B.TECH/ME/5TH SEM/MECH 3105/2021

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) If the resultant of forces acting on a body does not pass through the centre of mass, then the inertia force and inertia couple is replaced by (CO1)
(a) Equivalent inertia force (b) Equivalent inertia couple
(c) Equivalent offset inertia force (d) Equivalent offset inertia couple.

(ii) In an engine, the work done by inertia forces in a cycle is (CO1)
(a) Positive (b) Negative
(c) Zero (d) Can be anything.

(iii) The total reaction of ground on wheels of a vehicle due to gyroscopic couple and centrifugal force while negotiating curve is (CO2)
(a) Increased on inner wheels and decreased on outer wheels
(b) Decreased on inner wheels and increased on outer wheels
(c) Decreased on all the wheels
(d) Increased on all the wheels.

(iv) The gyroscopic couple is introduced in a ship whose spin axis is parallel to starboard, when it is (CO2)
(a) Pitching (b) Rolling
(c) Pitching or Rolling (d) Neither pitching nor rolling.

(v) If the ratio of the length of connecting rod to crank radius increases, then (CO3)
(a) Primary force increases (b) Primary force decreases
(c) Secondary force increases (d) Secondary force increases.

(vi) In order to facilitate the starting of locomotive in any position, the cranks of a locomotive, with two cylinders, are placed at _____ to each other. (CO3)
(a) 45^0 (b) 90^0 (c) 180^0 (d) 360^0.

(vii) For a critically damping system, the motion will be: (CO4)
(a) Periodic (b) Aperiodic
(c) Harmonic (d) Random.

(viii) A cantilever shaft having 50 mm diameter and a length of 300 mm has a disc of mass 100 kg at its free end. The Young's modulus for the shaft material is 200 GN/m^2. Determine the frequency of transverse vibrations of the shaft. (CO5)
(a) 31 (b) 35 (c) 37 (d) 41.

(ix) The equivalent stiffness of two springs of equal stiffness in parallel becomes (CO4)
(a) Twice (b) One-half (c) One-third (d) One-fourth.

(x) If the mass moment of inertia is increased to four times, then what will be the effect on free torsional vibrations of a single motor system? (CO5, CO6)
(a) Increase 4 times (b) Decrease 4 times
(c) Increase 2 times (d) Decrease 2 times.

Group – B

2. (a) The equation of the turning moment curve of a three crank engine is (3000 + 1200 sin 3θ) N-m, where θ is the crank angle in radians. The moment of inertia of the flywheel is 1500 kg-m^2 and the mean speed is 340 r.p.m. Calculate:
(i) power of the engine, and
(ii) the maximum fluctuation of the speed of the flywheel in percentage when the resisting torque is constant, and the resisting torque is (3000 + 800 sinθ) N-m. [CO1][Analyse/IOCQ]

(b) A uniform disc of 120 mm diameter and 6 kg mass is mounted midway between bearings 200 mm apart, which keeps it in horizontal plane. The disc spins about its axis with a constant speed of 1500 rpm, as shown in Fig.1. Find the resultant reaction at each bearing due to the mass and gyroscopic effects. [CO2][Apply/IOCQ]

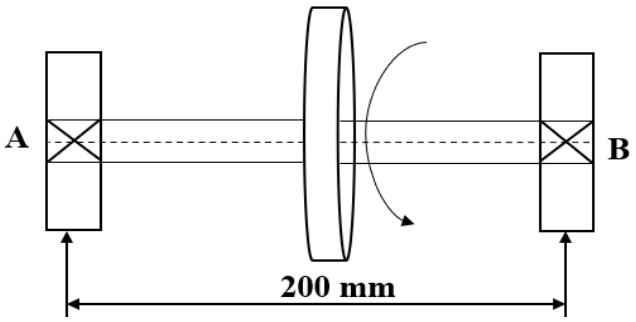

Fig.1

6 + 6 = 12

3. (a) A punching press is required to punch 45 mm diameter holes in a plate of 12 mm thickness at the rate of 25 holes per minute. It requires 8 N-m of energy per mm^2 of sheared area. If the punching takes 1/10 of a second and the r.p.m. of the flywheel varies from 140 to 160, design the flywheel having radius of gyration of 1.2 metre and width is twice the thickness. Assume density of flywheel material to be 7800 kg/m^3. [CO1][Design/HOCQ]

