CBCS SCHEME

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15ME52

Fifth Semester B.E. Degree Examination, Jan./Feb. 2023
Dynamics of Machinery

Time: 3 hrs. Max. Marks: 80

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. With neat sketches briefly discuss the equilibrium of three force and four force systems. **(04 Marks)**

b. With suitable sketches show the force conventions and force polygon for each link of a four-link mechanism. **(04 Marks)**

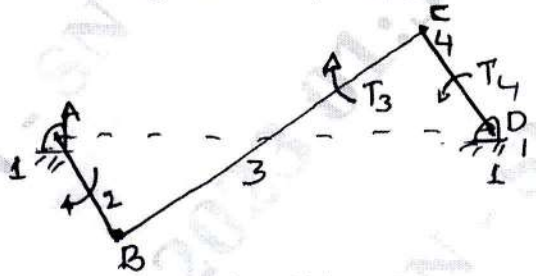
c. In four bar mechanism shown in Fig.Q1(c), the torque T_3 and T_4 have magnitudes of 50 Nm and 40 Nm respectively. For the static equilibrium of the mechanism, determine the required input torque T_2. **(08 Marks)**

OR

2 a. State the D'Alembert's principle. **(02 Marks)**

b. Define: (i) Inertia force (ii) Inertia torque **(02 Marks)**

c. The connecting rod of a vertical reciprocating engine is 2m long between centres and its mass is 250 kg. The mass centre is 800 mm from big end bearing. When suspended as a pendulum from the gudgeon pin axis, it makes 8 complete oscillations in 22 seconds. Calculate the radius of gyration of the rod about an axis through its mass centre. The crank is 400 mm long and rotates at 200 rpm. When the crank has turned through 40° from the TDC and the piston is moving downwards, find the inertia torque exerted on the crankshaft.



AB = 30 mm
BC = 74 mm
CD = 35 mm
AD = 70 mm

Fig.Q2(c) **(12 Marks)**

Module-2

3 a. A shaft carries four masses M_1, M_2, M_3 and M_4 attached to it. They all revolve in the same plane. The magnitude of the masses are 6, 5, 9 and 7.5 kg respectively. The C.G of the masses are located at a radial distance of 100, 125, 150 and 75 mm from the axis of the shaft. The angular positions of the masses are 60°, 135 ° and 270° from M_1. Determine the position and magnitude of mass M_5 at 250 mm radius to balance the system. **(08 Marks)**

b. A rotating shaft carries four unbalanced masses 18 kg, 14 kg, 16 kg and 12 kg at radii 50 mm, 60 mm, 70 mm and 60 mm respectively. The 2nd, 3rd and 4th masses revolve in planes 80 mm, 160 mm and 280 mm respectively measured from the plane of the first mass and are angularly located at 60°, 135° and 270° respectively measured anticlockwise from the first mass looking from this mass end of the shaft. The shaft is dynamically balanced by two masses, bolt located at 50 mm radii and revolving in planes mid way between those of 1st and 2nd masses and midway between those of 3rd and 4th masses. Determine the magnitudes of the masses and their respective angular positions. **(08 Marks)**

OR

4 A six cylinder two stroke single acting diesel engine with cylinder centre lines are spaced at 650 mm. In the end view the cranks are 60° apart and inorder 1-4-5-2-3-6. The stroke of each position is 400 mm and the crank to connecting rod ratio is 1:5. The mass of reciprocating part is 250 kg per cylinder and that of rotating part is 100 kg per crank. The engine rotates at 240 rpm. Determine the engine for out of balance primary and secondary forces and couples by analytically and graphically. **(16 Marks)**

