Course Code: 1950319 **Roll No:** **MLRS- R19**

MARRI LAXMAN REDDY
INSTITUTE OF TECHNOLOGY AND MANAGEMENT

(AN AUTONOMOUS INSTITUTION)
(Approved by AICTE, New Delhi & Affiliated to JNTUH, Hyderabad)
Accredited by NBA and NAAC with 'A' Grade & Recognized Under Section2(f) & 12(B)of the UGC act,1956

III B.Tech I Sem Regular End Examination, January 2022
DYNAMICS OF MACHINERY
(MECH)

Time: 3 Hours. **Max. Marks: 70**

Note: 1. Question paper consists: Part-A and Part-B.
2. In Part – A, answer all questions which carries 20 marks.
3. In Part – B, answer any one question from each unit.
Each question carries 10 marks and may have a, b as sub questions.

PART- A

(10*2 Marks = 20 Marks)

1.	a)	Explain the terms : spin and precession	2M	CO1	BL4
	b)	Differentiate between static & dynamic equilibrium	2M	CO1	BL2
	c)	What is the function of a flywheel in a prime mover?	2M	CO2	BL1
	d)	Define coefficient of fluctuation of energy and coefficient of fluctuation of speed.	2M	CO2	BL1
	e)	Explain the terms: friction circle, friction couple , boundary friction and Fluid friction	2M	CO3	BL4
	f)	Differentiate between brake and clutch	2M	CO3	BL2
	g)	Explain the term: Isochronism and hunting in governors.	2M	CO4	BL4
	h)	Why complete balancing is not possible in reciprocating engine	2M	CO4	BL1
	i)	Define the terms vibration isolation and transmissibility	2M	CO5	BL1
	j)	Explain the term 'whirling speed, or 'critical speed' of a shaft.	2M	CO5	BL4

PART- B

(10*5 Marks = 50 Marks)

2	An aero-plane makes a complete half circle of 50 m radius towards left in a time of 20 seconds when flying at 200kmph. The rotary engine and the propeller of the plane has a mass of 400kg and a radius of gyration of 0.3 m. The engine rotor rotates at 2400 rpm clockwise when seen from the rear. Find the gyroscopic couple on the air craft and state its effect on the aero-plane.	10M	CO1	BL3
	OR			
3	If the crank and connecting rod are 300 mm and 1 m long respectively and the crank rotates at a constant speed of 200 rpm, determine the maximum velocity of the piston and crank angle at which the maximum velocity occurs.	10M	CO1	BL3
4	A single cylinder, single acting, four stroke gas engine develops 20kW at 300rpm. The work done by the gases during the expansion stroke is three times the work done on the gases during the	10M	CO2	BL3

compression stroke, the work done during the suction and exhaust strokes being negligible. If the total fluctuation of speed is not to exceed ± 2 percent of the mean speed and the turning moment diagram during compression and expansion is assumed to be triangular in shape, find the moment of inertia of the flywheel

OR

5		The turning moment diagram for a multi cylinder engine has been drawn to a scale of 1mm to 500 Nm of torque and 1mm to 6DEG of crank displacement The intercepted areas between the output torque curve and the mean resistance line taken in order from one end of the engine are -30,+410, -280+320, -330, +250, -360, +280, -260 mm2 when the engine runs at 800 rpm. The engine has a stroke of 300mm and the fluctuation of speed is not to exceed 2% of mean speed. Determine suitable diameter and cross section of the flywheel rim for a limiting value of safecentrifugal stress of 7 Mega Pascal. The material density is 7200kg/m3. Width of the rim is 5 times the thickness.	10M	CO2	BL3
6	a)	Differentiate between Single and Multi-Plate Clutches	5M	CO3	BL2
	b)	A multi plate clutch is used to transmit 5 kw power at 1440 rpm. The inner & outer diameters of contacting surfaces are 50 mm and 80 mm respectively. The coefficient of friction and the average allowable pressure intensity for the lining may be assumed as 0.1 and 350 kPa respectively. Determine (i) Number of friction plates & pressure plates (ii) Axial force required to transmit power (iii) The actual average pressure (iv) Actual maximum pressure intensity after wear.	5M	CO3	BL3

