Q. Code: 941316

B.E./B.TECH. Degree Examination, December 2020

Fifth Semester

ME18502 Dynamics of Machinery

(Regulation 2018)

Time: Three hours Maximum: 80 Marks

Answer **ALL** questions

PART A - (8 X 2 = 16 marks)

1. Which of the following statements are associated with complete dynamic balancing of rotating systems?

   1. Resultant couple due to all inertia forces is zero.
   2. Support reactions due to forces are zero but not due to couples.
   3. The system is automatically statically balanced.
   4. Centre of masses of the system lies on the axis of rotation.

   a) 1, 2, 3 and 4

   b) 1, 2, and 3 only

   c) 2, 3 and 4 only

   d) 1, 3 and 4 only

2. A simple pendulum of length 5 m, with a bob of mass 1 kg, is in simple harmonic motion as it passes through its mean position, the bob has a speed of 5 m/s. The net force on the bob at the mean position is

   (a) zero (b) 2.5 N (c) 5 N (d) 25N

3. When a shaking force is transmitted through the spring, damping becomes detrimental when the ratio of its frequency to the natural frequency is greater than

   (a) 0.25 (b) 0.50 (c) 1.00 (d) 2

4. The pitching of a ship in the ocean is an oscillatory periodic motion. A ship is pitching 6° above and 6° below with a period of 20s from its horizontal plane. Consider the following statements in this regard:

   1.The motion has a frequency of oscillation (i.e. pitching) of 3 cycles/minute

   2. The motion has an angular frequency of 3.14 rad/s.

   3. The angular velocity of precession of ship's rotor is $\pi 2/300$ rad/s.

   4. The amplitude of pitching is $\pi/30$ rad.

   Which of these statements are correct?

   (a) 1 and 2 (b) 1, 2 and 4 (c) 2, 3 and 4 (d) 1, 3 and 4

5. Analyze the purpose of Flywheel in forging and pressing operations.

6. Show that the critical speed of a shaft is the same as the frequency of transverse vibration.
7. Whether vibration is desirable in engineering applications? Clarify with application.
8. The engine of an airplane rotates in clockwise direction when seen from tail end and the aerospace takes turn to the left. What will be the effect of gyroscopic couple on the airplane?

PART B - (4 X16 = 64 marks)

09. (a) In a vertical double acting steam engine, the connecting rod is 4 times the crank. The weight of the reciprocating part is 125 kg and the stroke of the piston is 450 mm. The engine runs at 250 rpm. If the net load on the piston due to steam pressure is 25 kN when the crank is turned through an angle of 120 degree from the top dead center determine the **(16)**

1. Pressure on slide bars, 2. thrust in the connecting rod, 3. tangential force on the crank-pin, 4. thrust on the bearings and 5. turning moment on the crank shaft.

(OR)

(b) A steam engine runs at 150 rpm. Its turning moment diagram gave the following area measurements in mm^2 taken in order above and below the mean torque line: **(16)**

500, -250, 270, -390, 190, -340, 270, -250

The scale for the turning moment is 1 mm = 500 N m and for crank angle is 1 mm = 5°. If the fluctuation of speed is not to exceed ± 1.5% of the mean speed, determine the cross-section of the rim of the flywheel assuming rectangular with axial dimension equal to 1.5 times the radial dimension. The hoop stress is limited to 3.5 MPa and the flywheel is 7470 kg/m^3.

10. (a) The following data relate to a shaft held in long bearings. **(16)**

Length of shaft = 1.2 m,

Diameter of shaft = 14 m,

Mass of a rotor at midpoint = 16 kg,

Eccentricity of centre of mass of rotor from centre of rotor = 0.4 mm,

Modulus of elasticity of shaft material = 200 GN/m^2,

Permissible stress in shaft material = $70 * 10^6$ N/m^2.

Determine the critical speed of the shaft and the range of speed over which it is unsafe to run the shaft. Assume the shaft to be massless.

(OR)

(b) A machine of mass 75 kg is mounted on springs and is fitted with a dashpot to damp out vibrations. There are three springs each of stiffness 10 N/mm and it is found that the amplitude of vibration diminishes from 38.4 mm to 6.4 mm in two complete oscillations. Assuming that the damping force varies as the velocity, **(16)**

Determine:

1. the resistance of the dashpot at unit velocity;
2. the ratio of the frequency of the damped vibration to the frequency of the undamped vibration; and
3. the periodic time of the damped vibration

11. (a) A column of structure weighing 15 kg is suspended from one end of a helical spring, the other end being fixed. The stiffness of the spring is 12 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 160 cos 50 t N is applied at the mass in the vertical direction, find the amplitude of the forced vibrations. What is its value of resonance? **(16)**

(OR)

(b) A Single-cylinder engine of total mass 250 kg is to be mounted on an elastic support which permits vibratory movement in vertical direction only. The mass of the piston is 4.5 kg and has a vertical reciprocating motion which may be assumed simple harmonic with a stroke of 140 mm. It is desired that the maximum vibratory force transmitted through the elastic support to the foundation shall be 700 N when the engine speed is 900 r.p.m. and less than this at all higher speeds. **(16)**

1. Find the necessary stiffness of the elastic support, and the amplitude of vibration at 900 r.p.m., and
2. If the engine speed is reduced below 900 r.p.m. at what speed will the transmitted force again becomes 700 N?

12. (a) A spring-loaded governor of the Hartnell type has arms of equal length. The masses rotate in a circle of 140 mm diameter when the sleeve is in the mid position and the ball arms are vertical. The equilibrium speed for this position is 500 r.p.m., neglecting friction. The maximum sleeve movement **(16)**

is to be 23 mm and the maximum variation of speed taking in account the friction to be 5 per cent of the mid position speed. The mass of the sleeve is 5 kg and the friction may be considered equivalent to 28 N at the sleeve. The power of the governor must be sufficient to overcome the friction by one per cent change of speed either way at mid-position. Determine, neglecting obliquity effect of arms; 1. The value of each rotating mass: 2. The spring stiffness in N/mm; and 3. The initial compression of spring.

(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: **(16)**

(a) The ship runs at a speed of 15 knots (1 knot =1860 m/h). It steers to the left in a curve of 60 m radius.

(b) The spin pitches ± 5° from the horizontal position with the time period of 20 s of simple harmonic motion.

(c) The ship rolls with angular velocity of 0.04 rad/s clockwise when viewed from stern. Also calculate the maximum angular acceleration during pitching.