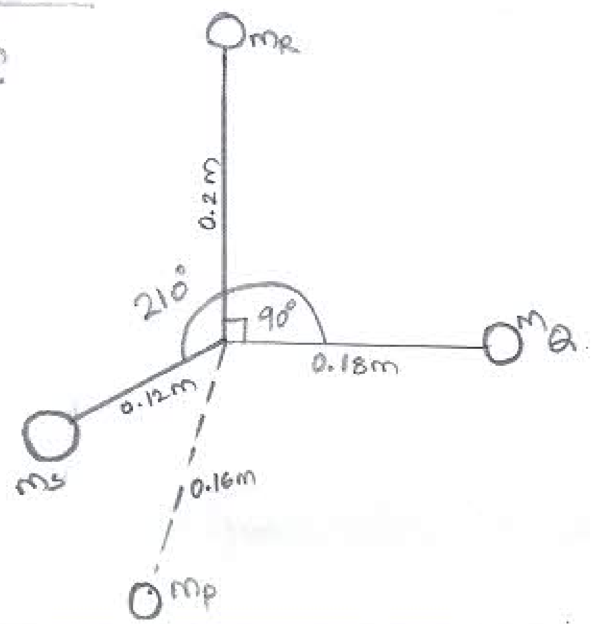
ii) Positions of planes P & S.

Sol



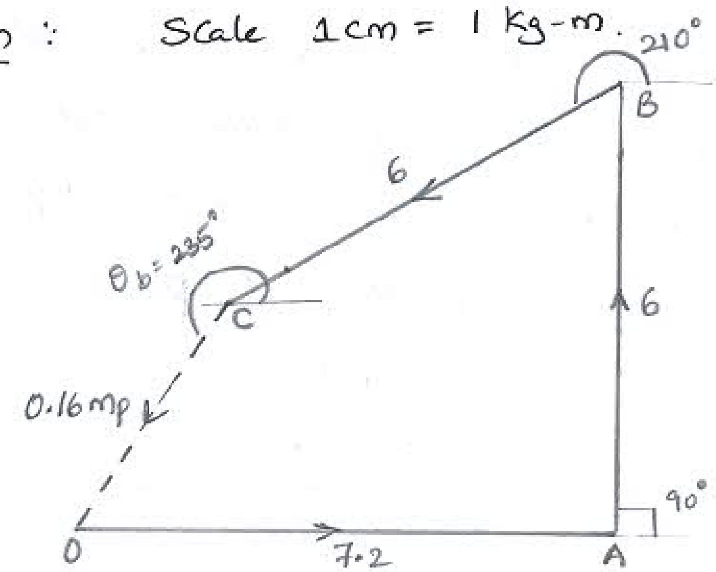
Position of planes.

Space diagram



Planes	Masses m (Kg)	Radius of rotation r (m)	Centrifugal force $\div \omega^2$ mr (Kg-m)	Distance from R.P 'l' (m)	Couple $\div \omega^2$ m r l Kg-m^2
P	m_p	0.16	$0.16\,m_p$	$-x$	$-0.16 m_p . x$
Q	40	0.18	7.2	0	0
R	30	0.2	6	0.3	1.8
S	50	0.12	6	y	6y

<u>Force</u> <u>Polygon</u> : Scale 1cm = 1 Kg-m.



OC = 3.6cm

$0.16 m_p = OC \times Scale$

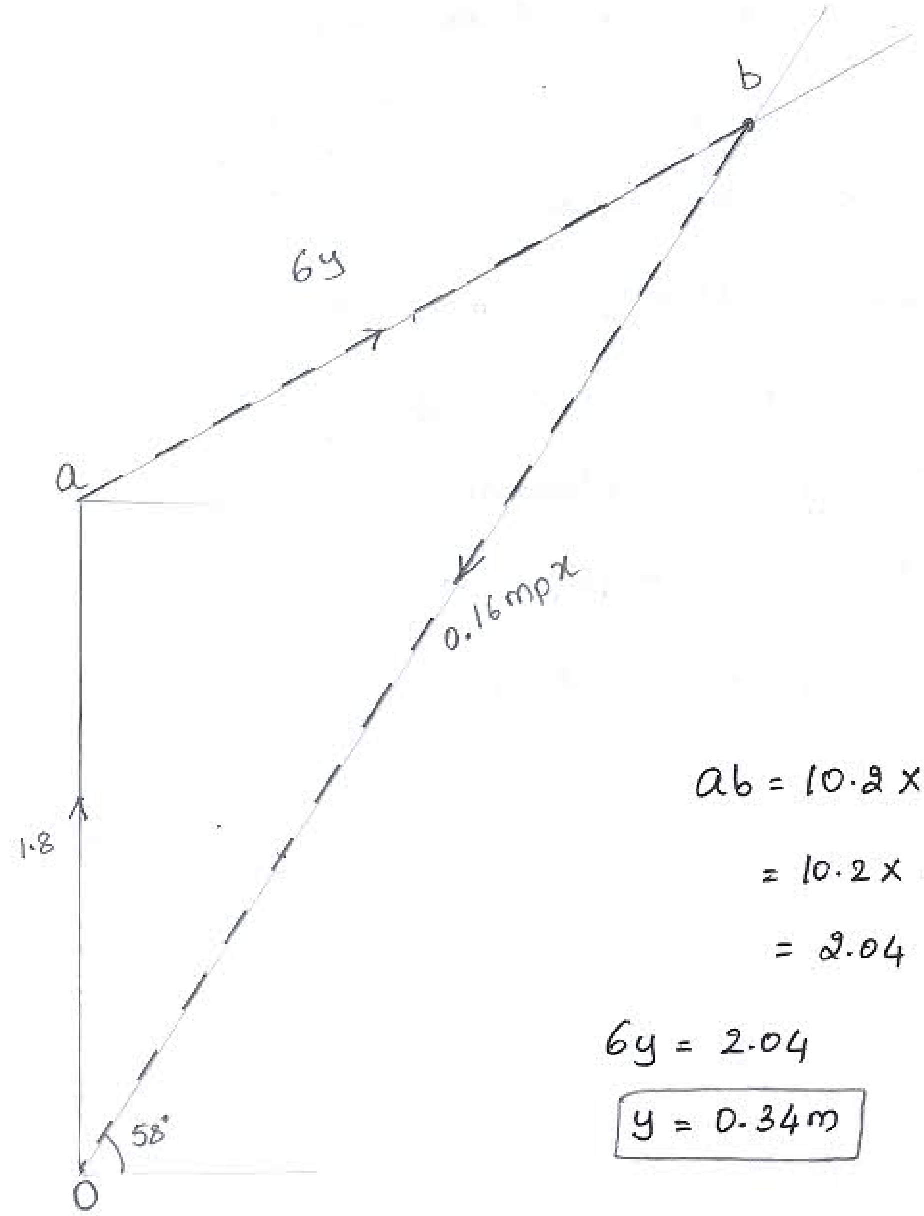
$0.16 m_p = 3.6$

$\boxed{m_p = 22.5 \text{ Kg-m}}$

$\boxed{\theta = 235°}$

Couple polygon

Scale $1\,cm = 0.2\ Kg \cdot m^2$



$$ab = 10.2 \times Scale$$
$$= 10.2 \times 0.2$$
$$= 2.04$$

$$6y = 2.04$$

$$\boxed{y = 0.34m}$$

$$-0.16\,mpx = ob \times Scale$$

$$-0.16 \times 22.5 \times x = 16.6 \times 0.2$$

$$x = \frac{-3.32}{-0.16 \times 22.5}$$

$$\boxed{x = -0.92\,m}$$