OR

7	a)	Describe a suitable arrangement to cool the pulley of a rope brake dynamometer	5M	CO3	BL2
	b)	A conical pivot supports a load of 20kN, cone angle is 1200 and intensity of pressure normal to the cone is 0.3N/mm2. The outer diameter is twice the inner diameter. Find the outer and inner radii of bearing surface if the shaft rotates at 200 rpm and μ= 0.1. Find the power absorbed in friction assuming uniform wear.	5M	CO3	BL3
8		Each of the rotating balls of a Hartung governor has a mass of 3.2 kg. The minimum and maximum radii of rotation of the governor balls are 11.4 cm and 14cm respectively. Each spring has a stiffness of 87 N/cm and an initial compression of 5 cm. The mass of the sleeve is negligible. Determine the equilibrium speed of the governor at the mean position when the radius is 12.7 cm. Also, find the required spring stiffness and the initial compression to make the governor isochronous at this speed.	10M	CO4	BL3

OR

9	A shaft carries four rotating masses A, B, and C which are completely balanced. The masses B, C and D are 50 kg, 80 kg and 70 kg respectively. The masses C and D make angles of 90DEG and 195DEG respectively with mass B in the same sense. The masses A, B, C and D are concentrated at radius 75 mm, 100 mm, 50 mm and 90 mm respectively. The plane of rotation of masses B and C are 250 mm apart. Determine: (i) the mass A and its angular position, (ii) the position of planes of A and D.	10M	CO4	BL3
10	A horizontal shaft 10mm diameter rotates in long bearings and a disc of mass of 4 kg is secured to the shaft at the middle of its length. The span of the shaft between the bearings is 0.75m. The mass centre of the disc is 0.2mm from the axis of the shaft. Neglecting the mass of the shaft, determine its central deflections in terms of the speed of rotation in rpm if E=200 GN/m^2.	5M	CO5	BL3
	OR			
11	A steel shaft 1.5m long is supported on simply supported bearings at its ends. It carries two rotors, 50 kg each at its one-third points. The shaft is hollow, external diameters is 8 cm and the internal diameter is half of the external diameter. Determine the natural frequency by Dunkerley's method	10M	CO5	BL3

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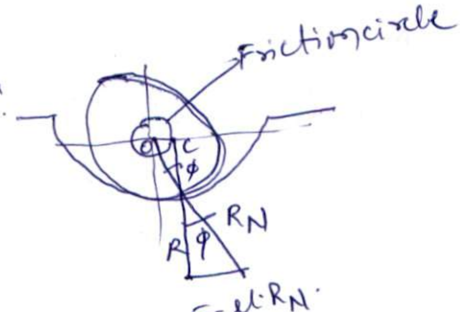
EXAMINATION BRANCH

Academic Year	2021-22
Year & Semester	B.Tech III & I Sem.
Regulation	R-19 (MLRS).
Branch	Mechanical.
Course Code	1950319
Course Name	Dynamics of Machinery
Course Faculty	P. Satya Krishna.
Course Moderator	P. Satya Krishna.
Date of Exam	3/1/22.
Reporting Time & Sign	8:30

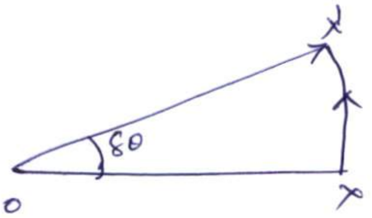
SCHEME OF VALUATION

QNO	ANSWER	MARKS
	PART-A.	
1A) a)	Spin: The plane in which wheel intended to rotate.	1/2 m. + 1/2 = 1M
	Precession: The axis about which the spin axis itself is made to turn	1/2m + 1/2 = 1m.
b)	Static equilibrium: when body is at rest.	1/2M + 1/2 = 1m
	Dynamic equilibrium: when body in motion	1m.
c)	Function of flywheel: To control the speed variation caused by fluctuation of engine turning moment during each cycle of operation	2M.

QNO	ANSWER	MARKS
d)	Coefficient of fluctuation of speed: The ratio of max. fluctuation of speed to the mean speed is coefficient fluctuation of speed. $C_s = \frac{N_1 - N_2}{N}$	1M.
	Coefficient of fluctuation of energy: The ratio of max. fluctuation of energy to W.D per cycle. $C_E = \frac{\text{Max. fluctuation}}{\text{W.D/cycle}}$	1M
e)	Friction circle: 	
	The circle drawn with centre O with radius $OC = r\sin\phi$ then that circle is friction circle	1/2M.
	Friction couple: 1/2M.	
	Boundary friction: It is friction experienced b/w rubbing surfaces, when surfaces have a very thin layer of lubricant — 1/2M.	

