Q.5 i. What do you mean by static balancing and dynamic balancing? Explain the method for Balancing of single Rotating Masse in same plane and different planes. **4**

ii. A shaft carries four rotating masses A, B, C and D in this order along its axis. The mass A may be assumed to be concentrated at radius of 18 cm, B of 24 cm, C of 12 cm and D of 15 cm. The masses of B, C and D are 30 kg, 50 kg and 40 kg respectively. The planes containing B and C are 30 cm apart. The angular spacing of the planes containing C and D are 90^0 and 210^0 respectively relative to B measured in the same sense. If the shaft and masses are to be in complete dynamic balance, find **6**
(a) the mass and the angular position of mass A
(b) the position of planes A and D.

OR iii. Derive the following expressions, for an uncoupled two cylinder locomotive engine **6**
(a) Variation is tractive force
(b) Swaying couple
(c) Hammer Blow

Q.6 Attempt any two:

i. State the laws of Dry friction and explain uniform pressure & uniform wear theory. **5**

ii. A vertical pivot bearing 200 mm diameter has a cone angle of 150^0. If the shaft supports an axial load of 25 kN, and the coefficient of friction is 0.25, find the power lost in friction when the shaft rotates at 300 rpm, assuming **5**
(a) Uniform pressure, and (b) Uniform wear.

iii. Describe with a neat sketch a centrifugal clutch and deduce an equation for the total torque transmitted. **5**

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Enrollment No.....

Faculty of Engineering

End Sem (Even) Examination May-2019

ME3CO10 Dynamics of Machines

Programme: B.Tech. Branch/Specialisation: ME

Duration: 3 Hrs. **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d.

Q.1 i. According to D' Alembert's principle, the body is in equilibrium position if **1**
(a) Inertia force is applied in the direction opposite to the resultant force
(b) Inertia force is applied in the same direction of the resultant force
(c) Both (a) and (b)
(d) None of the these

ii. The essential condition of placing the two masses, so that the system becomes dynamically equivalent is **1**
(a) $l_1.l_2 = k_G^2$ (b) $l_1.l_2 = k_G$ (c) $l_1 - l_2 = k_G$(d) $l_1 - l_2 = k_G^2$
where l_1 and l_2 = Distance of two masses from the centre of gravity of the body, and K_G = Radius of gyration of the body.

iii. Acceleration of the piston of a reciprocating engine is **1**
(a) $\omega^2 r\left[sin\theta + \frac{Sin\,2\theta}{2}\right]$ (b) $\omega^2 r\left[sin\theta + \frac{Cos\,2\theta}{n}\right]$
(c) $\omega^2 r\left[Cos\theta + \frac{Cos\,2\theta}{n}\right]$ (d) $\omega^2 r\left[Cos\theta + \frac{Sin\,2\theta}{n}\right]$

iv. The ratio of the maximum fluctuation of speed to the mean speed is called **1**
(a) Fluctuation of speed
(b) Maximum fluctuation of speed
(c) Coefficient of fluctuation of speed
(d) None of these

v. A governor is said to be hunting, if the speed of the engine **1**
(a) Remains constant at the mean speed
(b) Is above the mean speed
(c) Is below the mean speed
(d) Fluctuates continuously above and below the mean speed.

vi. The sensitiveness of a governor is given by **1**
(a) $\frac{\omega_{mean}}{\omega_2 - \omega_1}$ (b) $\frac{\omega_2 - \omega_1}{\omega_{mean}}$ (c) $\frac{\omega_2 - \omega_1}{2\omega_{mean}}$ (d) None of these
where ω_1 and ω_2 = Minimum and maximum angular speed, and ω_{mean} = Mean angular speed.

vii. If there are several unbalanced masses in a rotor in different planes, the minimum number of balancing masses required, is **1**
(a) One (b) Two (c) Three (d) Four

viii. The swaying couple is maximum or minimum when the angle of inclination of the crank to the line of stroke is equal to **1**
(a) 180^0 and 315^0 (b) 45^0 and 135^0
(c) 90^0 and 135^0 (d) 45^0 and 225^0

ix. For a safe design, a friction clutch is designed assuming **1**
(a) Uniform pressure theory (b) Uniform wear theory
(c) Any one of the two (d) None of these.

x. The frictional torque transmitted by a cone clutch is same as that **1**
(a) Flat pivot bearing (b) Flat collar bearing
(c) Conical pivot bearing (d) Trapezoidal pivot bearing

