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B.E./B.Tech. DEGREE EXAMINATION, NOVEMBER/DECEMBER 2015.

Fourth/Fifth Semester

Mechanical Engineering

ME 6505 — DYNAMICS OF MACHINES

(Common to Mechanical Engineering (Sandwich)/B.E. Mechatronics Engineering)

(Regulations 2013)

Time : Three hours Maximum : 100 marks

Answer ALL questions.

PART A — ($10 \times 2 = 20$ marks)

1. Define D-Alembert's principle for translation and hence define inertia force.

2. Define co-efficient of fluctuation of energy of a flywheel.

3. Define static balancing of shaft.

4. State the reasons for choosing multi-cylinder engine in comparison with that of the single cylinder engine.

5. Write the mathematical expression for a free vibration system with viscous damping.

6. Write the expression for estimation of the natural frequency of free torsional vibration of a shaft.

7. What is the phase difference between the transmitted force and the disturbing force system if $\omega / \omega_n > 1$.

8. Write the equation of motion for the forced damped vibration.

9. What is meant by hunting in a governor?

10. What is the angular speed of precession of the shaft (whose mass moment of inertia is 20 kg-m^2) if it spins about its axis and torque of 100 N-m applied about an axis normal to it.

PART B — (5 × 16 = 80 marks)

11. (a) During a trail on steam engine, it is found that the acceleration of the piston is 36 m/s^2 when the crank has moved 30° from the inner dead centre position. The net effective steam pressure on the piston is 0.5 MPa and the frictional resistance is equivalent to a force of 600 N. The diameter of the piston is 300 mm and the mass of the reciprocating parts is 180 kg. If the length of the crank is 300 mm and the ratio of the connecting rod length to the crank length is 4.5. Find (i) reaction on the guide bars (ii) thrust on the crank shaft bearings and (iii) Turning moment on the crank shaft. (16)

Or

(b) A single cylinder double acting steam engine develops 150 kW at a mean speed of 80 rpm. The coefficient of fluctuation of energy is 0.1 and the fluctuation of speed is ±2% of mean speed. If the mean diameter of the flywheel rim is 2 m and the hub and spokes provide 5% of the rotational inertia of the flywheel, find the mass and cross-sectional area of the flywheel rim. Assume the density of the flywheel material (which is cast iron) as 7200 kg/m^3. (16)

12. (a) A, B, C and D are four masses carried by a rotating shaft at radii 100, 125, 200 and 150mm respectively. The planes in which the masses revolve are spaced 600 mm apart and the mass of B, C and D are 10 kg, 5 kg and 4 kg respectively. Find the required mass A and the relative angular settings of the four masses so that the shaft shall be in complete balance. (16)

Or

(b) A 90°-V engine has two cylinders which are placed symmetrically. The two connecting rods operate a common crank. The length of connecting rods are 320 mm each and crank radius is 80 mm. The reciprocating mass per cylinder is 12 kg. If the engine speed is 600 rpm, then find the resultant primary and resultant secondary forces. Also find the maximum resultant secondary force. (16)

13. (a) Determine (i) the critical damping co-efficient, (ii) the damping factor, (iii) the natural frequency of damped vibrations, (iv) the logarithmic decrement and (v) the ratio of two consecutive amplitudes of a vibrating system which consists of a mass of 25 kg, a spring of stiffness 15 kN/m and a damper. The damping provided is only 15% of the critical value. (16)

Or

(b) A shaft of length 1.25 m is 75 mm in diameter for the first 275 mm of its length, 125 mm in diameter for the next 500 mm length, 87.5 mm in diameter for the next 375 mm length and 175 mm in diameter for the remaining 100 mm of its length. The shaft carries two rotors at two ends. The mass moment of inertia of the first rotor is 75 kg-m^2 whereas of the second rotor is 50 kg-m^2 Find the frequency of natural torsional vibrations of the system. The modulus of rigidity of the shaft material may be taken as 80 GPa. (16)

14. (a) A single cylinder vertical petrol engine has a mass of 200 kg and is mounted upon a steel chasis frame. The vertical static deflection of the frame is 2.4 mm due to the weight of the engine. The reciprocating parts of the engine has a mass of 9 kg and move through a vertical stroke of 160 mm with simple harmonic motion. A dashpot with a damping coefficient of 1 N/mm/s is also used to dampen the vibrations. Considering that the steady-state of vibration is reached, determine:

(i) amplitude of the forced vibration if the driving shaft rotates at 500 rpm and

(ii) the speed of the driving shaft at which resonance will occur. (16)

Or

(b) A machine has a total mass of 90 kg and unbalanced reciprocating parts of mass 2 kg which moves through a vertical stroke of 100 mm with simple harmonic motion. The machine is mounted on four springs. The machine is having only one degree of freedom and can undergo vertical displacement only.

Calculate (i) the combined stiffness of the springs if the force transmitted to the foundation is one-thirtieth of the applied force. Neglect damping and take the speed of rotation of the machine crank-shaft as 1000 rpm.

When the machine is actually supported on the springs, it is found that the damping reduces the amplitude of the successive free vibrations by 30 %. Find (ii) the force transmitted to the foundation at 900 rpm. (16)

15. (a) Calculate the minimum speed, maximum speed and range of the speed of a Porter governor, which has equal arms each 200 mm long and pivoted on the axis of rotation. The mass of each ball is 4 kg and the central mass on the sleeve is 20 kg. The radius of rotation of the ball is 100 mm when the governor begins to lift and 130 mm when the governor is at maximum speed. (16)

Or

(b) The turbine rotor of a ship has a mass of 3500 kg. It has a radius of gyration of 0.45 m and a Speed of 3000 rpm clockwise When looking from stern. Determine the gyroscopic couple and its effect upon the ship:

(i) When the ship is steering to the left on a curve of 100 m radius at a speed of 36 kmph

(ii) When the ship is pitching in a simple harmonic motion the bow falling with its maximum velocity The period of pitching is 40 seconds and the total angular displacement between the two extreme Positions of Pitching is 12°. (16)