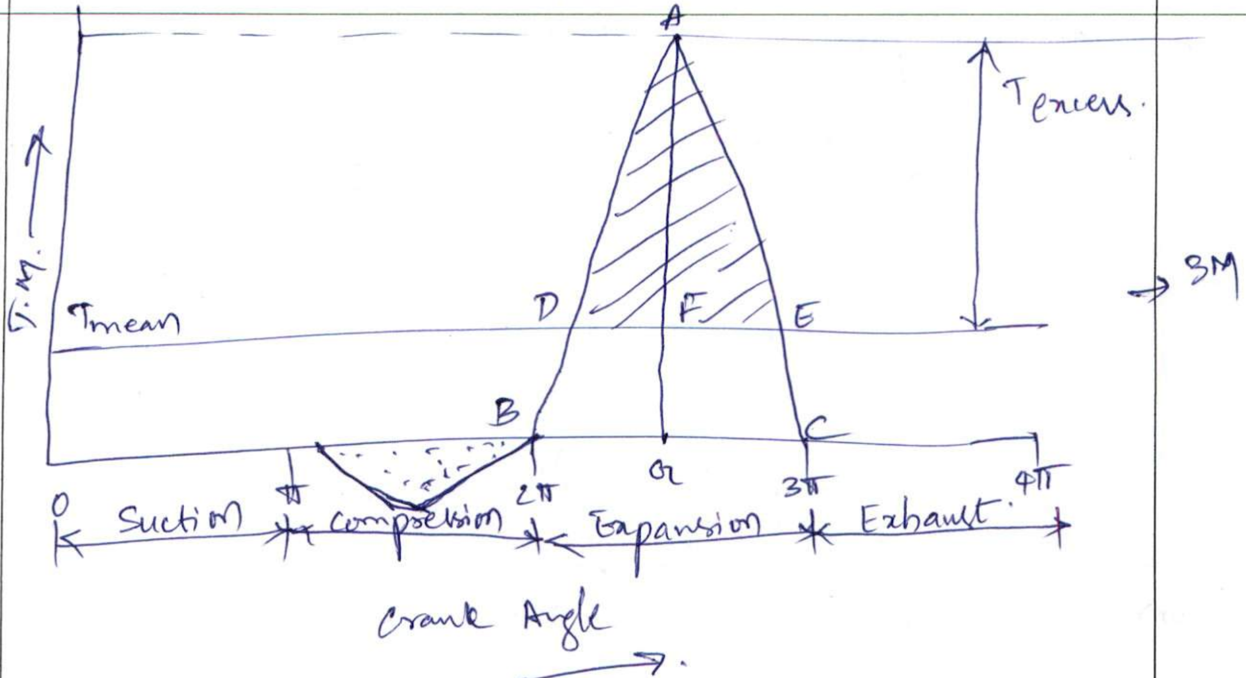
QNO	ANSWER	MARKS
	Fluid friction: It is friction experienced b/w the rubbing surfaces, when surfaces have a thick layer of lubricant.	1/2M
f)	Brake: It is device by means of Artificial friction resistance applied to moving m/c in order to retard or stop.	1M
	Clutch: A friction clutch used in transmission of power of shafts and m/c's which must be started and stopped frequently.	1M.
g)	Isochronism: A governor is said to be isochronism when equilibrium speed is constant (i,e range of speed is zero).	1M.
	Hunting: A governor is said to be hunt if speed of engine fluctuates continously above and below mean speed.	1M

QNO	ANSWER	MARKS
h)	The purpose of balance in reciprocating process is to eliminate shaking force, but in practical whe can't eliminate completely due unbalanced force acts along ⊥r to line of stroke.	2M
i.)	vibration: when elastic bodies are displaced from equilibrium position by application of external forces, and the released, they execute at motion which is called vibration.	1M
	isolation – 1/2M, transmittibility – 1/2M.	
j.)	whirling Speed: The speed at which the shaft runs so that the additional deflection of the shaft from the axis of rotation becomes infinite, is known as critical or whirling Speed.	2M