Q.2 i. Define 'inertia force' and 'inertia torque'. What do you mean by dynamical equivalent system? Explain. **3**

ii. The following data refer to a steam engine **7**
Diameter of piston = 240 mm; stroke = 600 mm; length of connecting rod = 1.5 m; mass of reciprocating parts = 300 kg; mass of connecting rod = 250 kg; speed = 125 rpm; centre of gravity of connecting rod from crank pin = 500 mm; radius of gyration of the connecting rod about an axis through the centre of gravity = 650 mm. Determine the magnitude and direction of the torque exerted on the crankshaft when the crank has turned through 30° from inner dead centre by Graphical Method.

OR iii. A four-bar mechanism with the following dimensions is acted upon by a force F = 80∠150° N on the link DC shown in Fig 2.1 AD = 500 mm, AB = 400 mm, BC = 1000 mm, DC = 750 mm, DE = 350 mm. Determine the input torque T on link AB for the static equilibrium of the mechanism for the given configuration. **7**

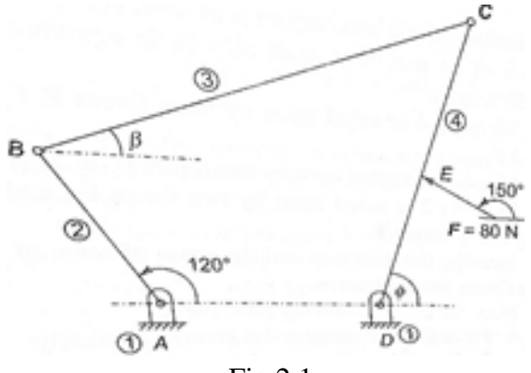

Fig 2.1

Q.3 i. Draw the turning moment diagram of a single cylinder double acting steam engine. Define the terms 'coefficient of fluctuation of energy' and 'coefficient of fluctuation of speed', in the case of flywheels. **3**

ii. Derive an expression for approximate analytical method for velocity and acceleration of the piston and angular velocity and angular acceleration of the connecting rod. **7**

OR iii. The turning moment diagram for a multi-cylinder engine has been drawn to a scale of 1 mm to 500 N-m torque and 1 mm to 6° of crank displacement. The intercepted areas between output torque curve and mean resistance line taken in order from one end, in sq. mm are – 30, + 410, – 280, + 320, – 330, + 250, – 360, + 280, – 260 sq. mm, when the engine is running at 800 r.p.m. **7**
The engine has a stroke of 300 mm and the fluctuation of speed is not to exceed ± 2% of the mean speed. Determine a suitable diameter and cross-section of the flywheel rim for a limiting value of the safe centrifugal stress of 7 MPa. The material density may be assumed as 7200 kg/m3. The width of the rim is to be 5 times the thickness.

Q.4 i. Explain the terms sensitiveness, hunting, isochronism and effort relating to governors. **4**

ii. Prove that the height of Porter governor is given by **6**

$$h = \frac{m \times g\left(\frac{M \times g \pm F_f}{2}\right)(1+k)}{m \times \omega^2} \quad \text{where} \quad k = \frac{\tan\beta}{\tan\alpha}$$

where m = Mass of each ball, M = Mass of central load, F_f = Force of friction, ω = Angular velocity of rotation,

OR iii. In a spring-loaded Hartnell type of governor, the mass of each ball is 4 kg and the lift of the sleeve is 40 mm. The governor begins to float at 200 rpm when the radius of the ball path is 90 mm. The mean working speed of the governor is 16 times the range of speed when friction is neglected. The lengths of the ball and roller arms of the bell-crank lever are 100 mm and 80 mm respectively. The pivot centre and the axis of governor are 115 mm apart. Determine the initial compression of the spring, taking into account the obliquity of arms. Assuming the friction at the sleeve to be equivalent to a force of 15 N, determine the total alteration is speed before the sleeve begins to move from the mid-position. **6**

