W 6441

M.E. DEGREE EXAMINATION, JANUARY 2008.

First Semester

Structural Engineering

ST 1602 — STRUCTURAL DYNAMICS

(Regulation 2005)

Time : Three hours   Maximum : 100 marks

Answer ALL questions.

PART A — (10 × 2 = 20 marks)

1.   Define the terms : Amplitude, Period, Cycle.

2.   What is logarithmic decrement? What is its use?

3.   Differentiate

   (a)   Free and Forced vibration

   (b)   SDOF and MDOF system.

4.   Enumerate the methods of finding frequency and mode shapes of MDOF systems.

5.   What is the effect of shear on deep beams subjected to vibration?

6.   Find the fundamental frequency of a cantilever beam by Rayleigh's method by taking $\psi = Ax^2$.

7.   What do you mean by modal matrix? Give example.

8.   In a two DOF system, the mass matrix is $\begin{bmatrix} m & 0 \\ 0 & 2m \end{bmatrix}$ and the two modes are given by $\begin{Bmatrix} 1.00 \\ 1.37 \end{Bmatrix}$ and $\begin{Bmatrix} 1.00 \\ -0.37 \end{Bmatrix}$. Show that they are orthogonal.

9. What is a Gaussian random process? Why is it frequently used in vibration analysis?

10. Define : Power spectral density function.

PART B — (5 × 16 = 80 marks)

Assume any missing data suitably.

11. (a) The column of a water tank shown in Fig. 1 is 90 m high and is made of reinforced concrete with a tubular cross-section of inner diameter 2.4 m and outer diameter 3 m. The tank weighs 3000 kN with water. By neglecting the mass of the column and taking $E = 28 \times 10^6$ kPa, determine the following :

   (i) the natural frequency and the period of vibration of the water tank

   (ii) the vibration response of the tank due to an initial displacement of 250 mm

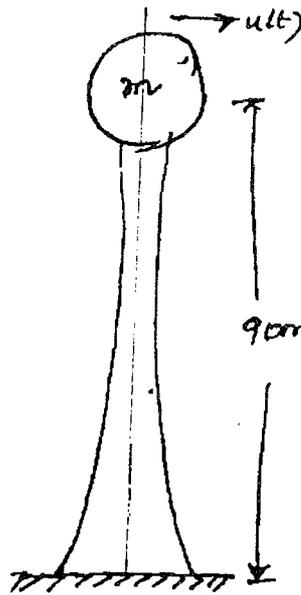   (iii) the maximum values of the velocity and acceleration experienced by the tank.

Fig. 1

Or

(b) (i) A simply supported beam of square cross-section 5 mm × 5 mm and length 1 m, carrying a mass of 2.3 kg at the middle is found to have a natural frequency of 30 rad/s. Find its modulus of elasticity. (8)

   (ii) A spring-mass system has a natural frequency of 10 Hz. When the spring constant is reduced by 800 N/m, the frequency is altered by 45%. Find the mass and spring constant of the original system. (8)

12. (a) For the shear building shown in Fig. 2, determine the frequencies and mode shapes. The values given are consistent units.
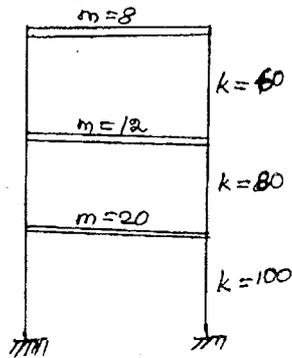

Fig. 2

Or

(b) For a two storeyed building shown in Fig. 3, compute the displacement at the top storey.
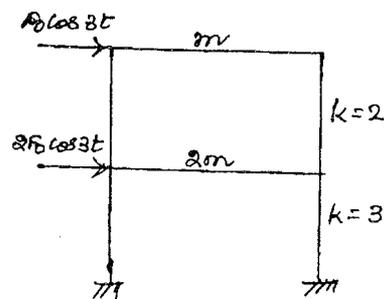

Fig. 3

13. (a) Derive an expression for the natural frequencies of transverse vibration of a uniform beam with both ends simply supported. Hence determine its mode shapes.

Or

(b) (i) Find the fundamental frequency of longitudinal vibration of the tapered bar shown in Fig. 4 using Rayleigh's method with the mode shape $v(x) = C_1 \sin \dfrac{\pi x}{2l}$. The mass per unit length is given by (8)

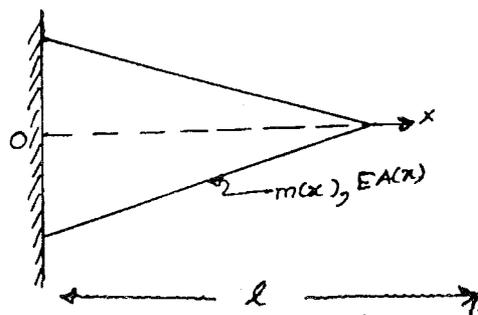$$m(x) = 2m_0 \left(1 - \frac{x}{l}\right).$$

Fig. 4

(ii) Write a note on the effects of rotary inertia and shear deformation on transverse vibration of beams. (8)

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14. (a) The stiffness and mass matrices of a vibrating system are given by

$$[K] = \begin{bmatrix} 4 & -2 & 0 & 0 \\ -2 & 3 & -1 & 0 \\ 0 & -1 & 2 & -1 \\ 0 & 0 & -1 & 1 \end{bmatrix} \text{ and } [m] = \begin{bmatrix} 3 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}.$$

By any numerical method, obtain its fundamental frequency and mode shape.

Or

(b) For a two degrees of freedom system, the stiffness matrix, mass matrix and forcing function are as follows :

$$[K] = \begin{bmatrix} 6 & -2 \\ -2 & 8 \end{bmatrix}; [m] = \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix}; \{F(t)\} = \begin{Bmatrix} 0 \\ 10 \end{Bmatrix}.$$

The system starts at rest using any numerical integration procedure find its response. Show atleast 4 iterations.

15. (a) For a two degrees of freedom system, the mass and stiffness matrices are as given below :

$$[m] = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}; [K] = \begin{bmatrix} 2 & -1 \\ -1 & 2 \end{bmatrix}.$$

The frequencies and the mode shapes are $\{w^2\} = \begin{Bmatrix} 1 \\ 3 \end{Bmatrix}, \{Q\} = \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix}.$

Determine the power spectral density function $s_{u_1 u_1}$ corresponding to random displacement u_1, when the excitation is a single stationary random process $F_1(t)$ with a white noise s_0. Also determine the stationary mean square value.

Or

(b) Write a brief note on Random and stochastic vibration of civil engineering systems.

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