Sem. VI / CBCGS / Auto 12/12/2019

Paper / Subject Code: 88804 / Mechanical Vibrations

[Total Marks : 80]

(3 Hours)

N.B : 1. Question No.**1** is **compulsory**
2. Attempt **any three** from the remaining five questions
3. **Assume suitable data wherever required** with proper justification

1. Attempt **any four** of the following. **All sub-questions carry equal marks.** 20

(a) A thick helical spring of stiffness 10 kN/m weighs 500 grams. It is connected to a lumped mass of 3 kg at one of its ends, and fixed at the other end. The lumped mass moves in a direction inclined at 30° to the spring axis. Calculate the natural frequency in Hertz.

(b) A vibratory system consists of a mass 12.5 kg, a spring of stiffness 1 kN/m, and a dashpot with damping coefficient of 15 Ns/m. Calculate the values of critical damping coefficient, and logarithmic decrement.

(c) Define or state the following—(i) Influence coefficient (ii) Maxwell's reciprocal theorem (iii) Lagrange's equation for free undamped multi-degree of freedom system, for generalized coordinate x_i (iv) Semi-definite system (v) Mode shape.

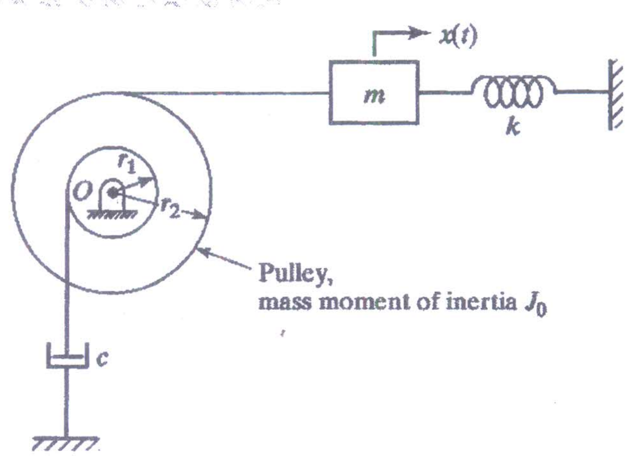
(d) Compare Frahm tachometer and Fullarton tachometer, with neat sketches.

(e) Three masses weighing 100 gm, 150 gm and 500 gm, are attached around the rim of diameter 75 mm, of a flywheel at the angular locations Θ = 10°, 100° and 150° respectively. Find the weight and the angular location of the fourth mass to be attached on the rim that leads to the static balance of the flywheel.

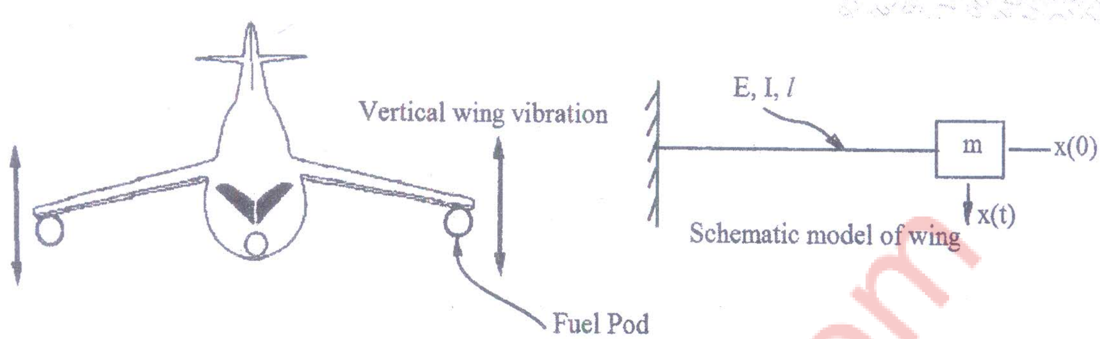
(f) What is gyroscopic effect? How does it affect cars, planes and ships?