QNO	ANSWER	MARKS
	PART-B.	
2A)	Given $R = 50$ m, $v = 200$ km/hr $= 55.6$ m/s, $m = 400$ kg and $k = 0.3$ m, $N = 2400$ rpm, $\omega = \frac{2\pi \times 2400}{60} = 251$ rad/s.	
	$I = m \cdot k^2 = 400(0.3)^2 = 36$ kg-m^2	2M
	$\omega_p = v/R = 55.6/50 = 1.11$ rad/s.	2M
	$C = I \cdot \omega \cdot \omega_p = 36 \times 251.4 \times 1.11 = 10046$ N-m $= 10.046$ kN-m.	4M
	 Aeroplane takingleft turn	2M
	when aeroplane turns towards left, the effect of gyroscopic couple is to lift nose upwards and tail downwards.	

QNO	ANSWER	MARKS
3A)	Given: $r = 300mm = 0.3m$, $l = 1m$, $N = 200rpm$ $\left(\frac{2\pi \times 200}{60}\right)$, $\omega = 20.95$ rad/s	→ 2M
	Crank angle at which max. vel. occurs.	
	let θ = Crank angle from IDC at which max. vel. occurs.	
	$n = l/r = 1/0.3 = 3.33$	
	vel. of piston $v_p = \omega \cdot r\left(\sin\theta + \frac{\sin 2\theta}{n}\right)$	→ 5M.
	for max. vel. $\frac{dv_p}{d\theta} = 0$	
	$\Rightarrow \omega \cdot r\left(\cos\theta + \frac{2\cos 2\theta}{2n}\right) = 0$ $(\cos 2\theta = 2\cos^2\theta - 1)$	
	$\Rightarrow n\cos\theta + 2\cos^2\theta - 1 = 0$	
	$= 2\cos^2\theta + 3.33\cos\theta - 1 = 0$	
	$\cos\theta = \frac{-3.33 \pm \sqrt{(3.33)^2 + 4\times 2\times 1}}{2\times 2} = 0.26$	
	$\theta = 75°$ (Taking +ve sign).	

QNO	ANSWER	MARKS
	Max. vel. of piston at $\theta = 75^0$.	
	$v_{p(max)} = \omega \cdot r \left[\sin 75^0 + \frac{\sin 150}{2n} \right]$	— 3M.
	$= 20.95 \times 0.3 \left[0.966 + \frac{0.5}{3.33} \right]$ m/s.	
	$= 6.54$ m/s.	
4A)	Given: $P = 20kW = 20 \times 10^3 W$, $N = 300$ rpm, $\omega = 31.42$ rad/s.	
	Since total fluctuation not to exceed $\pm 2\%$	→ 2M
	$\omega_1 - \omega_2 = 4\% \omega$	
	coefficient of fluctuation of speed	
	$C_s = \frac{\omega_1 - \omega_2}{\omega} = 4\% = 0.4$	
	Assume turning moment dia during compression and expansion to be triangular in shape, neglecting suction and exhaust.	

QNO	ANSWER	MARKS
		
	Net W.D/cycle $= W_E - W_C = W_E - \frac{W_E}{3}$ $(\because W_E = 3W_C)$	
	$= \frac{2}{3} W_E$	
	We know for 4-stroke engine, as no. of working strokes / cycle	
	$= n = N/2 = 300/2 = 150$	
	$\therefore$ W.D/cycle $= P \times \frac{60}{n} = 20 \times 10^3 \times \frac{60}{150}$	
	$= 8000$ N-m.	
	$\therefore W_E = 8000 \times 3/2 = 12000$ N-m.	
	W.D during expansion stroke (W_E) = Area of Δ ABC.	

