MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

ME-501

DYNAMICS OF MACHINES

Time Allotted: 3 Hours | Full Marks: 70

The questions are of equal value.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.
All symbols are of usual significance.

GROUP A
(Multiple Choice Type Questions)

1. Answer *all* questions. $10 \times 1 = 10$

(i) The most suitable follower motion program for high speed engine is

(A) uniform acceleration and deceleration
(B) uniform velocity
(C) S. H. M.
(D) cycloid

(ii) The danger of breakage and vibration is maximum

(A) below the critical speed
(B) near the critical speed
(C) above the critical speed
(D) none of these

(iii) The ratio of height of porter governor (when length of arms and links are equal) to the height of watt governor is (where m is the mass of the ball and M is the mass of sleeve).

(A) (m+M)/m (B) M/(m+M)
(C) m/(m+M) (D) none of these

(iv) When a body moves with simple harmonic motion, the product of its periodic time and frequency is equal to

(A) 0 (B) 1
(C) π (D) $\pi/2$

(v) In a vibrating system, if the actual damping coefficient is 40 N/m/s and critical damping coefficient is 400 N/m/s, damping ratio is

(A) 0.2 (B) 0.1
(C) 1.2 (D) none of these

(vi) In order to have complete balance of several revolving masses in different plane

(A) the resultant force must be zero
(B) the resultant couple must be zero
(C) both (A) and (B)
(D) none of these

(vii) A flywheel starting from rest and accelerating uniformly rotates 25 radians in 9 sec. Its angular velocity in 10 sec would be approximately

(A) 60 r.p.m. (B) 46 r.p.m.
(C) 30 r.p.m. (D) 120 r.p.m.

(viii) In case of involute gear teeth the pressure angle is

(A) maximum at the engagement of teeth

(B) same at all points of cantact

(C) minimum at the engagement of the teeth

(D) zero at the pitch point.

(ix) A torsional vibratory system having n rotors connected by a shaft has

(A) n nodes (B) $(n + 1)$ nodes

(C) $(n - 1)$ nodes (D) $(n + 2)$ nodes

(x) The axis of spin, the axis of precession and the axis of gyroscopic torque are in

(A) two perpendicular planes

(B) three perpendicular planes

(C) three parallel planes

(D) none of these

GROUP B
(Short Answer Type Questions)

Answer any *three* questions. $3 \times 5 = 15$

2. (a) State the differences between a Governor and a Flywheel. 2

(b) The arms of a Porter governor are each 250 mm long and pivoted on the governor axis. Mass of each ball is 5 kg and the mass of the central sleeve is 30 kg. The radius of rotation of the balls is 150 mm when the sleeve begins to rise and reaches a value of 200 mm for maximum speed. Determine the speed range of the governor. 3

3. Find the maximum and minimum speed of a flywheel of mass 5200 kg and radius of gyration 1.8 m when the fluctuation energy 100800 N-m and the mean speed of the engine is 180 rpm. 5

4. A machine weighing 3.5 kg vibrates in a viscous medium. A harmonic excitation of 40 N acts on the machine and produces resonant amplitude of 18 mm with a period of 0.2 sec. Determine the damping coefficient. 5

5. What do you mean by 'dynamically equivalent system'? Explain. 5

6. A rotating disc is provided with four masses 200 kg, 300 kg, 240 kg and 260 kg respectively with their mass centers at a distance of 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 mass center is at a distance of 0.2 m. 5

GROUP C
(Long Answer Type Questions)

Answer any *three* questions. $3 \times 15 = 45$

7. (a) Why rotating masses are to be dynamically balanced?

(b) A shaft is rotating at a uniform angular speed. Four masses M1, M2, and M3 and M4 of magnitudes 300 kg, 450 kg, 360 kg, 390 kg respectively are attached rigidly to the shaft. The masses are rotating in the same plane. The corresponding radii of rotation are 200 mm, 150 mm, 250 mm and 300 mm respectively. The angle made by these masses with horizontal are 0°, 45°, 120° and 255° respectively.

Find, (i) the magnitude of balancing mass

(ii) the position of balancing mass if its radius of rotation is 200 mm.

8. (a) Describe the Dunkerley's method to find out the natural frequency of a shaft carrying several loads. 3

(b) What do you mean by whirling of shafts? What is the whirling or critical speed? Explain. 3

(c) A rotor has a mass of 12 kg and is mounted midway on a 24 mm diameter horizontal shaft supported at the ends by two bearings. The bearings are 1m apart. The shaft rotates at 2400 rpm. If the centre of mass of the rotor is 0.11 mm away from the geometric centre of the rotor due of a certain manufacturing defects, find the amplitude of the steady-state vibration and the dynamic force transmitted to the bearing. Given $E = 200\ GN/m^2$. 9

9. (a) The rotor of the turbine of a ship makes 1200 rpm clockwise when viewed from stern. The rotor has mass 750 kg and its radius of gyration is 300 mm. Find gyroscopic couple transmitted to the body when it pitches with maximum angular velocity 1 rad/s. 12

(b) Explain the term 'balancing of in-line cylinder'? 3

10.(a) Discuss the effect of damping on vibratory system. What is meant by under damping, over damping and critical damping? 4

(b) Define the terms vibration isolation and transmissibility. 3

(c) In a single-degree damped vibrating system a suspended mass of 8 kg makes 30 oscillations in 18 seconds. The amplitude decreases to 0.25 of the initial value after 5 oscillations. Determine: 8

(i) The stiffness of the spring

(ii) The logarithmic decrement

(iii) The damping factor

(iv) The damping coefficient.

11.(a) With a neat sketch, derive the process of energy storage in flywheel. 5

(b) The equation of the turning moment curve of a three crank is $(5000 + 1500 \sin 3\theta)$N-m, where θ is crank angle in radians. The moment of inertia of the flywheel is 1000 kg-m^2 and the mean speed is 300 rpm. Calculate the maximum fluctuation of the speed of the flywheel in percentage when 10

(i) The resisting tourque is constant,

(ii) The resisting torque is $(5000 + 600 \sin\theta)$ N-m.

12.(a) Define and explain the governor's isochronism. 3

(b) A governor of the Hartnell type has equal balls of mass 3 kg, set initially at a radius of 200 mm. The arms of the bell crank lever are 110 mm vertically and 150 mm horizontally. Find the following : 12

(i) The initial compressive force on the spring, if the speed for an initial ball radius of 200 mm is 240 rpm.

(ii) The stiffness of the spring required to permit a sleeve movement of 4 mm on a fluctuation of 7.5 per cent in the engine speed.