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2013

DYNAMICS OF MACHINES

Time Allotted : 3 Hours *Full Marks :* 70

The figures in the margin indicate full marks.

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

GROUP – A

(Multiple Choice Type Questions)

1. Choose the correct alternatives for the following : $10 \times 1 = 10$

   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 velocity of the piston of a reciprocating engine is equal to

      a) $r\omega (\sin \theta + \sin 2\theta/2n)$

      b) $r\omega (\cos \theta + \cos 2\theta/2n)$

      c) $r\omega (\sin \theta + \sin 2\theta/n)$

      d) $r\omega (\cos \theta + \cos 2\theta/n)$

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iii) If rotating system is dynamically balanced, it is statically

a) balanced b) unbalanced

c) partially balanced d) none of these.

iv) In a free vibration system, the amplitude decreases to 0·25 of the initial value after five consecutive cycles. The logarithmic decrement of the system is

a) 0·278 b) 0·12

c) 0·73 d) 0.

v) The engine of an aeroplane rotates in clockwise direction when seen from the tail end and the aeroplane takes a turn to the left. The effect of the gyroscopic couple on the aeroplane will be

a) to raise the nose and dip the tail

b) to dip the nose and raise the tail

c) to raise both nose and tail

d) to dip both nose and tail.

vi) The maximum fluctuation energy in a flywheel is equal to

a) $I\omega\left(\omega_1 - \omega_2\right)$ b) $I\omega^2 k$

c) $2kE$ d) All of these.

vii) Advantage of critical damping is

a) that vibratory body comes to rest in smallest possible time

b) there is no vibration

c) the amplitude of vibration is maximum

d) the amplitude of vibration is minimum.

viii) A disc is spinning with an angular velocity ω rad/s about the axis of spin. The couple applied to the disc causing precession will be

a) $\frac{1}{2}I\omega^2$ b) $I\omega^2$

c) $\frac{1}{2}I\omega\omega_P$ d) $I\omega\omega_P$.

ix) A flywheel weighs ($981/\pi$) kg and has a radius of gyration of 100 cm. It is given a spin of 100 rpm about its horizontal axis. The whole assembly is rotating about a vertical axis at 6 rad/s. The gyroscopic couple experienced will be

a) 2000 kgm b) 19620 kgm

c) 20000 kgm d) 1962 kgm.

x) In a spring mass system if the mass is halved and stiffness is doubled then natural frequency is

a) halved b) doubled

c) unchanged d) quadrupled.

GROUP – B

(Short Answer Type Questions)

Answer any *three* of the following. $3 \times 5 = 15$

2. a) For a flywheel show that $K = e/(2E)$ where K = coefficient of speed, e = maximum fluctuation of energy and E = kinetic energy of flywheel at mean speed.

b) A flywheel releases 25 kJ energy when its speed gets reduced from 110 rpm to 105 rpm. Determine its kinetic energy at 140 rpm.

3. What is critical speed of a rotating shaft ? Prove that the whirling speed of a shaft in rps is given by the relation $N_c = 0{\cdot}4985/\sqrt{\delta}$.

4. a) State the differences between a governor and a flywheel.

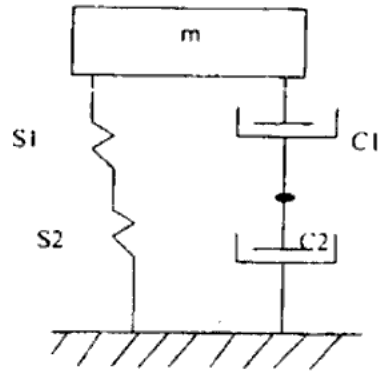
   b) The arms of a Porter governor are each 250 mm long and pivoted on the governor axis. Mass of each ball is 5 kg and the mass of the central sleeve is 30 kg. The radius of rotation of the balls is 150 mm when the sleeve begins to rise and reaches a value of 200 mm for maximum speed. Determine speed range of the governor. 2 + 3

