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Question Paper Code : 70903

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2023.

Fourth/Fifth Semester

Mechanical Engineering

ME 8594 — DYNAMICS OF MACHINES

(Common to : Mechanical engineering (Sandwich)/Mechatronics Engineering)

(Regulations 2017)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is the function of a flywheel?

2. Define 'inertia force' and 'inertia torque'.

3. Why is the balancing of rotating parts necessary for high-speed engines?

4. Why only a part of the unbalanced force due to reciprocating masses is balanced by revolving mass?

5. What are the causes of vibrations?

6. Distinguish between free and forced vibrations.

7. What do you mean by the steady-state response of the system in case of forced vibrations?

8. What is meant by the magnification factor in case of forced vibrations?

9. What is spring controlled governor?

10. In what way does the gyroscopic couple affect the motion of an aircraft while taking a turn?

PART B — (5 × 13 = 65 marks)

11. (a) The crank and connecting rod of a reciprocating engine are 200 mm and 700 mm respectively. The crank is rotating in a clockwise direction at 120 rad/s. Find with the help of Klein's construction: (i) Velocity and acceleration of the piston, (ii) Velocity and acceleration of the midpoint of the connecting rod, and (iii) Angular velocity and angular acceleration of the connecting rod, at the instant, when the crank is at 30° to I.D.C. (5 + 4 + 4)

Or

(b) A punching press is driven by a constant torque electric motor. The press is provided with a flywheel that rotates at a maximum speed of 225 r.p.m. The radius of gyration of the flywheel is 0.5 m. The press punches 720 holes per hour; each punching operation takes 2 seconds and requires 15 kN-m of energy. Find the power of the motor and the minimum mass of the flywheel it the speed of the same is not to fall below 200 r.p.m.

12. (a) Four masses m_1, m_2, m_3 and m_4 are 200 kg, 300 kg, 240 kg and 260 kg respectively. The corresponding radii of rotation are 0.2 m, 0.15 m, 0.25 m and 0.3 m respectively and the angles between successive masses are 45°, 75° and 135°. Find the position and magnitude of the balance mass required, if its radius of rotation is 0.2 m.

Or

(b) The reciprocating mass per cylinder in a 60° V-twin engine is 1.5 kg. The stroke and connecting rod length are 100 mm and 250 mm respectively. If the engine runs at 2500 r.p.m., determine the maximum and minimum values of the primary and secondary forces. Also find out the crank position corresponding these values.

13. (a) (i) Explain the terms under damping, critical damping and over damping. (7)

(ii) Explain longitudinal, transverse and torsional vibrations. (6)

Or

(b) A cantilever shaft 50 mm in diameter and 300 mm long has a disc of mass 100 kg at its free end. The Young's modulus for the shaft material is 200 GN/m². Determine the frequency of longitudinal and transverse vibrations of the shaft.

14. (a) A machine part having a mass of 2.5 kg vibrates in a viscous medium. A harmonic exciting force of 30 N acts on the part and causes a resonant amplitude of 14 mm with a period of 0.22 seconds. Find the damping coefficient. If the frequency of the exiting force is changed to 4 Hz, determine the increase in the amplitude of the forced vibrations upon the removal of the damper.

Or

(b) A machine supported symmetrically on four springs has a mass of 80 kg. The mass of the reciprocating parts is 2.2 kg which moves through a vertical stroke of 100 mm with simple harmonic motion. Neglecting damping, determine the combined stiffness of the springs so that the force transmitted to the foundation is 1/20th of the impressed force. The machine crankshaft rotates at 800 r.p.m. If under actual working conditions, the damping reduces the amplitudes of successive vibrations by 30%, find the (i) force transmitted to the foundation at 800 r.p.m., (ii) force transmitted to the foundation at resonance and (iii) amplitude of the vibrations at resonance. (5 + 4 + 4)

15. (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 minimum and maximum speeds and range of speed of the governor.

Or

(b) A four-wheeled trolley car has a total mass of 3000 kg. Each axle with its two wheels and gears has a total moment of inertia of 32 kg.m^2. Each wheel is of 450 mm radius. The centre distance between two wheels on an axle is 1.4 m. Each axle is driven by a motor with a speed ratio of 1:3. Each motor along with its gear has a moment of inertia of 16 kg.m^2 and is rotated in the opposite direction to that of the axle. The centre of mass of the car is 1 m above the rails. Calculate the limiting speed of the car when it has to travel around a curve of 250 m radius without the wheels leaving the rails.

PART C — (1 × 15 = 15 marks)

16. (a) A shaft 1.5 m long, supported in flexible bearings at the ends carries two wheels each of 50 kg mass. One wheel is situated at the centre of the shaft and the other at a distance of 375 mm from the centre towards the left. The shaft is hollow with an external diameter of 75 mm and an internal diameter of 40 mm. The density of the shaft material is 7700 kg/m^3 and its modulus of elasticity is 200 GN/m^2. Find the lowest whirling speed of the shaft, taking into account the mass of the shaft.

Or

(b) Calculate the whirling speed of a shaft 20 mm diameter and 0.6 m long carrying a mass of 1 kg at its mid-point. The density of the shaft material is 40 × 10^3 kg/m^3, and Young's modulus is 200 GN/m^2. Assume the shaft to be freely supported.