M. TECH. DEGREE EXAMINATION, MODEL QUESTION PAPER – I

First Semester

Branch: Mechanical Engineering

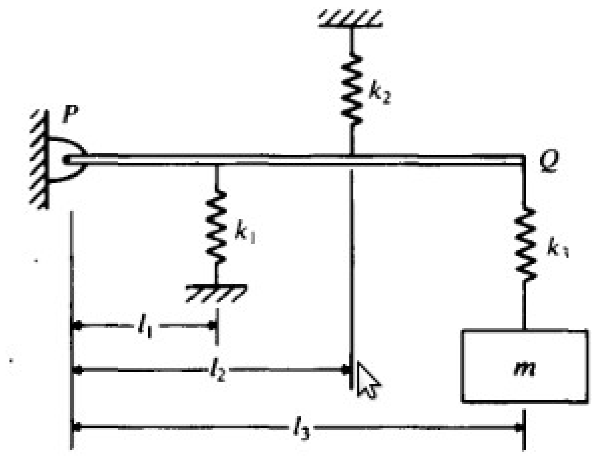
Specialisation: Machine Design

MMEMD 102 Theory of Vibrations
(Regular – 2013 Admissions)

Time: Three Hours Maximum: 100 Marks

(Answer **all** *questions)*

1. a) Three springs and a mass are attached to a rigid, weightless bar PQ as shown in the figure below. Find the natural frequency of vibration of the system.



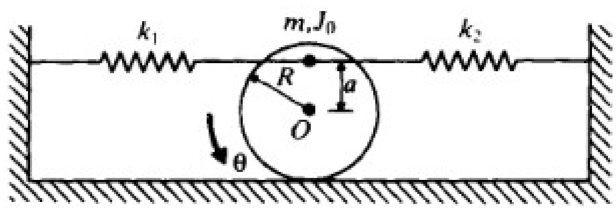
(10)

b) A body of mass 5 kg is supported on a spring of stiffness 1960 N/m and has a dash pot connected to it, which produces a resistance of 0.98N at velocity 0.5 m/s. Find
- Natural frequency of the system
- Damping ratio
- Displacement of the mass, 0.5 sec after it was displaced through 20mm and released.

(15)

Or

2. a) A cylinder of mass m and moment of inertia J_0 is free to roll without slipping but is constrained by two springs as shown in the figure below. Find its natural frequency of vibration. Also find the value of '*a*' that maximizes the natural frequency.



(12)

b) The maximum velocity attained by a simple harmonic oscillator is 10 cm/s and the period of oscillation is 2 sec. If the mass is released with an initial displacement of 2 cm, find a) the amplitude of vibration, b) the maximum acceleration, c) the phase angle.

(8)

c) A body vibrating with viscous damping completes 5 oscillations per second and in 50 cycles its amplitude reduces to 10%. Determine the logarithmic decrement and the damping ratio. In what proportion will the period of vibration be decreased if the damping is removed?

(5)

3. a) Find the total response of a viscously damped single degree of freedom system subjected to a harmonic base excitation for the following data: m = 10 kg, c = 20 Ns/m, k = 4100N/m, $y(t)$ = 0.05cos(6t) with initial displacement 0.1m and initial velocity 1 m/s.

(12)

b) A 100 kg mass is supported on a spring having stiffness 196000 N/m and acted upon by a harmonic force of 39 N at the undamped natural frequency. The damping is viscous with coefficient of 98 Ns/m. Find

• Amplitude of vibration of the mass
• phase difference between force and displacement

(13)

Or

4. a) A spring – mass – damper system is subjected to a harmonic force. The amplitude is found to be 20mm at resonance and 10mm at a frequency 0.75 times the resonant frequency. Find the damping ratio of the system.

(7)

b) A weight of 55 N suspended by a spring of stiffness 1.1 kN/m is forced to vibrate by a harmonic force of 9 N amplitude. Assuming the viscous damping coefficient to be 77 Ns/m, find the amplitude of vibration at resonance.

(8)

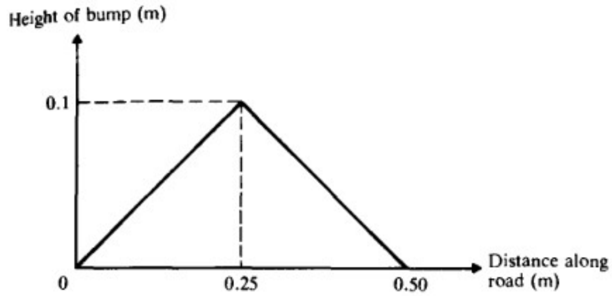
c) Clearly explain how Fourier series can be used to find out the response of a single dof system excited by a general periodic force.

(10)

5. a) Prove the following statement with reference to single degree of freedom system vibration: "The operation of convolution in time domain is identical to multiplication in the corresponding frequency domain."

(12)

b) An automobile having a mass of 1000 kg, runs over a road bump of the shape shown in the figure below. Speed of the automobile is 50 km/hr. Find the response of the automobile assuming it to be an undamped single degree of freedom system vibrating in the vertical direction. The natural period of vibration in the vertical direction is given as 1 sec.



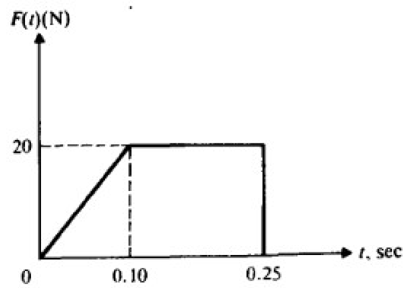
(13)

Or

6. a) Derive the impulse response and step response of a sdof spring – mass – damper system . What is the relationship between the two?

(13)

b) An undamped system with mass 2 kg and stiffness 1500 N/m is forced by a forcing function shown in the figure below. Find the response of the system if all the initial conditions are zero.

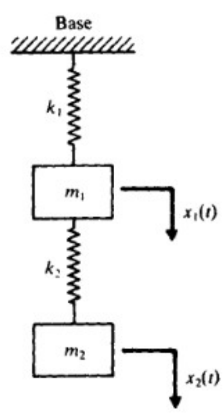


(12)

7. a) What do you mean by coordinate coupling in a 2 dof vibrating system? What are principal coordinates and how are they useful to solve coupling?

(10)

b) Find all the natural frequencies and mode shapes of the system shown below with masses 20 kg and 40 kg respectively and the stiffness values 1000 N/m and 2000 N/m.



(15)

Or

8. a) What is a tuned mass damper? Explain the tuning methodology for a tuned mass damper.

(13)

b) The governing equations of a 2 dof system are given by

$$m\begin{bmatrix} 2 & 0 \\ 0 & 1 \end{bmatrix}\begin{Bmatrix} \ddot{x}_1 \\ \ddot{x}_2 \end{Bmatrix} + k\begin{bmatrix} 3 & -1 \\ -1 & 1 \end{bmatrix}\begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{Bmatrix} 0 \\ F \end{Bmatrix}$$

The normal modes of the homogeneous equation are

$$\phi_1 = \begin{Bmatrix} 0.5 \\ 1 \end{Bmatrix}, \qquad \phi_2 = \begin{Bmatrix} -1 \\ 1 \end{Bmatrix}$$

Use principal coordinates to write the equations in the uncoupled form and find the response of each mass. (12)