

DYNAMICS OF MACHINES (MECH 3105)

Time Allotted : 2½ hrs

Full Marks : 60

Figures out of the right margin indicate full marks.

*Candidates are required to answer Group A and
any 4 (four) from Group B to E, taking one from each group.*

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve:

12 × 1 = 12

Choose the correct alternative for the following

- (i) When a ship travels in sea, which of the following effects is more dangerous?
(a) Steering (b) Pitching (c) Rolling (d) All of the above.
- (ii) The gyroscopic couple acting on a disc of moment of inertia I , rotating with speed ω and speed of precession ω_p , is given by
(a) $I \omega^2 \omega_p$ (b) $I \omega \omega_p^2$ (c) $I \omega \omega_p$ (d) $I \omega^2 \omega_p^2$
- (iii) The partial balancing of reciprocating parts in locomotives produces
(a) hammer Blow (b) swaying Couple
(c) variation of tractive force along the line of stroke (d) all of these.
- (iv) The primary unbalanced force is maximum when the angle of inclination of the crank with the line of stroke is
(a) 0 and 90 (b) 0 and 180
(c) 90 and 180 (d) 180 and 360.
- (v) In order to balance the reciprocating masses,
(a) primary forces and couples must be balanced
(b) secondary forces and couples must be balanced
(c) both (a) and (b)
(d) none of these.
- (vi) The equivalent stiffness of two springs of equal stiffness in parallel becomes
(a) Twice (b) One-half (c) One-third (d) One-fourth
- (vii) In vibration isolation system, if $\omega/\omega_n > 1$, then the phase difference between the transmitted force and the disturbing force is
(a) 0° (b) 90° (c) 180° (d) 270° .
- (viii) At a nodal point in a shaft, the amplitude of torsional vibration is
(a) zero (b) minimum (c) maximum (d) infinity.
- (ix) At a certain speed, revolving shaft tends to vibrate violently in transverse directions. The speed is known as _____.
(a) Whirling speed (b) Critical speed
(c) Whipping speed (d) Jump speed
- (x) The factor which affects the critical speed of a shaft is
(a) diameter of disc (b) eccentricity
(c) span of shaft (d) all of these.

Fill in the blanks with the correct word

- (xi) The coefficient of fluctuation of energy is the ratio of _____ to _____.
- (xii) The pitching of a ship produces forces on the bearings which act _____ to the motion of the ship.
- (xiii) When the crank is at the inner dead centre, in a reciprocating steam engine, then the velocity of the piston will be _____.
- (xiv) If the stiffness of a system is 'k' and mass is 'm' then the natural frequency of free vibration of the system is _____.
- (xv) Resonance is a condition, when the frequency of the external force is the _____ as that of the natural frequency of the system.

Group - B

2. (a) The lengths of crank and connecting rod of a horizontal reciprocating engine are 200 mm and 1 m, respectively. The crank is rotating at 400 rpm. When the crank has turned 30 degree from the inner dead centre, the difference of pressure between the cover end and piston end is 0.4 N/mm². If the mass of the reciprocating parts is 100 kg and cylinder bore is 0.4 m, then calculate,
 (i) Inertia force, (ii) Force on piston, (iii) Piston effort,
 (iv) Thrust on the side of the cylinder walls, (v) Thrust in the connecting rods
 (vi) Crank-effort and (vii) Turning moment on the moment shaft. [[CO1](Evaluate/LOCQ)]
- (b) A flywheel with a mass of 5 KN has a radius of gyration of 1.8 m. Find the energy stored in the flywheel when its speed increases from 310 to 350 rpm. [[CO1](Evaluate/IOCQ)]
- 9 + 3 = 12**
3. (a) A punching press pierces 35 holes per minute in a plate using 10 KN.m of energy per hole during each revolution. Each piercing takes 40% of the time needed to make one revolution. A cast iron flywheel used with the punching machine is driven by a constant torque electric motor. The flywheel rotates at a mean speed of 210 rpm and the fluctuation of speed is not to exceed $\pm 1\%$ of the mean speed. Find
 (i) Power of the electric motor, (ii) Mass of the flywheel, and
 (iii) Cross-sectional dimensions of the rim when the width is twice its thickness. Take hoop stress for cast iron = 4 MPa and density of cast iron = 7200 kg/m³. [[CO1](Evaluate/IOCQ)]
- (b) A uniform disc of 100 mm diameter and 5 kg mass is mounted midway between bearings 100 mm apart, which keeps it in horizontal plane. The disc spins about its axis with a constant speed of 1200 rpm, as shown in Fig. 1. Find the resultant reaction at each bearing due to the mass and gyroscopic effects. [[CO2](Analyse/IOCQ)]

