15. (a) A Porter governor has all four arms 250mm long. The upper arms are attached on the axis of rotation and the lower arms are attached to the sleeve at a distance of 30 mm from the axis. The mass of each ball is 5 kg and the sleeve has a mass of 50 kg. The extreme radii of rotation are 150 mm and 200 mm. Determine the range of speed of the governor.

Or

(b) A ship propelled by a turbine rotor which has a mass of 5 tonnes and a speed of 2100 r.p.m. 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 a speed of 30 km/h and steers to the left in a curve having 60 m radius. (4)

(ii) The ship pitches 6 degree above and 6 degree below the horizontal position. The bow is descending with its maximum velocity. The motion due to pitching is simple harmonic and the periodic time is 20 seconds. (4)

(iii) The ship rolls and at a certain instant it has an angular velocity of 0.03 rad/s clockwise when viewed from stern. (3)

Determine also the maximum angular acceleration during pitching. Explain how the direction of motion due to gyroscopic effect is determined in each case. (2)

PART C — (1 × 15 = 15 marks)

16. (a) A vehicle has a mass of 490 kg and the total spring constant of its suspension system is 58800 N/m. The profile of the road may be approximated to a sine wave of amplitude 40 mm and wavelength 4.0 meters. Determine

(i) The critical speed of the vehicle (5)

(ii) The amplitude of the steady state motion of the mass when the vehicle is driven at critical speed and the damping factor is 0.5 and (5)

(iii) The amplitude of steady state motion of the mass when the vehicle is driven at 57 km/hr and the damping factor is 0.5. (5)

Or

(b) 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. 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.

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Reg. No. : | | | | | | | | | | | | |

Question Paper Code : 90864

B.E./B.Tech. DEGREE EXAMINATIONS, NOVEMBER/DECEMBER 2022

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. State D' Alembert's principle.

2. Define coefficient of fluctuation of energy.

3. What is dynamic balancing?

4. What are the different types of balancing machines?

5. What is meant by degrees of freedom in a vibrating system?

6. When do you say a vibrating system in under-damped?

7. What is meant by harmonic forcing?

8. Define transmissibility.

9. What is the function of the Governor?

10. What is the effect of gyroscopic couple on the rolling of the ship? Why?

PART B — (5 × 13 = 65 marks)

11. (a) The crank-pin circle radius of a horizontal engine is 300 mm, The mass of the reciprocating parts is 250 kg. When the crank has travelled 60° from I.D.C., the difference between the driving and the back pressures is 0.35 N/mm^2. The connecting rod length between centres is 1.2 m and the cylinder bore is 0.5 m. If the engine runs at 250 r.p.m. and if the effect of piston rod diameter is neglected.

Calculate (i) pressure on slide bars, (ii) thrust in the connecting rod, (iii) tangential force on the crank-pin, and (iv) turning moment on the crank shaft.

Or

(b) The equation of the turning moment curve of a three-crank engine is (5000 + 1500 sin 3θ) N-m. where θ is the crank angle in radians. The moment of inertia of the flywheel is 1000 kg m^2 and the mean speed is 300 r.p.m. Calculate: (i) power of the engine, and (ii) the maximum fluctuation of the speed of the flywheel in percentage when (6+7)

(1) the resisting torque is constant, and

(2) the resisting torque is (5000 + 600 sin θ) N-m.

12. (a) A shaft carries four masses A, B, C and D of magnitude 200 kg, 300 kg, 400 kg and 200 kg respectively and revolving at radii 80 mm, 70 mm, 60 mm and 80 mm in planes measured from A at 300 mm, 400 mm and 700 mm. The angles between the cranks measured anticlockwise are A to B 45°, B to C 70° and C to D 120°. The balancing masses are to be placed in planes X and Y. The distance between planes A and X is 100 mm, between X and Y is 400mm and between Y and D is 200 mm. If the balancing masses revolve at a radius of 100 mm, find their magnitudes and angular positions.

Or

(b) The cranks and connecting rods of a 4-cylinder in-line engine running at 1800 r.p.m. are 60 mm and 240mm each respectively and the cylinders are spaced 150 mm apart. If the cylinders are numbered 1 to 4 in sequence from one end, the cranks appear at intervals of 90° in an end view in the order 1-4-2-3. The reciprocating mass corresponding to each cylinder is 1 .5 kg.

Determine:

(i) Unbalanced primary and secondary forces, if any, and (6)

(ii) Unbalanced primary and secondary couples with reference to central plane of the engine (7)

13. (a) A vibratory system consists of a mass of 8 kg, spring stiffness 5.6 N/mm and a dashpot of damped coefficient of 40 N/m/s. Find:

(i) the critical damping coefficient, (2)

(ii) the damping factor, (2)

(iii) the natural frequency of damped vibration, (2)

(iv) the logarithmic decrement, (2)

(v) the ratio of two consecutive amplitudes, and (2)

(vi) the number of cycles after which the original amplitude is reduced to 20 percent (3)

Or

(b) A steel shaft ABCD 1.5 m long has flywheels at its ends A and D. The mass of the flywheel A is 600 kg and has a radius of gyration of 0.6 m. The mass of the flywheel D is 800 kg and has a radius of gyration of 0.9 m. The connecting shaft has a diameter of 50 mm for portion AB which is 0.4 m long; and has a diameter of 60mm for portion BC which is 0.5 m long, and has a diameter of d mm for portion CD which is 0.6 m long. Determine:

(i) The diameter 'd' of the portion CD so that the node of the torsional vibration of the system will be at the centre of the length BC; and (6)

(ii) The natural frequency of the torsional vibrations. The modulus of rigidity for the shaft material is 80 GN/m^2. (7)

14. (a) A mass of 10 kg is suspended from one end of a helical spring, the other end being fixed. The stiffness of the spring is 10 N/mm. The viscous damping causes the amplitude to decrease to one-tenth of the initial value in four complete oscillations. If a periodic force of 150 cos 50 t N is applied at the mass in the vertical direction, find the amplitude of the forced vibrations? What is its values of resonance?

Or

(b) A single-cylinder engine has an out-of-balance force of 500 N at an engine speed of 300 r.p.m. The total mass of the engine is 150 kg and it is carried on a set of springs of total stiffness 300 N/cm.

(i) Find the amplitude of the steady motion of the mass and the maximum oscillating force transmitted to the foundation. (6)

(ii) If a viscous damping is interposed between the mass and the foundation, the damping force being 1000 N at 1 m/s of velocity, find the amplitude of the forced damped oscillation of the mass and its angle of lag with disturbing force. (7)