DYNAMICS OF MACHINES
(MECH 3105)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

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

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) Inertia force on a body in non-inertial frame seems to act
(a) In the direction of acceleration
(b) In the direction of velocity
(c) In perpendicular direction of acceleration
(d) In opposite direction of acceleration.

(ii) Degree of freedom for a gyroscope rotor is
(a) 1 (b) 2 (c) 3 (d) 4.

(iii) If the ratio of the length of connecting rod to crank radius increases, then
(a) primary force increases (b) primary force decreases
(c) secondary force increases (d) secondary force decreases.

(iv) When there is a reduction in amplitude over every cycle of vibration, then the body is said to have
(a) Free vibration (b) Damped vibration
(c) Forced vibration (d) Under damped vibration.

(v) If a system is dynamically balanced, then it is statically
(a) balanced (b) unbalanced
(c) partially balanced (d) cannot be said.

(vi) If the damping factor for a vibrating system is unity, then the system will be
(a) Under damped (b) Over damped
(c) Critically damped (d) Without vibration another.

(vii) For a critically damped system, damping ratio is
(a) 1.0 (b) 0.5 (c) 2 (d) 3.

(viii) In a vibrating system, if the actual damping coefficient is 40 N/(m/s) and critical damping coefficient is 420 N/(m/s), then logarithmic decrement is equal to
(a) 0.2 (b) 0.4 (c) 0.6 (d) 0.8.

(ix) The equivalent stiffness of two springs of equal stiffness in parallel becomes
(a) Twice (b) One-half (c) One-third (d) One-fourth.

(x) At the nodal point in a shaft, the amplitude for torsional vibration will be
(a) Zero (b) Minimum (c) Maximum (d) Infinity.

Group – B

2. (a) A vertical engine running at 1000 r.p.m. with a stroke of 100 mm, has a connecting rod 250 mm between centres and mass 1.50 kg. The mass centre of the connecting rod is 80 mm from the big end centre and when suspended as a pendulum from the gudgeon pin axis makes 25 complete oscillations in 20 seconds.
(i) Calculate the radius of gyration of the connecting rod about an axis through its mass centre.
(ii) When the crank is at 50° from the top dead centre and the piston is moving downwards.
Find the acceleration of the piston and the angular acceleration of the connecting rod. Hence find the inertia torque exerted on the crankshaft.
To make the two-mass system to be dynamically equivalent to the connecting rod, necessary correction torque has to be applied and since the engine is vertical, gravity effects are to be considered.

(b) Why a two-wheeler rider leans towards the inside while negotiating a turn?

10 + 2 = 12

3. (a) A riveting machine is driven by a constant torque 4 kW motor. The moving parts including the flywheel are equivalent to 250 kg at 0.8 m radius. One riveting operation takes 1.5 second and absorbs 10500 N-m of energy. The speed of the flywheel is 400 r.p.m. before riveting.
Find the speed immediately after riveting. How many rivets can be closed per minute?

(b) The mass of a turbine rotor of a ship is 10000 kg and has a radius of gyration of 0.80 m. It rotates at 1500 rpm clockwise when viewed from the stern. Determine the gyroscopic effects in the following cases:
(i) If the ship traveling at 120 km/h steers to the left along a curve of 100 m radius.
(ii) If the ship is pitching and the bow is descending with maximum velocity. The pitching is with simple harmonic motion with periodic time of 25 s and the total angular movement between extreme positions is 15°.
(iii) If the ship is rolling with an angular velocity of 0.05 rad/s clockwise when looking from stern.
In each case, determine the direction in which the ship tends to move.

6 + 6 = 12

Group – C

4. (a) The three cranks of a three-cylinder locomotive are all on the same axle and are set at 120°. The pitch of the cylinders is 1.2 metre and the stroke of each piston is 0.8 m. The reciprocating masses are 320 kg for inside cylinder and 280 kg for

each outside cylinder and the planes of rotation of the balance masses are 1.0 m from the inside crank. If 30% of the reciprocating parts are to be balanced, find:

(i) The magnitude and the position of the balancing masses required at a radius of 0.75 m; and

(ii) The hammer blow per wheel when the axle makes 7 r.p.s.

(b) Reciprocating mass per cylinder in a 60° V-twin engine is 1.6 kg. The stroke and connecting rod length are 120 mm and 300 mm, respectively. If the engine runs at 2400 rpm, determine the maximum and minimum values of primary and secondary forces.