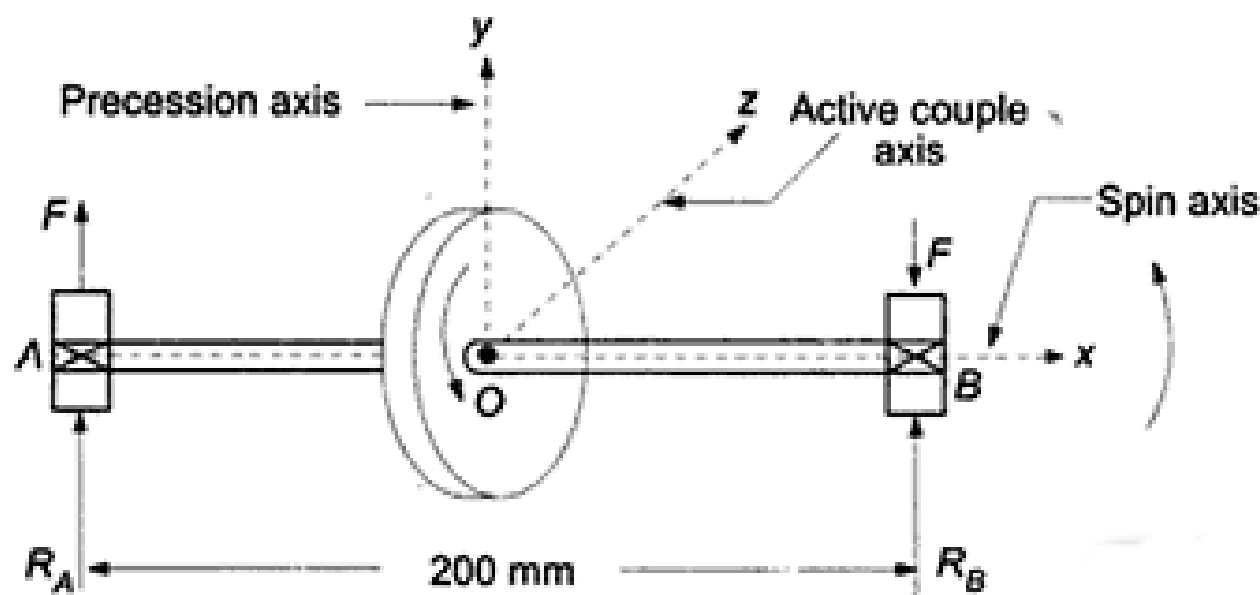


Fig. 1

8 + 4 = 12

Group - C

4. (a) What is balancing and why is it necessary for high speed engines? [[CO3](Understand/LOCQ)]
- (b) A shaft carries four rotating masses A, B, C and D in this order along the axis. The mass A may be assumed to be concentrated at a radius of 120 mm, B at 150 mm, C at 130 mm and D at 180 mm. the masses at A, C and D are 10, 15 and 12 kg, respectively. The planes of rotation of A and B are 150 mm apart and of B & C are 200 mm apart. The angle between A and C is 90 degree. If the shaft is in complete dynamic balance, determine
 (i) The angles between the radii of A, B and D
 (ii) The distance between the planes of rotation of C and D
 (iii) The Mass at B. [[CO3](Evaluate/IOCQ)]
- (c) Determine the magnitude of hammer blow for partial balancing of a reciprocating engine? [[CO3](Remember/LOCQ)]
- 2 + 8 + 2 = 12**
5. (a) What are the effects of partial balancing? Explain. [[CO3](Understand/LOCQ)]
- (b) For an inside cylinder locomotive with two cranks at right angles, the reciprocating parts are 300 kg per cylinder. The distance between cylinder centre lines is 60 cm and between the planes of rotation of the wheels is 150 cm. Each crank is 32.5 cm long and the driving wheels are 1.875 m diameter. The balancing mass are introduced in the planes of rotation of the wheel. Find
 (i) Tractive effort. (ii) Wheel load.
 When the locomotive is running at 92.25 km/hr. [[CO3](Analyse/IOCQ)]
- (c) Why complete balancing of reciprocating masses is not done? [[CO3](Understand / LOCQ)]
- 3 + 7 + 2 = 12**