5. a) What do you mean by gyroscopic couple ?

   b) A flywheel of mass 10 kg has a radius of gyration of 200 mm. It is given a spin of 1000 RPM about its axis which is horizontal. The flywheel is suspended at a point 150 mm from the plane of rotation of the flywheel. Determine the motion of the wheel. 1 + 4

6. Determine the undamped and damped natural frequencies of the systems as shown in following figure.

   S_1 = 2 kN/m, S_2 = 3 kN/m, C_1 = 100 N-s/m, C_2 = 200 N-s/m and m = 15 kg.



GROUP – C

(Long Answer Type Questions)

Answer any *three* of the following. 3 × 15 = 45

7. a) Prove that $f_n = \dfrac{0{\cdot}4985}{\sqrt{\delta_1 + \delta_2 + \delta_3 + \ldots + \dfrac{\delta_S}{1{\cdot}27}}}$ Hz, where f_n = natural frequency of free transverse vibration for a simple supported beam subjected to a number of point loads and uniformly distributed load acting simultaneously. δ_i = static deflection due to point loads, δ_S = static deflection due to uniformly distributed load. 7

   b) A mass of 5 kg hangs from a spring and makes damped oscillations. If the time of 50 complete oscillations is found to be 20 sec and the ratio of the first downward displacement to the sixth is found to be 22·5, find the stiffness of the spring and the damping coefficient. 8

8. a) A five cylinder in-line engine running at 750 rpm has successive cranks 144° apart, the distance between the cylinder centre lines being 375 mm. The piston stroke is 225 mm and the ratio of length of the connecting rod to that of crank is 4. Examine the engine for balance of primary and secondary forces and couples. Knowing that the reciprocating mass of each cylinder is 15 kg, determine (i) the maximum values of these and (ii) the position of the central crank at which these maximum values occur. 11

b) Prove that the resultant unbalanced force is minimum when half of the reciprocating masses are balanced by rotating masses. 4

9. a) Explain the terms Hammer-blow and Swaying couple. 4

b) Discuss gyroscopic effects on steering, pitching and rolling of a naval ship. 4

c) An aeroplane flying at 240 km/hr turns towards left and completes a quarter circle of 60 m radius. The mass of rotary engine and the propeller of the plane amounts to 450 kg with a radius of gyration of 320 mm. The engine speed is 2000 rpm clockwise when viewed from the rear. Determine the gyroscopic couple on the aircraft and state its effect. In what ways is the effect changed when the aeroplane turns towards right ? 7

10. a) What do you mean by dynamical equivalent system ? Explain. 2

b) A flywheel is used to give up 18 kJ of energy in reducing its speed from 100 rpm to 98 rpm. Determine its kinetic energy at 140 rpm. 3

c) A constant torque moor of 2·5 kW drives a riveting machine. The mass of the moving parts including the flywheel is 125 kg at 700 mm radius of gyration. One riveting operation absorbs 10 kJ of energy and takes one second. Speed of the flywheel is 240 rpm before riveting.

Determine :

i) reduction in speed after the riveting operation

ii) number of rivets closed per hour

Explain the role of flywheel in the given set-up if one riveting operation absorbs 1 kJ/s of energy instead of 10 kJ/s. 4 + 4 + 2

11. a) What do you mean by the term sensitiveness and isochronism of a governor ? 6

b) A prowell governor has arms 30·5 long. The upper arms are hinged on the axis of rotation whereas the lower arms are pivoted at a distance of 3·8 cm from the axis of rotation. The extension of the lower arms to which the balls are attached is 10·2 cm long. Each ball weighs 4·8 kg and the load on the sleeve is 54·5 kg. At the minimum radius of rotation of 16·5 cm, the extensions are parallel to the governor axis. Determine the equilibrium speeds at radii of 16·5 cm and 21·6 cm. 9