Seat No.: _____ Enrolment No._____

GUJARAT TECHNOLOGICAL UNIVERSITY

ME - SEMESTER– I (OLD course)• EXAMINATION – SUMMER 2015

Subject Code: 712002 **Date: 12/05/2015**

Subject Name: Structural Dynamics

Time: 10:30 am to 1:00 pm **Total Marks: 70**

Instructions:

1. **Attempt all questions.**
2. **Make suitable assumptions wherever necessary.**
3. **Figures to the right indicate full marks.**

Q.1 **(a)** Explain the following terms: **06**

(i) Lumped mass matrix

(ii) Consistent mass matrix.

(b) Derive the equation for the free vibration displacement response of a viscously critically damped single-degree-of-freedom (SDOF) system due to initial displacement x_0 and initial velocity v_0. **08**

Q.2 **(a)** A water tank is supported on a cantilever tower. It is idealized as a SDOF system with weight, W = 10,000 kN, lateral stiffness, k = 20,000 kN/m and damping ratio, ξ = 4 %. Calculate (i) the natural time period, (ii) the damped time period, (iii) the damping constant, and (iv) the maximum horizontal displacement at top of the water tank, if it is loaded by a seismic force equivalent to 30,000 *sin* (5t) N. **07**

(b) Explain in detail the Dunkerleyôs method for finding out the natural frequency for the structure. **07**

OR

(b) Find the natural frequency for the building frame shown in Figure 1. During test, the frame is given 50 mm initial lateral displacement and released from the rest to vibrate freely. Find the displacement at t = 5 sec. Consider 10% damping. Take $EI_{column} = 5.4 \times 10^{12}$ N-mm^2, $EI_{beam} =$ Ð. **07**

Q.3 **(a)** For a free undamped vibration system shown in Figure 2, Formulate the equation of motion. **07**

(b) A reinforced concrete chimney, 180 m high, has a uniform hollow circular cross section with out side diameter 15 m and wall thickness 750 mm. For the purpose of preliminary earthquake analysis, the chimney is assumed to be clamped at the base, the mass and flexural rigidity are computed from the gross area of the concrete (neglecting the reinforcing steel), and the damping ratio is estimated as 5%. The unit weight of concrete is 25 kN/m^3 and its elastic modulus 25000 N/mm^2. Assuming the shape function ψ (x) = 1 - cos ($\pi x/2L$), formulate the equation of motion for the system excited by ground motion, and determine its natural frequency. **07**

OR

Q.3 **(a)** A single-degree-of-freedom (SDOF) with natural time period T_n and damping ratio ξ is subjected to the periodic force shown in Figure 3 with an amplitude F_0 and time period T. Expand the forcing function in its Fourier Series. **07**

(b) A simply supported beam, having uniform mass of 1000 kg/m, carries two concentrated masses each of 10×10^3 kg at 3m and 6m. If the flexural rigidity and span of the beam is 2000 kN-m^2 and 9m, respectively, calculate the natural frequency of the beam. Assume the shape function as $\psi(x) = \sin(\pi x/L)$ **07**

Q.4	**(a)**	From the fourth order differential equation, derive suitable expression for frequency for a uniform beam with both ends free and having transverse vibration.	**07**
	(b)	Calculate the lowest natural frequency of the system shown in Figure 4.	**07**

OR

Q.4		A single spring mass system has spring constant of 10 kN/m and mass of 2500 kg. If it is loaded by an impulsive load as shown in the Figure 5, derive the equation for the displacement response of the system after completion of the impulse.	**14**

Q.5	**(a)**	Calculate the natural frequencies and mode shapes of the two-storey shear building shown in Figure 6.	**07**
	(b)	If the 1000 kg and 500 kg masses of the two-storey shear building shown in Figure 6 are displaced to right 25 mm and 50 mm from their steady position, respectively and left to vibrate, derive the displacement function of all the masses.	**07**

OR

Q.5	**(a)**	For the three-storey shear building shown in Figure 7, obtain natural frequencies and mode shapes.	**07**
	(b)	Show that the modes of vibration of the three-storey shear building shown in Figure 7 satisfy the orthogonality properties.	**07**

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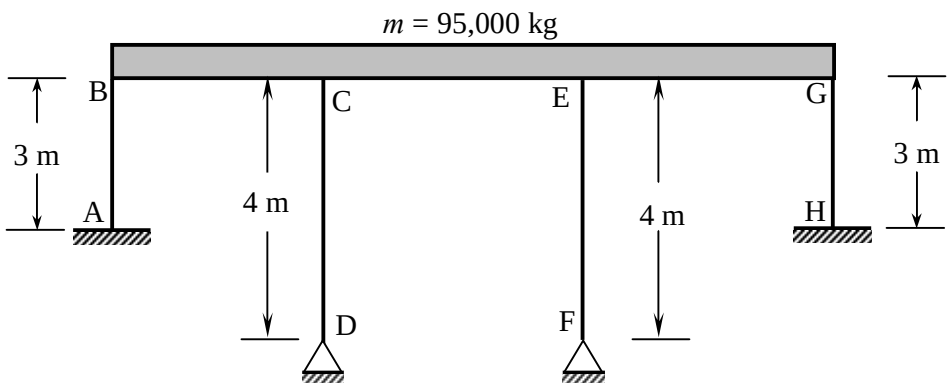

Figure 1.