2. (a) A small spring-mass system has the following properties: mass = 49.2×10^{-3} kg and stiffness = 857.8 N/m. If the spring is initially deflected by 10 mm and then released, calculate the position of mass from its equilibrium, after a time of 0.04 second. 10

(b) The system shown below has a natural frequency of 5 Hz for the following data: **m** = 12 kg, J_0 = 7 kg-m², r_1 = 12 cm, r_2 = 20 cm. When the system is disturbed by giving it an initial displacement, the amplitude of free vibration is reduced by 80 percent in 10 cycles. Determine the values of **k** and **c**. 10



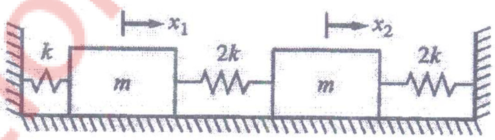
3. (a) 10



Consider an airplane wing with a fuel pod mounted at its tip as shown above. The schematic model of the wing is also shown, as a cantilever beam with lumped mass at its end. The pod has a mass of 10 kg when it is empty and 1000 kg when it is full. If the airplane uses up fuel in the wing pod completely, calculate the change in the natural frequency of vibration of the wing. Find the ratio of natural frequencies of the wing (empty to full). The estimated physical parameters of the beam are: $I = 5.2 \times 10^{-5}$ m^4, $E = 6.9 \times 10^9$ Pa, and $l = 2$ m.

(b) A horizontal spring mass system with Coulomb damping has a mass of 5 kg attached to a spring of stiffness 980 N/m. If the coefficient of friction is 0.025, calculate—(i) the frequency of free oscillations, (ii) the number of cycles corresponding to 50% reduction in amplitude if the initial amplitude is 5 cm, (iii) time taken to achieve this 50% reduction. 10

4. (a) Using exact analysis, calculate the natural frequencies and draw the corresponding mode shapes for the two degree of freedom system as shown below. 10



(b) A spring-mass-damper system, having an undamped natural frequency of 140 Hz and a damping constant of 25 N-s/m, is used as an accelerometer to measure the vibration of a machine operating at a speed of 3000 rpm. If the actual acceleration is 10 m/s^2 and the recorded acceleration is 9 m/s^2, find the mass and the spring constant of the accelerometer. 10

5. (a) The mass and stiffness matrices of a vibrating system are given by: 10

$$[M] = \begin{bmatrix} 2 & 0 \\ 0 & 5 \end{bmatrix}, \quad [K] = \begin{bmatrix} 5 & -2 \\ -2 & 7 \end{bmatrix}$$

Using Holzer's method, determine the two natural frequencies and draw the corresponding mode shapes.

(b) A, B, C & D are four masses carried by a rotating shaft at radii 100 mm, 125 mm, 200 mm and 150 mm respectively. The planes in which the masses revolve are spaced 600 mm apart and the mass of B, C and D are 10 kg, 5 kg, and 4 kg respectively. Find the required mass A, and the relative angular settings of the four masses—so that the shaft shall be in complete balance. 10

6. (a) An electric motor, of mass 70 kg, rated speed 5000 rpm, and an unbalance 0.003 kg-m, is to be mounted on an isolator to achieve a force transmissibility of less than 0.25. Determine (i) the stiffness of the isolator (ii) the dynamic amplitude of the motor, and (iii) the force transmitted to the foundation. 10

(b) The cranks and connecting rods of a 4-cylinder in-line engine running at 1800 r.p.m. are 60 mm and 240 mm each respectively and the cylinders are spaced 150 mm apart. The cylinders are numbered 1 to 4 in sequence from one end, and the cranks appear at intervals of 90° in an end view in the order 1-4-2-3. The reciprocating mass corresponding to each cylinder is 1.5 kg. Determine: (i) Unbalanced primary and secondary forces, if any, and (ii) Unbalanced primary and secondary couples with reference to central plane of the engine. 10

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