QNO	ANSWER	MARKS
	$= 12{,}000 = \Delta ABC = \frac{1}{2} \times BC \times AG$ $= \frac{1}{2} \times \pi \times AG$ $AG = T_{max} = 12000 \times 2/\pi = 7638$ N-m. * $T_{mean} = FG = \frac{W.D/cycle}{Crankangle/cycle} = \frac{8000}{4\pi}$ $= 637$ N-m. $\therefore T_{excess} = AF = AG - FG$ $= 7638 - 637$ $= 7001$ N-m. Now, for similar ΔADE & ABC $\frac{DE}{BC} = \frac{AF}{AG}$ or $DE = \frac{AF}{AG} \times BC$ $= \frac{7001}{7638} \times \pi$ $= 2.88$ rad. $\Delta E = \Delta ADE$ $= \frac{1}{2} \times DE \times AF = \frac{1}{2} \times 2.88 \times 7001$ $= 10081$ N-m. Let I – Moment of Inertia. $\Rightarrow \Delta E = I \cdot \omega^2 \cdot C_s$ ·	

(OR) * $P = T_{mean} \times \omega \Rightarrow T_{mean} = \frac{P}{\omega} = \frac{20\times10^3}{31.42} = 637$ N-m.

QNO	ANSWER	MARKS
	$\Rightarrow 10081 = I \times (31.42)^2 \times 0.04 = 39.5 I$.	— 5M.
	$\Rightarrow I = \frac{10081}{39.5} = 255.2 \text{ kg-m}^2$	
5A)	Given: $N = 800$ rpm.	
	$\omega = \frac{2\pi \times 800}{60} = 83.8$ rad/s.	
	Stroke = 300 mm	
	$\sigma = 7 MPa = 7 \times 10^6 N/m^2$	— 2M
	* Taking $\rho = 7200 kg/m^3$	
	∵ fluctuation of speed is ± 2%.	
	$\omega_1 - \omega_2 = 4\% \omega = 0.04\omega$.	
	$C_s = \frac{\omega_1 - \omega_2}{\omega} = 0.04$.	
	D = Dia. of flywheel rim in m.	
	v = peripheral vel.	
	centrifugal stress (σ) $= \rho . v^2$	
	$= 7 \times 10^6 = \rho . v^2 = 7200 v^2$	
	$v = \sqrt{972.2}$ $= 31.2$ m/s.	— 2M

* procedure is same when $\rho = 720 kg/m^3$ but answers may vary.

QNO	ANSWER	MARKS
	⇒ but $V = \pi D \cdot N/60$	
	$D = v \times 60/\pi N = \frac{31.2 \times 60}{\pi} \times 800 = 0.745m$	
	let t = Thickness of flywheel rim in m.	
	b = width of flywheel rim in m. = 5t.	
	$\therefore A = b \times t = 5t \times t = 5t^2$	3M
	From turning moment dia.	
	ΔE = Max. energy − Min energy	
	$= (E+420) - (E-30) = 450\ mm^2$	
	$= 450 \times 52.37 = 23566$ N-m	
	$\Delta E = m \cdot v^2 \cdot C_s$.	
	$= 23566 = m \times (31.2)^2 \times 0.04 = 39m$.	
	$m = \frac{23566}{39} = 604$ kg.	
	$m = vol. \times density = \pi D \cdot A \cdot \rho$.	
	$= \pi \times 0.745 \times 5t^2 \times 7200$	
	$= 84268\, t^2$	3M
	$t^2 = 604/84268 = 0.00717\ m^2$ or $t = 0.085m = 85mm$.	

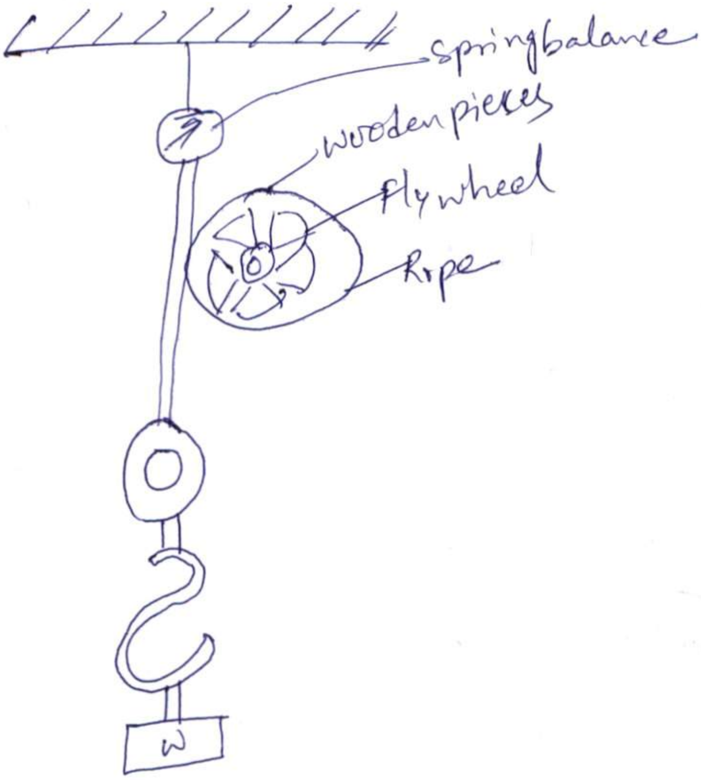
$b = 5t = 5 \times 85 = 425$ mm.

