Internal Assessment Test I – Nov 2022

Sub:	Dynamics of Machinery	**Code:**	18ME53
Date: 05/ 11 / 2022	**Duration:** 90 mins **Max Marks:** 50 **Sem:** V	**Branch:**	MECH

Note: Answer **all** questions

		Marks	OBE	
			CO	RBT
1	Define the following i)Sensitiveness (ii) Isochronism (iii)Hunting of governor (iv)Effort of governor (v) Power of governor	**10**	CO3	L1
2	Derive an expression for equilibrium speed of governor.	**10**	CO3	L2
3	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.	**16**	CO3	L3
4	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.	**14**	CO2	L3

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Sub : Dynamics of Machines (18ME53)

IMP

SENSITIVENESS

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

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

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

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

STABILITY OF GOVERNORS

A governor is said to be stable when for every speed within the working range there is a definite configuration i.e there is only one radius of rotation of the governor balls at which the governor is in equilibrium.

For stable governor, if the equilibrium speed increases, the radius of governor balls must also increase.

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.

Consider a Porter governor running at Speeds N_1 & N_2

$$N_1^2 = \frac{895}{h_1}\left[\frac{m + \frac{M}{2}(1+K)}{m}\right]$$

$$N_2^2 = \frac{895}{h_2}\left[\frac{m + \frac{M}{2}(1+K)}{m}\right]$$

For isochronism, range of Speed should be zero.

i.e $N_2 - N_1 = 0$ or $N_2 = N_1$

i.e $h_1 = h_2$ which is impossible in case of Porter governor. Hence a Porter governor Cannot be isochronous.

Consider Hartnell governor running at Speeds N_1 & N_2.

$$Mg + S_1 = 2 F_{C_1} \times \frac{x}{y} = 2 m \omega_1^2 r_1 \cdot \frac{x}{y}$$

$$Mg + S_2 = 2 F_{C_2} \times \frac{x}{y} = 2 m \omega_2^2 r_2 \cdot \frac{x}{y}$$

For isochronism, $N_2 = N_1$

$$\frac{Mg + S_1}{Mg + S_2} = \frac{r_1}{r_2}$$

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

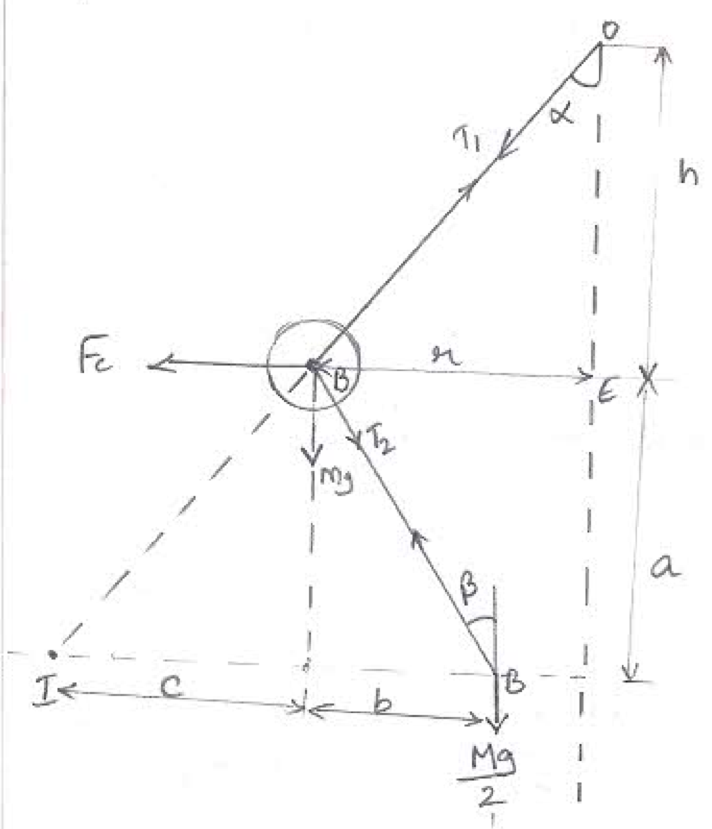
The effort of a governor is the mean force exerted at the sleeve for a given percentage change of speed.

