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# MANIPAL INSTITUTE OF TECHNOLOGY

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## I SEMESTER M.TECH. (STRUCTURAL ENGINEERING)

## END SEMESTER EXAMINATIONS, February 2021

## SUBJECT: STRUCTURAL DYNAMICS (CIE – 5174)

**REVISED CREDIT SYSTEM**
**(26 / 2 / 2021)**

Time: 3 Hours MAX. MARKS: 50

**Instructions to Candidates:**

- Answer **ALL** the questions.
- Missing data may be suitably assumed.

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| **1A.** | The tower shown in Fig. Q1A is having a uniform mass of m per unit length and constant EI. Formulate the equation of motion if the tower is subjected to a base excitation $\ddot{V}_g(t)$. Take m(x) = m and EI = constant. Use $\psi(x) = 1 - \cos\frac{\pi x}{2L}$ | **5** | CO1 |
| **1B.** | An undamped SDOF system is subjected to an external harmonic force of $P_0 \sin \bar{\omega} t$. Derive expression for resonant response for initial condition at t =0, V(t) = 0 and $\dot{v}(t) = 0$. Also show that in this case the response continues to grow by the amount $\pi$. | **5** | CO2 |
| **2A.** | An underdamped SDOF system is subjected to an external harmonic force of $P_0 \sin \bar{\omega} t$. Derive expression for response for initial condition at t =0, $V(t) = V_o$ and $\dot{v}(t) = \dot{v}_o$ | **5** | CO2 |
| **2B.** | A simple beam supports at its center a machine having a weight of 200 kN. The beam is made of two beams of clear span 4 m and each having $I = 5 \times 10^7$ mm$^4$. The motor runs at 350 rpm and its rotor is out of balance to the extent of 30 kg and at a radius of e = 25 mm. What will be the amplitude of the steady state response if the equivalent viscous damping is assumed 10% of the critical? E = 200 kN/ mm$^2$. | **5** | CO2 |
| **3A.** | A sine wave impulse of duration $t_1$ seconds (Fig. Q3A) is acting on a SDOF system. Derive expressions for the response at $t < t_1$ and $t > t_1$. Use the initial condition as at t = 0 V(t) = 0 and $\dot{v}(t) = 0$. Determine also the maximum response in the free vibration era. | **5** | CO3 |

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| **3B.** | Using rectangular rule for numerical evaluations of Duhamel's integral determine the dynamic response of SDOF system subjected to a blast loading shown in Fig. Q3B. The physical properties are W = 20000 N and K = 1000 kN/m. Take $\Delta\tau$ = 0.05 sec. | **5** | CO3 |
| **4A.** | For the three degree lumped mass system shown in Fig. Q4A, obtain the natural frequencies and the modes of vibration. Use classical method. | **7** | CO4 |
| **4B.** | Write a note on orthogonality relationship | **3** | CO4 |
| **5A.** | For the three storey building shown in Fig. Q5A, determine the displaced at time $t = \frac{2\pi}{\omega_1}$. Its undamped vibration mode shapes and frequencies are given below. The structure is set into free vibration by displacing the floors as follows: $V_1$ = 3mm, $V_2$ = - 8 mm, $V_3$ = 3 mm and then releasing them suddenly at time t = 0. Take $m_1$ = 1000 kg, $m_2$ = 2000 kg, $m_3$ = 3000 kg, $K_1$ = 400 kN/m, $K_2$ = 800 kN/m, and $K_3$ = 1200 kN/m, $\Phi = \begin{pmatrix} 1 & 1 & 1 \\ 0.7 & -0.304 & -1.566 \\ 0.342 & -0.59 & 1.165 \end{pmatrix}$ $\omega = \begin{Bmatrix} 10.94 \\ 22.85 \\ 32.02 \end{Bmatrix}$ rad /sec | **5** | CO4 |
| **5B.** | Treating the simply supported beam of uniform cross section as continuous systems obtain expression for frequency and vibration shape. | **5** | CO5 |