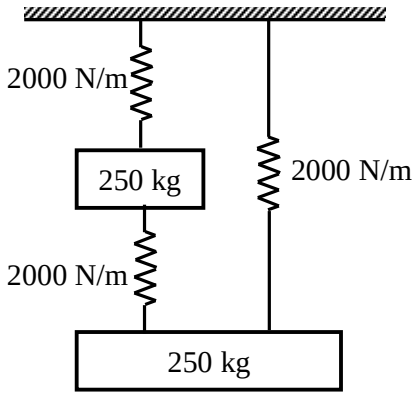

Figure 2.

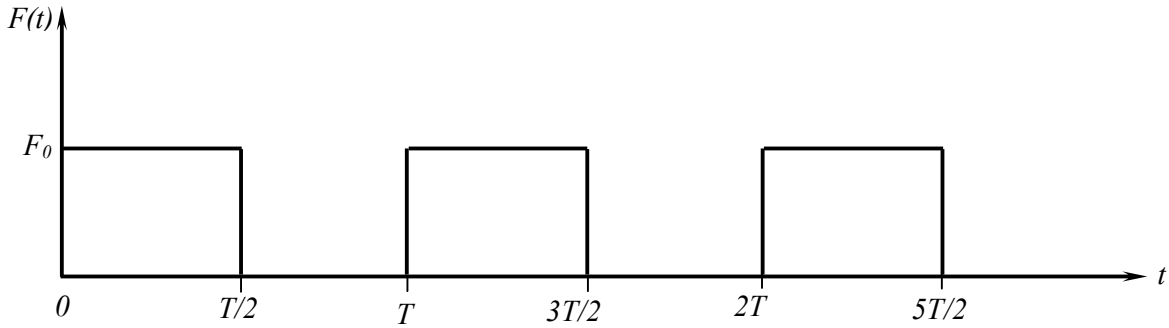

Figure 3.

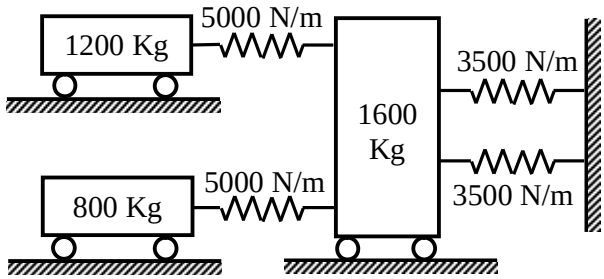

Figure 4.

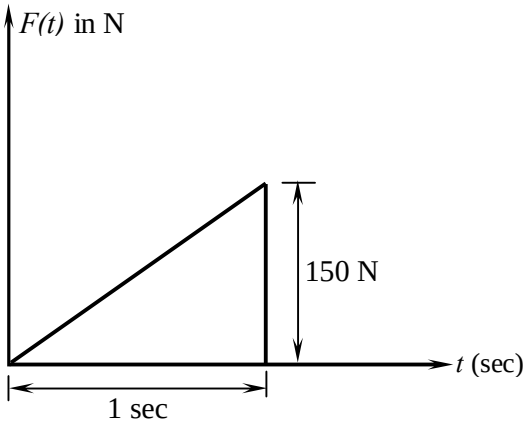

Figure 5.

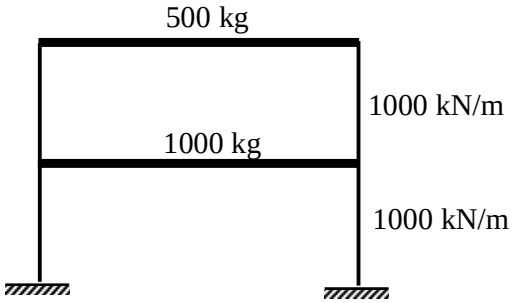

Figure 6

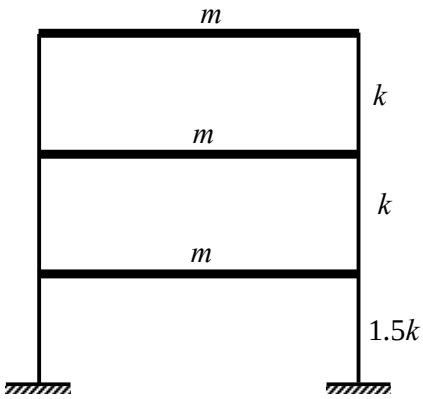

Figure 7.