QNO	ANSWER	MARKS
6(A)a)	Single plate Clutch → $2\frac{1}{2}$M ; Multiplateclutch → $2\frac{1}{2}$M. Refer pg No. 19 & 20 for Answer.	$2\frac{1}{2}+2\frac{1}{2}$ = 5M
b)	Given : $P = 5kW = 5\times10^3 W$. $N = 1440 rpm = \frac{2\pi \times 1440}{60} = 150.79 rad/s$. r_1 = outer radi = 80mm. r_2 = inner radi = 50mm. $P_{av} = 350 kpa = \frac{350}{1000} = 0.35 N/mm^2$ $\mu = 0.1$	2M
	$P_{av} = \frac{W}{\pi(r_1^2 - r_2^2)} = 0.35 = \frac{W}{\pi(80^2 - 50^2)}$ $W = 4286 N$.	
	The actual average pre. — 1M Actual max. pre intensity after wear — 1M No. of friction plates and pre. plates — 1M.	~~5M~~

7A) a) Rope Brake Dynamometer.

(13)

5M



It is another form of Absorption type. It consists one, two or more ropes wound around the flywheel or rim of a pulley fixed rigidly to shaft of an engine. The upper end of ropes kept constant.

$$W \cdot D / rev. = (W - S)\pi(D + d) \text{ N-m.}$$

$$W \cdot D / min. = (W - S)\pi(D + d)N \text{ N-m.}$$

$$B.P = \frac{W \cdot D / min}{60} = \frac{(W - S)\pi(D + d)N}{60} \text{ W.}$$

$$B.P = \frac{(W - S)\pi D N}{60} \text{ W.}$$

b) Given $W = 20\,kN = 20 \times 10^3\,N$

$N = 200\,rpm.$

$2\alpha = 120^0$

$\omega = 2\pi \times \frac{200}{60}$

$\alpha = 60^0$

$= 20.95\ rad/s.$

$P_n = 0.3\,N/mm^2$

$\mu = 1.$

$r_1 = 2 r_2.$

$$P_n = \frac{W}{\pi(r_1^2 - r_2^2)}$$

$$= 0.3 = \frac{20 \times 10^3}{\pi((2r_2)^2 - r_2^2)} = \frac{2.12 \times 10^3}{r_2^2}$$

$$r_2^2 = \frac{2.12 \times 10^3}{0.3} = 7.07 \times 10^3$$

$r_2 = 84\,mm.$

$r_1 = 2r_2 = 168\,mm.$

Power absorbed assuming uniform wear

~~$T = \frac{2}{3} \times \mu . W . \operatorname{cosec}\alpha \left[\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}\right]$~~

~~$= \frac{2}{3} \times$~~

$T = \frac{1}{2} \times \mu \times W \times R \operatorname{cosec}\alpha.$

$R = \frac{r_1 + r_2}{2} = \frac{168 + 84}{2} = 126\,mm.$

$= 0.126\,m$

$T = \frac{1}{2} \times \mu \times W \times R \operatorname{cosec}\alpha$

$= \frac{1}{2} \times 1 \times 20 \times 10^3 \times \frac{126}{1000} \times \operatorname{cosec} 60^\circ$

$= 1454.92$ N-m.