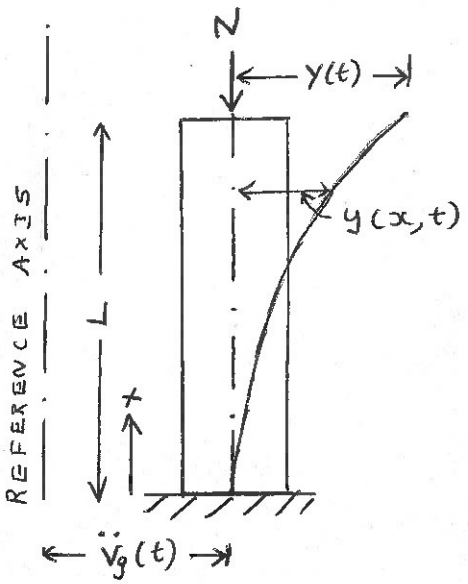


Fig Q1A

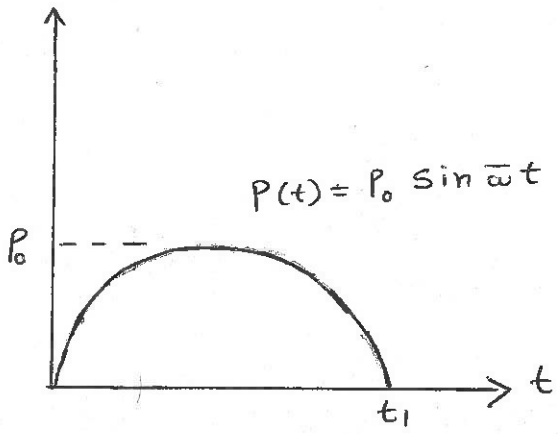


Fig Q3A

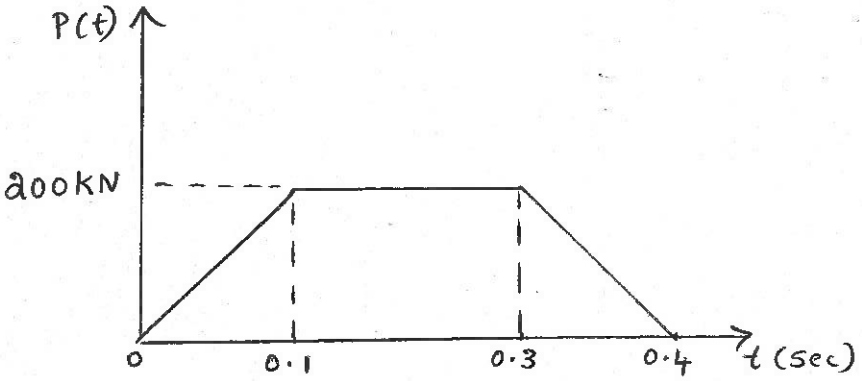


Fig Q3B

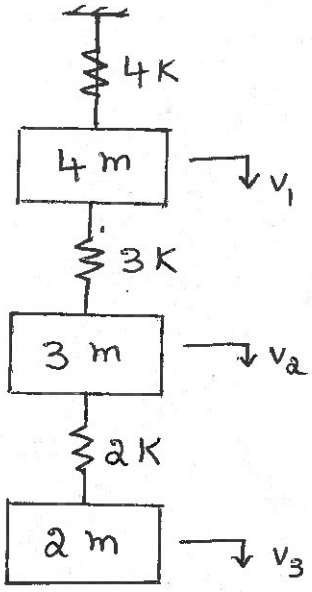


Fig Q4A

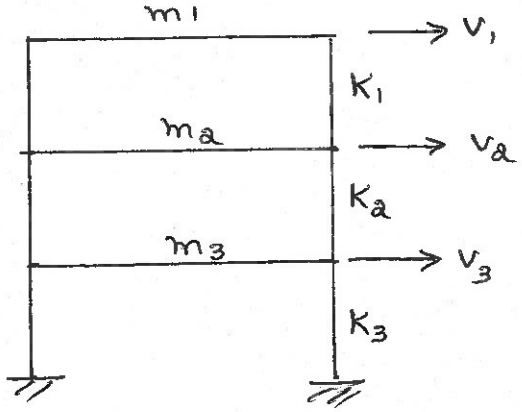


Fig. Q5A