The power of a governor is the work done at a sleeve for a given percentage change of speed. It is the product of the mean value of the effort & the distance through which the sleeve moves.

Power = Mean effort × lift of sleeve.

2. Instantaneous Centre method.

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



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

Taking moment about I.

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

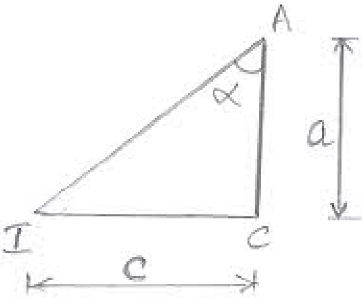
Centrifugal force $F_c = m\omega^2 r$

Substituting this in eqn (1)

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

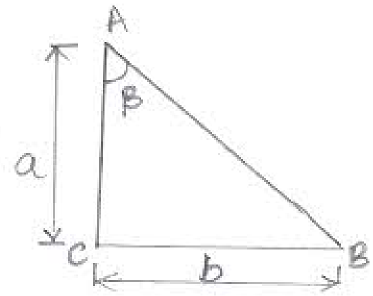
$$m\omega^2 r = mg . \frac{c}{a} + \frac{Mg}{2}\left[\frac{c}{a} + \frac{b}{a}\right] \rightarrow (2)$$

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

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

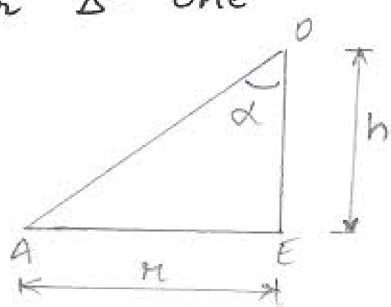
$$m\omega^2 r = \tan\alpha\left[mg + \frac{Mg}{2}\left(1 + \frac{\tan\beta}{\tan\alpha}\right)\right] \rightarrow (3)$$

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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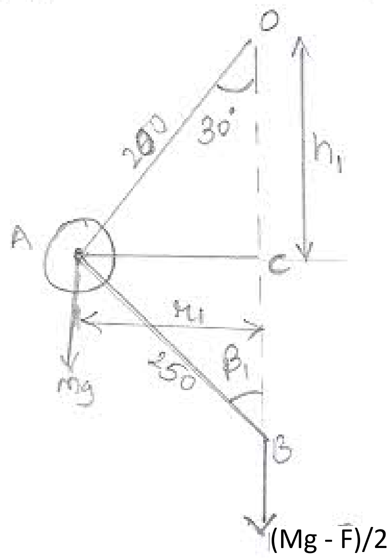
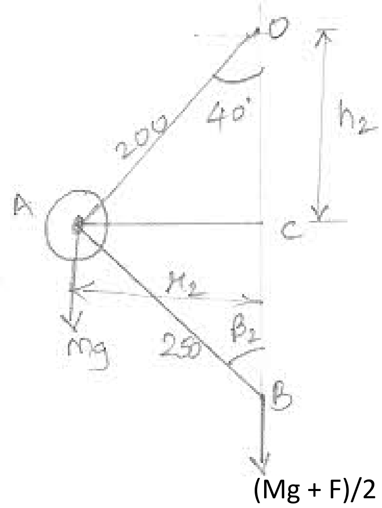
(P) In an engine governor of the Porter type, the upper & lower arms are 200 mm & 250 mm respectively & pivoted on the axis of rotation. The mass of the Central load is 15 Kg, the mass of each ball is 2 kg & friction of the sleeve together with the resistance of the operating gear is equal to a load of 24 N at the sleeve. If the limiting inclinations of the upper arms to the 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

$$= N_2 - N_1$$

$$= 222 - 183.3$$

$$= 38.7 \text{ rpm}$$

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

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

2. Given

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

$r_1 = 75\text{mm} = 0.075\text{m}$;

$r_2 = 112.5\text{mm} = 0.1125\text{m}$; $r = 0.09\text{m}$

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

$S = ?$; $N = ?$

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

Centrifugal force

$F_{c_1} = m\omega_1^2 r_1^2$

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

$F_{c_1} = 103.66$ N

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

$F_{c2} = m\,\omega_2^2\, r_2 = 1.4\,(33.3)\,0.1125$

$F_{c_2} = 174.65$ 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

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

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

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