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Paper Code : ME-501

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 any *ten* of the following : 10 × 1 = 10

   i) If the airscrew of an aeroplane rotates clockwise when viewed from the rear and the aeroplane takes a right turn, the gyroscopic effect will

   a) tend to raise the tail and depress the nose

   b) tend to raise the nose and depress the tail

   c) till the aeroplane about spin axis

   d) none of these.

ii) In vibration isolation system, if $\frac{\omega}{\omega_n} < \sqrt{2}$, then for all values of the damping factor, the transmissibility will be

a) less than unity b) equal to unity

c) greater than unity d) zero.

iii) Primary force is maximum when the angle of inclination of crank with the line of stroke is

a) 0° b) 90°

c) 180° d) 360°.

iv) Logarithmic decrement (δ) is defined as

a) $\delta = \ln(x_{n+1}/x_n)$ b) $\delta = \ln(x_n/x_{n+1})$

c) $\delta = 2\ln(x_n/x_{n+1})$ d) $\delta = \frac{1}{2}\ln(x_n/x_{n+1})$.

v) In a free damped 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.

vi) In a critical damped system, the value of damping ratio is

a) infinity b) 1

c) 0 d) 0.707.

vii) What is the change in the vertical height of a watt governor when its speed increases from 60 rpm to 61 rpm ?

a) 85 mm b) 37 mm

c) 8 mm d) none of these.

viii) A flywheel with a mass of 3 kN has a radius of gyration 1.6 m. The energy stored in a flywheel when its angular velocity increased from 33 rad/s to 85.6 rad/s is

a) 355.5 kJ b) 486.6 kJ
c) 684.9 kJ d) 721.4 kJ.

ix) In a free vibration the acceleration vector leads the displacement vector by

a) 2π b) π
c) $\frac{3\pi}{2}$ d) $-\pi$.

x) The natural frequency of a spring mass system on earth surface is ω_n. The natural frequency of the same system on moon surface is $(g_{moon} = g_{earth}/6)$

a) ω_n b) $0.408\ \omega_n$
c) $0.204\ \omega_n$ d) $0.167\ \omega_n$.

xi) The ratio of connecting rod length to crank radius is kept large in locomotive to

a) minimize primary forces
b) minimize secondary forces
c) enable starting of locomotive in any position
d) achieve complete balancing.

GROUP – B
(Short Answer Type Questions)

Answer any *three* of the following. 3 × 5 = 15

2. a) What do you mean by 'Vibration' ?
   b) In a spring-mass vibrating system, the natural frequency of vibration is 3.56 Hz. When the amount of the suspended mass is increased by 5 kg, the natural frequency is lowered to 2.9 Hz. Determine the original unknown mass and the spring constant. 1 + 4

3. A riveting machine is driven by a motor of 3 kW. The actual time to complete one riveting operation is 1.5 seconds and it absords 12 kN. m of energy. The moving parts including the flywheel are equivalent to 220 kg at 0.5 m radius. What is the speed of the flywheel immediately after riveting if it was 360 rpm before riveting ?

   a) 323.6 rpm b) 44.47 rpm
   c) 444.7 rpm d) none of these.

4. What is the functional difference between a governor and a flywheel ? Deduce an expression for the power of a centrifugal governor.

5. Calculate the whirling speed of a shaft 20 mm diameter & 0.6 m long carrying a mass of 1 kg at its mid point. The density of shaft material is 40 mg/m^3 young's modulus of elasticity is 200 Gpa. Assume the shaft to be freely supported.

