(vii) In Coulomb damping, the amplitude of motion is reduced in each cycle by:
(a) $\frac{\mu N}{k}$ (b) $\frac{2\mu N}{k}$ (c) $\frac{4\mu N}{k}$ (d) $\frac{5\mu N}{k}$

(viii) The equation of motion of a machine (rotating at frequency ω) of mass M, with an unbalanced mass m, at radius e, is given by
(a) $m\ddot{x} + c\dot{x} + kx = me\omega^2 \sin \omega t$
(b) $M\ddot{x} + c\dot{x} + kx = me\omega^2 \sin \omega t$
(c) $M\ddot{x} + c\dot{x} + kx = Me\omega^2 \sin \omega t$
(d) $m\ddot{x} + c\dot{x} + kx = Me\omega^2 \sin \omega t$

(ix) Which of the following factors are responsible for unbalancing in rotating systems?
(a) eccentricity
(b) deflection
(c) non-uniform distribution of mass around the axis
(d) all of the above.

(x) When a ship travels in a sea, which effect is most dangerous?
(a) Steering (b) Pitching
(c) Rolling (d) None of the above.

Group – B

2. (a) The lengths of crank and connecting rod of a vertical reciprocating engine are 350 mm and 1.75 m respectively. The crank is rotating at 250 r.p.m. clockwise. Find analytically
(i) Velocity and acceleration of piston
(ii) Angular acceleration of connecting rod when the crank has turned through 30° from the top dead centre and the piston is moving downwards.

(b) A small connecting rod 250 mm long between centres has a mass of 3 kg and moment of inertia of 3 x 10^4 kg-mm^2 about its centre of gravity. Centre of gravity is located at a distance of 175 mm from the small end centre. Determine a dynamically equivalent two mass system, when one mass is located at the small end centre.
If the connecting rod is replaced by two masses located at the two centres, find the correction couple that must be applied for complete dynamically equivalent two mass system when the angular acceleration of the connecting rod is 18500 rad/s^2 clockwise.

4 + (6 + 2) = 12

3. (a) Find the natural frequency of the pulley system shown in figure 1 by neglecting the friction and the masses of the pulleys.

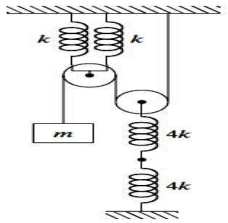

Figure 1

(b) Determine the equivalent spring stiffness and the natural freque the following vibrating system given in figure 2. Take S_1 = 5 N/m = 8 N/mm; m = 10 kg; a = 20 mm and b = 12 mm.

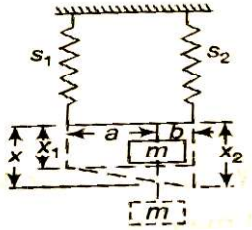

Figure 2

5 + 7

Group – C

4. (a) What do you understand by Critical Damping Constant?

(b) The maximum permissible recoil distance of a gun is specified as 0.5 m initial recoil velocity is to be between 8 m/s and 10 m/s, find the stiffness of the recoil mechanism. Assume that a critically damped das used in the recoil mechanism and the mass of the gun has to be at least 5

3 + 9

5. (a) A shaft 40 mm diameter and 2.5 m long has a mass of 15 kg per length. It is simply supported at the ends and carries three masses 140 kg and 60 kg at 0.8 m, 1.5 m and 2 m respectively from the left su Taking E = 200 GN/m^2, find the frequency of the transverse vibration

(b) What do you understand by 'Whirling of Shaft'? Explain in detail.

8 + 4

Group – D

6. (a) Four masses A, B, C and D are rigidly attached to a shaft. The radii of r are 60 mm, 76 mm, 80 mm and 70 mm from the axis of rotatio magnitude of masses A, C and D are 15 kg, 10 kg and 8 kg respective axial distance between the planes of rotation A and B are 400 mm wh

between B and C is 500mm. The masses A and C are at right angled to each other. If the masses are in complete balance, then find

(i) the angle of masses B and D from mass A
(ii) the axial distance between the planes of rotation of C and D
(iii) the magnitude of mass B.

(b) Deduce the expression for maximum variation of tractive force and swaying couple for an uncoupled two cylinder locomotive engine.

(5 + 2 + 1) + (2 + 2) = 12

7. (a) The cylinders of a V-engine are set at an angle of 40^o with both cylinders connected to a common crank. The connecting rod is 300 mm long and the crank radius is 60 mm. The reciprocating mass is 1kg 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 minimum values of primary and secondary forces due to inertia of rotating and reciprocating masses if the engine rotates at 900 rpm.

(b) Explain with an example how multi-cylinder engine is more balanced than single cylinder engine without providing any balancing mass.

8 + 4 = 12

Group – E

8. (a) The mass of each ball of a proell governor is 3 kg and the weight on the sleeve is 20 kg. Each arm is 220 mm long and pivots of the upper and the lower arms are 20 mm from the axis. For the midposition of the sleeve, the extensions links of the lower arms are vertical, the height of the governor 180 mm and the speed 150 rpm. Determine the length of the extension links and the tension in the upper arms.

(b) Write short note: Isochronism, Sensitiveness and Hunting.

6 + (2 × 3) = 12

9. (a) Discuss the gyroscopic effect on sea vessels.

(b) The turbine rotor of a ship of mass 6000 kg has a radius of gyration 50 cm. It rotates at 1820 rpm clockwise when looking from stern. Determine the gyroscopic couple and its effect when

(i) The ship is travelling at 40 km/hr, steers to the left in a curve of 70 metre radius.
(ii) The ship is pitching and the bow is descending with the maximum velocity. The pitching is simple harmonic, periodic time being 20 seconds, and the total angular movement between the extreme positions is 10^o.
(iii) The ship is rolling and at certain instant has an angular velocity 0.02 rad/sec clockwise when looking from the stern.

In each explain clearly the direction in which the ship tends to move as a result of gyroscopic action.

3 + (3 + 3 + 3) = 12

DYNAMICS OF MACHINES
(MECH 3101)

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) A body of mass m and radius of gyration 'K' is to be replaced by two masses m_1 and m_2 located at distances h_1 and h_2 respectively from the c.g. of the original body. These will be kinetically equivalent to original body if
(a) $h_1 + h_2 = k$ (b) $h_1^2 + h_2^2 = k^2$
(c) $h_1 h_2 = k^2$ (d) $h_1 h_2 = k$.

(ii) Flywheels are used to
(a) control the mean speed (b) control the variation of speed
(c) both (a) and (b) (d) none of the above.

(iii) The maximum magnitude of the unbalanced force in a line perpendicular to the line of stroke is known as
(a) Swaying couple (b) Hammer Blow
(c) Variation in tractive effort (d) Unbalanced Force.

(iv) For isochronous, spring controlled governor, the controlling force with increase in radius of rotation
(a) increases
(b) decreases
(c) remains constant
(d) may increase or decrease depending on size.

(v) The spring constant of a cantilever beam of length l with an end mass m and having Young's modulus E is
(a) $\frac{3EI}{l^3}$ (b) $\frac{l^3}{3EI}$ (c) $\frac{3EI}{2l^3}$ (d) $\frac{mEI}{3l^3}$

(vi) 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°.