(b) An aero plane makes a complete half circle of 60 metres radius, towards left, when flying at 210 km per hr. The rotary engine and the propeller of the plane has a mass of 380 kg and a radius of gyration of 0.4 m. The engine rotates at 2500 r.p.m. clockwise when viewed from the rear. Find the gyroscopic couple on the aircraft and state its effect on it. [CO2][Analyse/IOCQ]

7 + 5 = 12

Group – C

4. (a) A rotating shaft carries four unbalanced masses 21 kg, 16 kg, 13 kg and 17 kg at radii 6 cm, 8 cm, 5 cm and 9 cm respectively. The 2nd, 3rd and 4th masses revolve in planes 10 cm, 15 cm and 24 cm respectively measured from the plane of the first mass and are angularly located at 60°, 135° and 270° respectively measured clockwise from the first mass looking from this mass end of the shaft. The shaft is dynamically balanced by two masses, both located at 6 cm radii and revolving in planes mid-way between those of 1s and 2nd masses and mid-way between those of 3rd and 4th masses. Determine the magnitudes of the masses and their respective angular positions. [CO3] [Apply/HOCQ]

   (b) A two-cylinder locomotive with cranks at 90^0 has a crank radius of 350 mm. The distance between centres of driving wheels is 1.4 m. The pitch of cylinders is 620 mm. The diameter of treads of driving wheels is 1.6 m. The radius of centres of gravity of balance weights is 680 mm. The pressure due to dead load on each wheel is 60 kN. The weights of reciprocating and rotating parts per cylinder are 4.5 kN and 3.6 kN, respectively. The speed of the locomotive is 60 km/h.
   Find,
   (i) The balancing weights both in magnitude and position required to be placed in the planes of driving wheels to balance whole of the revolving and two-third of the reciprocating masses;
   (ii) What is the maximum speed at which it is possible to run the locomotive, in order that the wheels are not lifted from the rails? [CO3][Create/HOCQ]

6 + 6 = 12

5. (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 0.75 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 0.80 m; and
   (ii) The hammer blow per wheel when the axle makes 8 r.p.s.
   [CO3] [Design/HOCQ]

   (b) The cylinders of a twin V-engine are set at 60^0 angle with both pistons connected to a single crank through their respective connecting rods. Each connecting rod is 600 mm long and the crank radius is 120 mm. The total rotating mass is equivalent to 3 Kg at the crank radius and the reciprocating mass is 1.5 kg per piston. A balance mass is also fitted opposite to the crank equivalent to 2.5 kg at a radius of 180 mm. Determine the maximum and minimum values of primary and secondary forces due to inertia of the reciprocating and the rotating masses if the engine speed is 800 rpm. [CO3][Analyse/IOCQ]

7 + 5 = 12

Group – D

6. (a) Find the equation of oscillation and natural frequency of roller rolling without slipping as shown in Fig.2. The mass of solid disc is 5 kg and diameter 150 mm. The spring has stiffness of 8 N/mm and is massless.

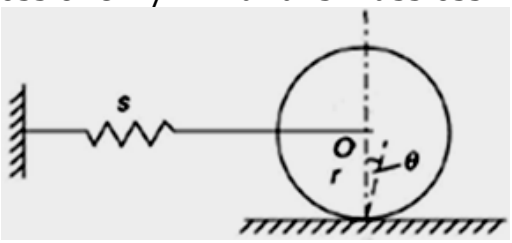

Fig.2

[CO4] [Create / IOCQ]

(b) Find the equation of motion for the spring mass-dashpot system shown in Fig.3. For the cases when (i) ζ = 1.8 (ii) ζ = 1 and (iii) ζ = 0.4. The mass 'm' is displaced by a distance of 20 mm horizontally and released.