6. Determine the natural frequency of the vibrating system as in the following figure 1.

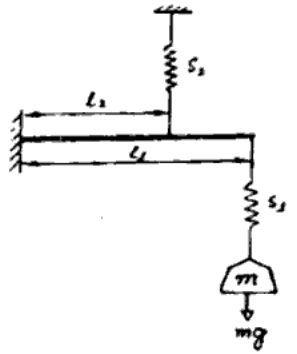

Fig. -1

GROUP – C
(Long Answer Type Questions)

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

7. a) An Otto cycle engine develops 55 kW at 150 rpm with 75 explosions per minute. The change of speed from the commencement to the end of the power stroke must not exceed 1.2% of mean speed on either side. Find effective diameter and suitable cross-section of the cast iron flywheel so that hoop stress does not exceed 4 MPa. Assume that the flywheel stores 1.06 times the energy stored by the rim and the work done during power stroke is 1.5 times the work done during the cycle.

   b) A twin cylinder V-engine has the cylinders set at an angle of 45° with the horizontal axis, with both piston connected to the common crank. The crank radius is 62.5 mm, connecting rod length 275 mm, reciprocating mass per cylinder 1.5 kg and equivalent revolving mass 2 kg at the crank pin. A balance mass fitted opposite to the crank is equivalent to 2.25 kg at a radius of 90 mm, engine sped 2000 rpm. Calculate maximum and minimum values primary and secondary force due to inertia.

8 + 7

8. a) What do you mean by effort and power of a governor ? Show that a watt governor is less than that of a porter governor.

   b) A Harnell governor having a central sleeve spring and two right-angled bell crank levers moves between 290 r.p.m. and 310 r.p.m. for a sleeve lift of 15 mm. The sleeve arms and ball arms of each ball is 2.5 kg. the ball arms are parallel to the governor axis at the lowest equilibrium speed. Determine (i) Loads on the spring at the lowest and highest equilibrium speeds, (ii) Stiffness of the spring. (2 + 4) + 9

9. a) A machine weighing 3.5 kg vibrates in a viscous medium. A harmonic exciting force of 40 N acts on the machine and produces resonant amplitude of 18 mm with a period of 0.2 s. Determine the damping co-efficient.

   b) Four masses *A*, *B*, *C* and *D* are completely balanced. The masses *C* and *D* make angle of 90° and 210° respectively with mass *B* in the same sense. The planes of rotation of masses *B* and *C* are 300 mm apart. The masses *A*, *B*, *C* and *D* are concentrated at radii 360, 480, 240 and 300 mm respectively. The masses *B*, *C* and *D* are 15, 25 and 20 kg respectively. Determine the (i) mass *A* and its angular position, (ii) positions of planes *A* and *D*.

5 + 10

10.

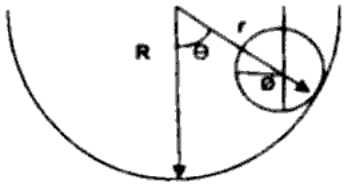

Fig. -2

A roller of mass *M* and radius *r*, rolls without slipping inside a cylinder of radius *R*. Determine the frequency of oscillation of the roller for small oscillations about the lowest point.(Fig. 2)

11. a) Discuss various effects of partial balancing in locomotives such as hammer blow, variation in tractive force and swaying couple.

b) The cranks of a three-cylinder locomotive are set at 120°. The reciprocating masses are 450 kg for the inside cylinder and 390 kg for each outside cylinder. The pitch of the cylinder is 1.2 m and the stroke of each piston 500 mm. The planes of rotation of the balance masses are 960 mm from the inside cylinder. If 41% of the reciprocating masses are to be balance, determine the magnitude and position of the balancing masses required at a radial distance of 500 mm, and the hammer blow per wheel when the axle rotates at 350 rpm. 7 + 8

12. a) Explain Rayleigh method to determine fundamental frequency of lateral vibration of a beam carrying points loads.

b) The equation of the turning moment curve of a three crank engine is (5000 + 1500 sin 3θ) N-m, where θ is the crank angle in radians. The moment of inertia of the flywheel is 1000 kg m^2 and the mean speed is 300 rpm. Calculate the maximum fluctuation of speed of the flywheel in percentage when (i) the resisting torque is constant (ii) the resisting torque is (5000 + 600 sinθ) N-m. 7 + 8