$P = T.\omega = 1454.92 \times 20.95$

$= 30480$ W $= 30.48$ kW. — (5M)

9A) Given:

$m_B = 50$ kg; $m_C = 80$ kg; $m_D = 70$ kg

$\angle BOC = 90^\circ$, $\angle BOD = 195^\circ$

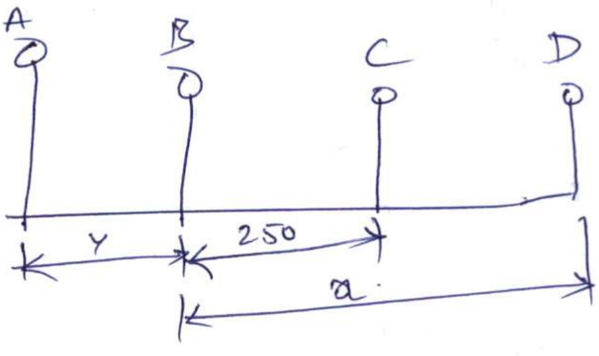
$r_A = 75$ mm $= 0.075$ m.

$r_B = 100$ mm $= 0.1$ m

$r_C = 50$ mm $= 0.05$ m

$r_D = 90$ mm $= 0.09$ m. -ve R.F +ve

position of planes

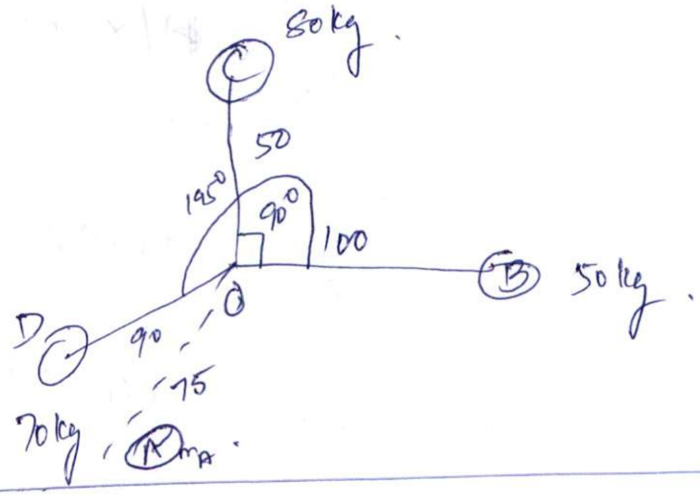


— (5M)

Assuming B as reference plane.

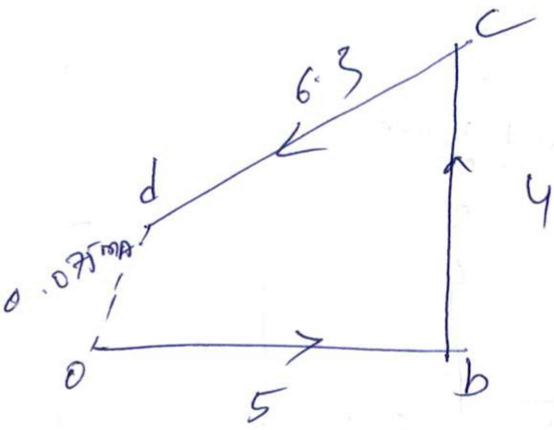
~~draw Force polygon~~

Space dia.



plane	mass (kg)	Radius (r) m	Cent. force ÷ ω^2 m·r	Distance from (B)	Couple ÷ ω^2 m·r·l
A	m_A	0.075	$0.075 m_A$	$-y$	$-0.075 m_A \cdot y$
B	50	0.1	5	0	0
C	80	0.05	4	0.25	1.8
D	70	0.09	6.3	x	$6x$

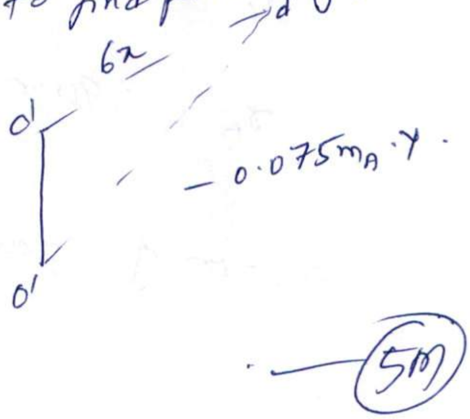
Draw force polygon to find m_A.



~~m_A~~

Draw couple polygon to find

to find position of planes.



(5M)

Given

10A) $d = 10\ mm = 0.01$ $E = 200\ GN/m^2$

$l = 0.75m$ $= 200 \times 10^9\ N/m^2$ — (2M)

$m = 4kg$.