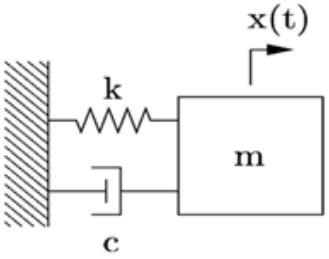

Fig.3

[CO4] [Create/HOCQ)]

6 + 6 =12

7. (a) A harmonic exiting force of 20 N is acting on a machine part which is having a mass of 1.5 kg and is vibrating in a viscous medium. The exciting force causes a resonant amplitude of 12 mm with a period of 0.2 sec. Determine the damping coefficient. [CO4][Apply/IOCQ)]

(b) The mass of an electric motor is 100 kg. The armature mass is 40 kg and its centre of mass lies 0.5 mm from the axis of rotation and it runs at 1490 r.p.m. The motor is mounted on four springs of negligible damping so that the force transmitted is one-eleventh of the impressed force. Assume that the mass of the motor is equally distributed among the four springs.
Determine:
(i) Stiffness of each spring;
(ii) Dynamic force transmitted to the base at the operating speed; and
(iii) Natural frequency of the system. [CO4][Analyse/IOCQ]

5 + 7 = 12

Group – E

8. (a) A shaft of 20 mm diameter and 2.4 m length has a mass of 12 kg per meter length. It is simply supported at the ends and carries three rotors of masses 60 kg, 80 kg and 100 kg at 0.8 m, 1.2 m and 1.6 m from the left support. Find out the suitable location of all three rotors for which the combined shaft and rotor natural frequency is maximum. Take E = 200 GN/m^2. [CO5][Analyse/IOCQ]

(b) A shaft of 18 mm diameter and 1 m long is held in long bearings. The weight of the disc at the centre of the shaft is 49.05 N. The eccentricity of the centre of gravity of the disc from centre of rotor is 0.3 mm. The permissible stress in the shaft material is 70 MPa and its modulus of elasticity is 207 GPa. Ignoring the mass of the shaft determine.

(i) The critical speed of the shaft, and

(ii) The range of speed over which it is unsafe to run the shaft.

[CO5][Analyse/IOCQ]

6 + 6 = 12

9. (a) A reciprocating IC engine is coupled to a centrifugal pump through a pair of gears. The shaft from the flywheel of the engine to the gear wheel has a 40 mm diameter and is 1m long. The shaft from the pinion to the pump has 30 mm diameter and is 1.2 m long. The pump speed is five times the engine speed. Moments of inertia of the flywheel, gear wheel, pinion and pump impeller are 800 kg-m^2, 15 kg-m^2, 3kg-m^2 and 20 kg-m^2, respectively. Find the natural frequency of the torsional oscillations of the system. Rigidity modulus, G = 79 GPa. [CO5, CO6][Analyse/IOCQ]

(b) A two degree of freedom system is shown in the Fig.4. The values of m_1, m_2, and stiffness k are 20 kg, 15 kg and 10 N/m, respectively. Find the frequencies of normal mode of vibration. Also find the equation of normal mode vibration for following initial conditions:

$x_1(0)$ = 5 mm, $x_2(0)$ = 2 mm and the system is at rest initially.

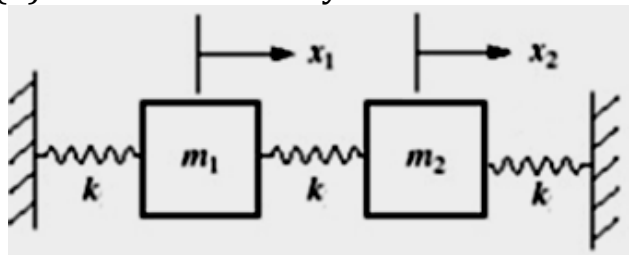

Fig.4

[CO5, CO6] [Create / HOCQ)]

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution		60.41%	39.58%

Course Outcome (CO):

After the completion of the course students will be able to

CO 1 - Analyze the dynamic forces, torque in mechanisms and its application to design a flywheel.

CO 2 - Explain the gyroscopic effects and analyze the stability of motion of different systems based on the effects.

CO 3 - Examine an unbalanced system and solve the problem for balancing the same graphically and analytically.

CO 4 - Analyze a free and forced single degree vibration system with and without damping.

CO 5 - Apply the knowledge of vibration in case of longitudinal, transverse and torsional vibrating systems.
CO 6 - Describe basic idea of vibration of multi-degree of freedom system.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question

Department & Section	Submission link:
ME-A	https://classroom.google.com/c/NDA0Mjk3MTYxNjEy/a/NDY0NTE0OTczOTY4/details
ME-B	https://docs.google.com/forms/d/e/1FAIpQLSd7CZoe-yliOaApc-mv2ti1h0GgzlGpAZ0x91KXbUwTCsfkpg/viewform?usp=pp_url