Module-3

5 a. A porter governor has equal arms each 250 mm long and pivoted on the axis of rotation. Each ball has a mass of 5 kg and the mass of the central load on the sleeve is 25 kg. The radius of rotation of the ball is 150 mm when the governor begins to lift and 200 mm when the governor is at maximum speed. Find the range of speed, sleeve lift, effort and power of the governor. **(08 Marks)**

b. In a Hartnell governor, the lengths of ball and sleeve arms of a ball crank lever are 120 mm and 100 mm respectively. The distance of the fulcrum of the bell crank lever from the governor axis is 140 mm. Each governor ball has a mass of 4 kg. The governor runs at a mean speed of 300 rpm with the ball arms vertical and sleeve arms horizontal. For an increase of speed of 4%, the sleeve moves 10 mm upwards. Neglecting friction, find:

(i) The minimum equilibrium speed if the total sleeve movement is limited to 20 mm
(ii) The spring stiffness
(iii) The sensitiveness of governor
(iv) The spring stiffness if the governor is to be isochronous at 300 rpm. **(08 Marks)**

OR

6 a. With neat sketches, explain the effect of gyroscopic couple on Aeroplane and Naval ship. **(08 Marks)**

b. A ship is propelled by a turbine rotor which has a mass of 5000 kg and a speed of 1200 rpm. The rotor has a radius of gyration of 0.5 m and rotates in a clockwise direction when viewed from the stern. Find the gyroscopic effects in the following conditions:

(i) The ship sails at speed of 16 knots (1 knot = 1860 m/hr). It steers to the left in a curve having 60 m radius.
(ii) The ship pitches 6° above and 6° below the horizontal position. The bow is descending with its maximum velocity. The motion due to pitching is simple harmonic and periodic time is 20 seconds.
(iii) The ship rolls and at a certain instant it has an angular velocity of 0.03 rad/sec, clockwise when viewed from stern. Determine also the maximum acceleration during pitching. Explain how the diversion of motion due to gyroscopic effect is determined in each case. **(08 Marks)**

Module-4

7 a. Define: (i) Periodic time (ii) Natural frequency (iii) Damping (iv) Resonance **(04 Marks)**

b. Derive an equation of motion for spring mass system by energy method. **(04 Marks)**

c. Determine the effect of the mass of the spring on the natural frequency of the spring mass system. **(08 Marks)**

OR

8 a. Add the following harmonic motions analytically and check the solution graphically:

$x_1 = 4\cos(\omega t + 10^\circ)$ and $x_2 = 6\sin(\omega t + 60^\circ)$ **(08 Marks)**

b. A circular cylinder of mass 4 kg and radius 150 mm is connected by a spring of stiffness 4000 N/m as shown in Fig.Q8(b). It is free to roll on horizontal rough surface without slipping, determine the natural frequency.

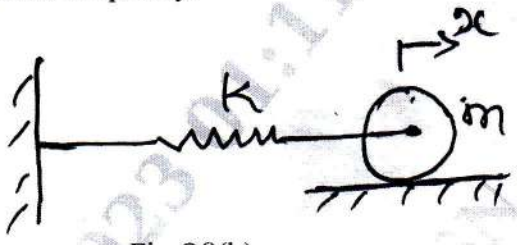


Fig.Q8(b) **(08 Marks)**

Module-5

9 a. Show the logarithmic decrement of successive amplitudes in a damped vibrating system. **(08 Marks)**

b. A vibrating system is defined by the following parameters: M = 3 kg, K = 100 N/m and C = 3 N-s/m. Determine:
(i) The damping factor
(ii) The natural frequency of damped vibration
(iii) Logarithmic decrement
(iv) The ratio of two consecutive amplitude
(v) The number of cycles after which the original amplitude is reduced to 20%. **(08 Marks)**

OR

10 a. Derive an expression for magnification factor or amplitude ratio for spring-mass system with viscous damping subjected to harmonic force. **(08 Marks)**

b. A machine of mass one tonne is acted upon by an external force of 2450 N at a frequency of 1500 rpm. To reduce the effects of vibration, isolator of rubber having a static deflection of 2 mm under the machine load and an estimated damping $\xi = 0.2$ are used. Determine:
(i) The force transmitted to the foundation
(ii) The amplitude of vibration of machine
(iii) The phase lag **(08 Marks)**

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