Marking Scheme
ME3CO10 Dynamics of Machines

Q.1	i.	According to D' Alembert's principle, the body is in equilibrium position if (a) Inertia force is applied in the direction opposite to the resultant force		**1**
	ii.	The essential condition of placing the two masses, so that the system becomes dynamically equivalent is (a) $l_1.l_2 = k_G^2$		**1**
	iii.	Acceleration of the piston of a reciprocating engine is (c) $\omega^2 r\left[Cos\theta + \frac{Cos\,2\theta}{n}\right]$		**1**
	iv.	The ratio of the maximum fluctuation of speed to the mean speed is called (c) Coefficient of fluctuation of speed		**1**
	v.	A governor is said to be hunting, if the speed of the engine (d) Fluctuates continuously above and below the mean speed.		**1**
	vi.	The sensitiveness of a governor is given by (b) $\frac{\omega_2-\omega_1}{\omega_{mean}}$		**1**
	vii.	If there are several unbalanced masses in a rotor in different planes, the minimum number of balancing masses required, is (b) Two		**1**
	viii.	The swaying couple is maximum or minimum when the angle of inclination of the crank to the line of stroke is equal to (d) 45^0 and 225^0		**1**
	ix.	For a safe design, a friction clutch is designed assuming (b) Uniform wear theory		**1**
	x.	The frictional torque transmitted by a cone clutch is same as that (d) Trapezoidal pivot bearing		**1**
Q.2	i.	Definition of inertia force	0.5 mark	**3**
		Definition of inertia torque	0.5 mark	
		Dynamical equivalent system		
		Three condition and derivation with diagram	2 marks	
	ii.	Determine the magnitude and direction of the torque exerted on the crankshaft when the crank has turned through 30° from inner dead centre by Graphical Method.		**7**
		Configuration diagram	1 mark	
		Klien's Construction	2 marks	
		Inertia force of reciprocating parts	1 mark	
		Inertia force of connecting rod	1 mark	
		Torque exerted on the crankshaft	2 marks.	
OR	iii.	Determine the input torque T on link AB for the static equilibrium of the mechanism for the given configuration.		**7**
		Configuration diagram	1 mark	
		Free Body Diagram	2 marks	
		Force calculation	2 marks	
		Torque calculation	2 marks	
Q.3	i.	Turning moment diagram	1 mark	**3**
		Definition - coefficient of fluctuation of energy	1 mark	
		Coefficient of fluctuation of speed	1 mark	
	ii.	Diagram and notation description	1 mark	**7**
		Displacement equation	1 mark	
		Velocity	1 mark	
		Acceleration	1 mark	
		Angular velocity C. Rod	1.5 marks	
		Angular acceleration C. Rod	1.5 marks	
OR	iii.	Determine a suitable diameter and cross-section of the flywheel rim for a limiting value of the safe centrifugal stress of 7 MPa.		**7**
		Coefficient of fluctuation of speed	1 mark	
		Fluctuation of energy with T.M.D	2 marks	
		Diameter of the flywheel rim	1 mark	
		Mass of the flywheel rim	1 mark	
		Width of the flywheel rim	2 marks	
Q.4	i.	Explain the terms sensitiveness, hunting, isochronism and effort relating to governors.		**4**
		Definition of each 1 mark	(1 mark *4)	
	ii.	Prove that the height of Porter governor is given by		**6**
		Diagram and details of Porter governor	2 marks	
		Centrifugal force calculation	1 mark	
		Speed calculation	1 mark	
		Height calculation	2 marks	
OR	iii.	Determine the total alteration is speed before the sleeve begins to move from the mid-position.		**6**
		Speed N_2	1 mark	
		Spring stiffness calculation	2 marks	
		Radial distance	1 mark	
		Alteration at speed	2 marks	
Q.5	i.	Static balancing	1 mark	**4**
		Dynamic balancing	1 mark	

		Method for Balancing of single Rotating Masse	2 marks	
	ii.	(a) the mass and the angular position of mass A (b) the position of planes A and D.		**6**
		Configuration diagram with end view	1 mark	
		Table for force and couple	1 mark	
		Mass of A	2 marks	
		Position of mass A	1 mark	
		Position of planes mass A and D	1 mark	
OR	iii.	Derive the following expressions, for an uncoupled two cylinder locomotive engine		**6**
		(a) Variation is tractive force	2 marks	
		(b) Swaying couple	2 marks	
		(c) Hammer Blow	2 marks	
Q.6		Attempt any two:		
	i.	Laws of Dry friction		**5**
		Any four points (0.5 mark * 4)	2 marks	
		Uniform pressure & uniform wear	3 marks	
	ii.	Uniform pressure calculation	2.5 marks	**5**
		Uniform wear calculation	2.5 marks	
	iii.	Centrifugal clutch sketch and description	2.5 marks	**5**
		Total torque transmitted expression	2.5 marks	

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