Group - D

6. (a) Derive the natural frequency of a simple vibrating system as shown in Fig. 2 using Equilibrium method. Express the solution graphically with the phase diagram by considering the initial solution as [[CO4](Analyse/HOCQ)]

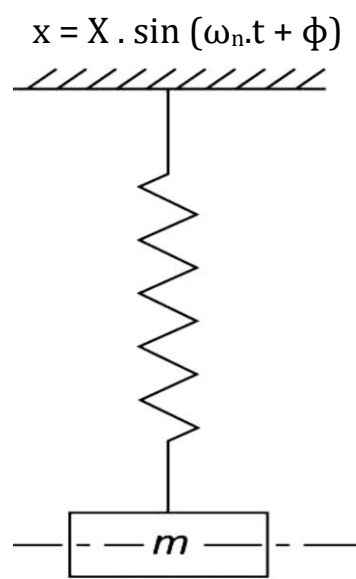


Fig. 2

- (b) Define the following term — (i) Resonance (ii) Frequency.

[[CO4](Remember/LOCQ)]
8 + 4 = 12

7. (a) 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, determine : (i) the resistance of the dashpot at unit velocity; (ii) The ratio of the frequency of the damped vibration to the frequency of the undamped vibration; and (iii) The periodic time of the damped vibration.
- (b) What do you mean by whirling of shafts?

[[CO4](Analyse/HOCQ)]
[[CO5](Remember/LOCQ)]
8 + 4 = 12

Group - E

8. (a) Determine the frequency of torsional vibration of the disc as shown in Fig. 3. If both the ends of the shafts are fixed and the diameter of the shaft is 40 mm. The disc has a mass of 96 Kg and a radius of gyration of 0.4 m. Take modulus of rigidity for the shaft material as 85 GN/m², $l_1 = 1\text{m}$ and $l_2 = 0.8\text{m}$.

[[CO5](Analyse/HOCQ)]

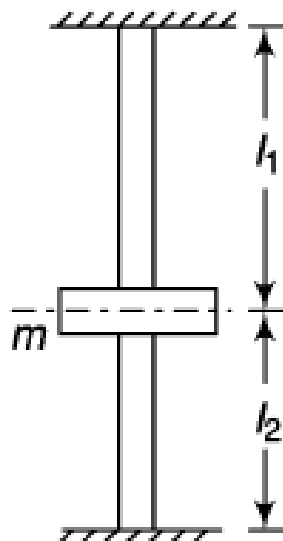


Fig. 3

- (b) Discuss the following multifilar system - (i) Bifilar suspension (ii) Trifilar suspension.

[[CO5](Remember/LOCQ)]
8 + 4 = 12

9. (a) The following data relate to a shaft held in long bearings.
- Length of shaft = 1.2 m
 - Diameter of shaft = 14 m
 - Mass of a rotor at midpoint = 16 kg
 - Eccentricity of center of mass of rotor from center of rotor = 0.4 mm
 - Modulus of elasticity of shaft material = 200 GN/m²
 - Permissible stress in shaft material = $70 \times 10^6 \text{ N/m}^2$

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.

[[CO6](Analyse/HOCQ)]

- (b) What are the harmful effects of transverse vibration of shaft?

[[CO5](Remember/LOCQ)]
8 + 4 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	35.41	31.25	33.34