8 + 4 = 12

5. (a) The cylinders of a V-engine are set at an angle of 60º with both cylinders connected to a common crank. The connecting rod is 360 mm long and the crank radius is 80 mm. The reciprocating mass is 1.2 kg per cylinder whereas the rotating mass at the crank pin is 1.5 kg. A balance mass equivalent to 1.8 kg is also fitted opposite to the crank at a radius of 80 mm. Determine the maximum and the minimum values of the primary and secondary forces due to inertia of the reciprocating and rotating masses if the engine rotates at 1000 rpm.

(b) What do you mean by primary and secondary unbalance in reciprocating engines?

9 + 3 = 12

Group – D

6. (a) Determine the equation of motion and natural frequency of oscillation of block 'm' of mass 5 kg as shown in Fig.1. Stiffness of both the spring is 5 N/mm and consider pulley to be massless.

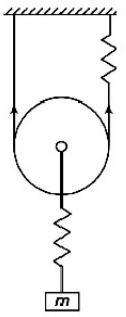

Fig.1

(b) In a single-degree damped vibrating system, a suspended mass of 15 kg makes 20 oscillations in 15 s. The amplitude decreases to 1/5th of the initial value after 5 oscillations.

Determine

(i) Stiffness of the spring,

(ii) Logarithmic decrement,

(iii) Damping factor, and

(iv) Damping coefficient.

6 + 6 = 12

7. (a) A washing machine unit having a mass of 40 kg is to be supported on four springs, each having a spring stiffness 'k'. The unit operates at 400 rpm. Find the

value of stiffness 'k' if only 8% of the shaking force is allowed to be transmitted to the supporting structure.

(b) An electric motor running at 400 rpm is supported on a spring and a dashpot. The spring stiffness is 5000 N/m and the dashpot offers resistance of 400 N at 4 m/s. The unbalanced mass 0.5 kg rotates at 5 cm radius and the total mass of vibratory system is 20 kg.
Determine
(i) Damping factor,
(ii) Amplitude of vibration and phase angle,
(iii) Resonant speed and resonant amplitude, and
(iv) Force exerted by the spring and dashpot on the motor.

4 + 8 = 12

Group – E

8. (a) A shaft of 25 mm diameter and 2.2 m long as a uniformly distributed load of 100 N/m. It is simply supported at the ends and carries three loads of 1.2 kN, 1.75 kN and 0.75 kN at 0.7 m, 1.1 m and 1.5 m respectively from the left end support. Calculate the natural frequency of transverse vibrations. E=207 GPa.

(b) The rotor of mass 14 kg is supported at the mid-span of a shaft of span 0.8 m. The rotor centre has an eccentricity of 0.5 mm from the shaft axis. Assuming the shaft to be held in short bearings at it ends and ignoring the mass of the shaft,
Determine
(i) The critical speed of the shaft and
(ii) The force exerted on the bearing at a speed of 3000 rpm.
(iii) The diameter of steel shaft is 25 mm and E = 207 GPa.

5 + 7 = 12

9. (a) A torsional system of an engine driving a propeller is shown in Fig.2. The moment of inertia of engine, flywheel and propeller are 25 kg-m^2, 70 kg-m^2 and 40 kg-m^2 respectively. The diameter of shaft connecting engine to flywheel is 20 mm and is 1.25 m long. The diameter of shaft connecting flywheel to propeller is 35 mm and is 2.5 m long. Find the frequencies of torsional vibrations and the positions of the nodes. Also find the amplitudes of vibrations. Rigidity modulus, G = 79 GPa.

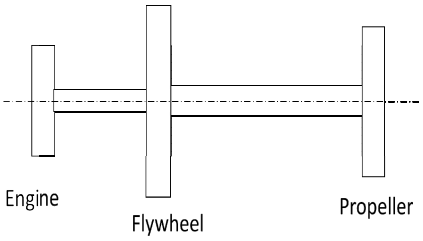

Fig.2 (not to scale)

(b) A two degree of freedom system is shown in the Fig.3. The values of m_1, m_2, k_1, k_2 are 15 kg, 5 kg, 20 N/m and 5 N/m respectively. Find the frequencies of normal mode of vibration. Also find the equation of normal mode vibration for following initial conditions:
$x_1(0)$ = 1 mm, $x_2(0)$ = 3 mm and the system is at rest initially.

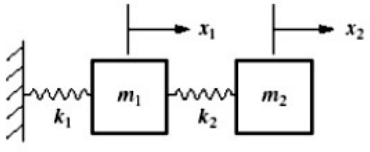

Fig.3

7 + 5 = 12

Department & Section	Submission link:
ME A	https://classroom.google.com/c/MTQzMTg4MTcwNTE4/a/Mjc0NDM0ODQzNzEx/details
ME B	https://classroom.google.com/c/MTQzMTg4MTcwNTE4/a/Mjc0NDM0ODQzNzEx/details