Since shaft is supported on long bearings, it is assumed to be fixed at both ends. Static deflection at centre of shaft due to mass of 4kg.

$$\delta = \frac{WL^3}{192EI}$$

$$= \frac{4 \times 9.81 \times (0.75)^3}{192 \times 200 \times 10^9 \times I} = \frac{4.31 \times 10^{-13}}{I}$$ — (3M)

$$I = \frac{\pi}{64} \times d^4$$

$$= \frac{\pi}{64} \times (0.01)^4 = 4.9 \times 10^{-10}\ m^4$$

$$\delta = \frac{4.31 \times 10^{-13}}{4.9 \times 10^{-10}} = \frac{4.31 \times 10^{10}}{4.9 \times 10^{13}} = 8.798 \times 10^{-9}\ m$$

$$N_c = \frac{0.4985}{\sqrt{8.798 \times 10^{-4}}} = 16.8\ r.p.s$$

$$= 1008.38\ rpm.$$ — (5M)

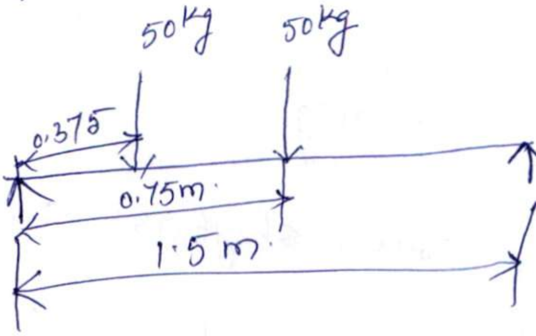
11. Given

Assume $E = 200\ GN/m^2$

$= 200 \times 10^9\ N/m^2$

$l = 1.5m$

$m_1 = m_2 = 50\ kg$



$d_1 = 8cm = 80mm$
external $= 0.08m$

$d_2 = 40mm$
internal $= 0.04m$

$\left(\because d_2 = \frac{1}{2} d_1\right)$

$$I = \frac{\pi}{64}\left(d_1^4 - d_2^4\right)$$

$$= \frac{\pi}{64}\left[(0.08)^4 - (0.04)^4\right]$$

$$= 1.884 \times 10^{-6}\ m^4$$

(5m)

Static deflection due to load W

$$\delta_1 = \frac{Wa^2b^2}{3EIl} = \frac{m_1 g \times a^2 b^2}{3EIl}$$

$$= \frac{50 \times 9.81 \times (0.375)^2 \times (1.125)^2}{3 \times 200 \times 10^9 \times 1.884 \times 10^{-6} \times 1.5}$$

$$= 5.1 \times 10^{-5}\ m = 51 \times 10^{-6}\ m$$

$$\delta_2 = \frac{m_2 \cdot g \times a^2 b^2}{3EIl} = \frac{50 \times 9.81 \times (0.75)^2 \times (0.75)^2}{3 \times 200 \times 10^9 \times 1.884 \times 10^{-6} \times 1.5} = 9.1 \times 10^{-5} = 91 \times 10^{-6}\ m$$

$$f_n = \frac{0.4985}{\sqrt{\delta_1 + \delta_2 + \frac{\delta_s}{1.27}}}$$

Assuming mass of shaft negligible $\delta_s = 0$.

$$f_n = \frac{0.4985}{\sqrt{\delta_1 + \delta_2}} = \frac{0.4985}{\sqrt{(51 \times 10^{-6}) + (91 \times 10^{-6})}}$$

$$= \frac{0.4985}{0.0119} = 41.83 \text{ HZ}$$

$$N_c = 41.83 \times 60 = 2509.99 \text{ rpm}$$

5M

6A) a)

Singleplate clutch	Multiplateclutch.
1. It consists of clutchplate whose both sides are coated with friction mat.	1. It consists more than on clutch plate.
2. Torque transmitting is less	2. High torque transmitting capacity. i.e multiplate clutch is smaller than single plate for given torque capacity.
3. Heat generation is less.	3. Heat generation is more.

4.	coefficient of friction is high.	4. coefficient of friction is low.
5.	Used where large radial Space is available	5. Used where compact construction is desirable.
6.	Used in Trucks, cars.	6. Used in scooter etc.

(20)

8A) Hartung governor

Given — 2M

Dia — 2M

cal. & Results. — 6M.