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B.E./B.Tech. DEGREE EXAMINATION, APRIL/MAY 2017.

Fourth/Fifth Semester

Mechanical Engineering

ME 6505 — DYNAMICS OF MACHINES

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

(Regulations 2013)

Time : Three hours

Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1. What is meant by piston effort?
2. List the uses of turning moment diagrams?
3. Why balancing is necessary?
4. What is hammer blow in engines with reciprocating masses?
5. Write the expression for the equivalent stiffness of two springs connected in series.
6. List the types of damping.
7. Quote two examples of forced vibration.
8. What is vibration isolation?
9. Define governor effort.
10. What is gyroscopic couple?

PART B — (5 × 13 = 65 marks)

11. (a) The crank-pin circle radius of a horizontal engine is 300mm. 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 1.2m and the cylinder bore is 0.5m. If the engine runs at 250 r.p.m., and if the effect of piston rod diameter is neglected, calculate the pressure on slide bars, the thrust in the connecting rod, the tangential force on the crank-pin and the turning moment on the crank shaft.

Or

- (b) The turning moment diagram for a multi-cylinder engine has been drawn to a vertical scale of $1 \text{ mm} = 650 \text{ Nm}$ and a horizontal scale of $1 \text{ mm} = 4.5^\circ$. The areas above and below the mean torque line are $-28, +380, -260, +310, -300, +242, -380, +265$ and -229 mm^2 . The fluctuation of speed is limited to $\pm 1.8\%$ of the mean speed which is 400 rpm. The density of the rim material is 7000 kg/m^3 and the width of the rim is 4.5 times its thickness. The centrifugal stress in the rim material is limited to 6 N/mm^2 . Neglecting the effect of the boss, and the arms, determine the diameter and the cross-section of the flywheel rim.
12. (a) A circular disc mounted on a shaft carries three attached masses of 4 kg, 3 kg, and 2.5 kg at radial distances of 75 mm, 85 mm, and 50 mm, and at angular positions of $45^\circ, 135^\circ$ and 240° respectively. The angular positions are measured counter-clockwise from the reference line along x-axis. Determine the amount of the counter-mass at a radial distance of 75 mm required for the static balance.

Or

- (b) The Following data refer to two cylinder locomotive with cranks at 90° Reciprocating mass per cylinder = 300 kg Crank radius = 0.3m; Driving wheel diameter = 1.8 m; Distance between cylinder centre lines = 0.65 m; Distance between the driving wheel central planes = 1.55 m. Determine the fraction of the reciprocating masses to be balanced, if the hammer blow is not to exceed 46 kN at 96.5 km/hr., the variation in tractive effort and the maximum swaying couple.
13. (a) (i) A mass of 5 kg hangs from a spring and makes damped oscillations. If the time of 50 complete oscillations is found to be 20 s, and the ratio of the first downward displacement to the sixth is found to be 22.5, find the stiffness of the spring and the damping coefficient. (5)
- (ii) A vibrating system has the following constants: $m = 17.5 \text{ kg}$, $k = 7 \text{ N/mm}$, and $c = 70 \text{ N s/m}$. Estimate the damping factor and the natural frequency of the damped free vibrations logarithmic decrement and the ratio of any two consecutive oscillations. (8)

Or

- (b) A rotor of mass 4kg is mounted midway on a 10mm diameter horizontal shaft simply supported on a span of 0.5 m. The C.G. of the rotor is 0.025 mm away from the geometric centre of the rotor. The shaft rotates at 2500 rpm. Find the amplitude of steady state vibrations and the dynamic force transmitted to the bearings. Take $E = 205 \text{ GPa}$.
14. (a) A vehicle of mass 1200 kg is travelling on a road, the surface of which varies sinusoidally with an amplitude of 0.05 m and wave length of 6 m. The suspension system has a spring constant of 400 kN/m and a damping factor of 0.5. If the vehicle speed is 100 km/hr, determine the displacement amplitude of the vehicle.

Or

- (b) A centrifugal fan of mass 5 kg has a rotating unbalance of 0.25 kg m. When dampers having damping factor of 0.2 are used, specify the springs for mounting such that only 10% of the unbalance force is transmitted to the floor. The fan is running at a constant speed of 1000 rpm.
15. (a) The arms of a Porter governor are 250 mm long. The upper arms are pivoted on the axis of revolution, but the lower arms are attached to a sleeve at a distance of 50 mm from the axis of rotation. The weight on the sleeve is 600 N and the weight of each ball is 80 N. Determine the equilibrium speed when the radius of rotation of the balls is 150 mm. If the friction is equivalent to a load of 25 N at the sleeve, determine the range of speed for this position.

Or

- (b) A ship is propelled by a turbine rotor of mass 500 kg and has a speed of 2400 rpm. The rotor has a radius of gyration of 0.5 m and rotates in clockwise direction when viewed from stern. Find the gyroscopic effects in the following cases:
- The ship runs at a speed of 15 knots (1 knot = 1860 m/hr). It steers to the left in a curve of 60 m radius.
 - The ship pitches $\pm 5^\circ$ from the horizontal position with the time period of 20 s of simple harmonic motion.
 - The ship rolls with angular velocity of 0.04 rad/s clockwise when viewed from stern. Also find the maximum acceleration during pitching.

PART C — (1 × 15 = 15 marks)

16. (a) The following data refer to the transmission gear of a motor ship: Moment of inertia of flywheel is 4800 kg.m^2 . Movement of inertia of propeller is 3200 kg.m^2 , modulus of rigidity of shaft material is 80 Gpa, and the equivalent moment of inertia per cylinder is 400 kg.m^2 . Assuming the diameter of the torsionally equivalent crankshaft to be 320 mm and treating the arrangement as a three-rotor system, determine the frequency of the free torsional vibrations.

Or

- (b) A governor of the Proell type has each arm 250 mm long. The pivots of the upper and lower arms are 25 mm from the axis. The central load acting on the sleeve has a mass of 25 kg and the each rotating ball has a mass of 3.2 kg. When the governor sleeve is in mid-position, the extension like of the lower arm is vertical and the radius of the path of rotation of the masses is 175 mm. The vertical height of the governor is 200 mm. If the governor speed is 160 r. p.m. when in mid-position, find the length of the extension link and the tension in the upper arm.