WEST BENGAL UNIVERSITY OF TECHNOLOGY

CE-604C

STRUCTURAL DYNAMICS AND EARTHQUAKE ENGINEERING

Time Allotted: 3 Hours | Full Marks: 70

The questions are of equal value.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.
All symbols are of usual significance.

GROUP A
(Multiple Choice Type Questions)

1. Answer any *ten* questions. $10\times1 = 10$

(i) Earthquake shaking measuring instrument is

(A) seismograph (B) seismogram
(C) seismoscope (D) all of these

(ii) The line joining points of same earthquake intensity is known as

(A) Isobar line (B) Isoseismal line
(C) Isopac line (D) None of these

(iii) The equivalent spring stiffness of two springs (k_1 & k_2) in series is

(A) $k_1 + k_2$ (B) $\frac{1}{k_1} + \frac{1}{k_2}$ (C) $\frac{k_1 + k_2}{k_1 k_2}$ (D) $\frac{k_1 k_2}{k_1 + k_2}$

(iv) A mass 2 kg is attached to the end of a spring with stiffness 0.8 kN/mm. The critical damping constant is

(A) 74.92 Ns/m (B) 80 Ns/m
(C) 40.7 Ns/m (D) None of these

(v) A vibrating system consisting of a weight of W = 15 N and a spring with stiffness k = 2 N/m. The angular natural frequency of the system is

(A) 4.4 (B) 5.7 (C) 3.5 (D) None of these

(vi) Ductile detailing of an RC Frame should be carried out in accordance with

(A) IS 1893-2002 (B) IS 13920
(C) IS 875 Part III (D) IS 456-2000

(vii) Earthquake A has a Richter magnitude of 6.0 and that of earthquake B is 5.0

(A) A is 0.1 times more intense than B
(B) A is 10 times more intense than B
(C) A is 100 times more intense than B
(D) None of these

(viii) P waves (seismic) involve soil deformation

(A) push-pull type (B) up and down in vertical plane
(C) sideways in horizontal plane (D) both (B) and (C)

(ix) Transmissibility is the ratio of

(A) Force transmitted to the foundation to the applied harmonic force
(B) Applied harmonic force to the force transmitted to the foundation
(C) Force transmitted to the foundation to the base isolation
(D) None of these

(x) How do rock particles move during the passage of P-waves through the rock?

(A) Back and forth, parallel to direction of wave travel
(B) Perpendicular to the direction of wave travel
(C) In a rolling elliptical motion
(D) In a rolling circular motion

(xi) The point of origin of earthquake is called

(A) Hypocentre (B) Epicentre
(C) Seismocentre (D) None of these

(xii) Richter scale indicates Earthquake

(A) Magnitude (B) Intensity
(C) Energy relased (D) Both (A) and (C)

GROUP B
(Short Answer Type Questions)

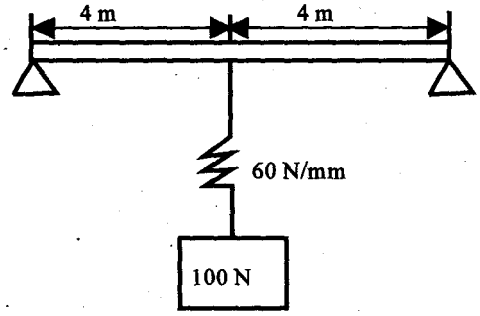
Answer any *three* questions. 3×5 = 15

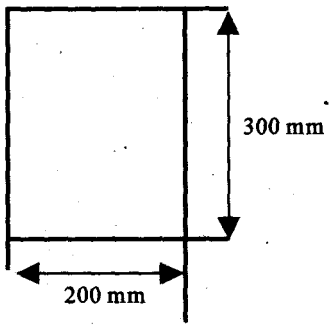
2. Determine the value of horizontal seismic coefficient for a community centre situated in Kolkata. The geotechnical exploration carried out at the site indicated soft clay up to 10 m depth and therefore needing pile foundation for the structure. Take natural time period as 0.4 sec with damping ratio of 5%. Use response spectrum method. (Use IS: 1893-2002).

3. An SDOF system consists of a mass with weight of 200 kg and a spring constant, K = 530 kN/m. While testing the system a relative velocity of 30 cm/s was observed on application of a force of 450 N. Determine the damping ratio, damped frequency of vibration, logarithmic decrement, and the ratio of two consecutive amplitude.

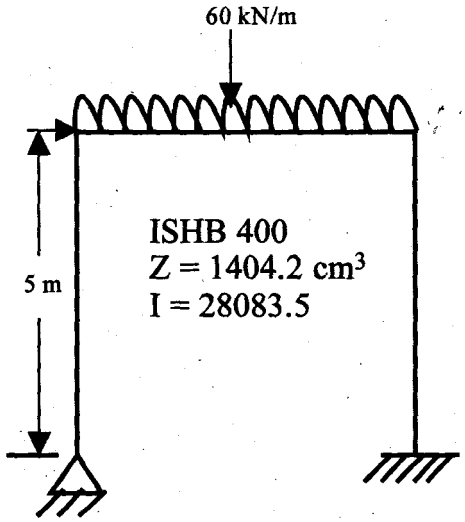
4. Determine the magnification factor of forced vibration produced by an oscillator fixed at the middle of a beam at a speed of 800 rpm. The weight concentrated at the middle of the beam is 5000 N and produces a statical deflection of the beam equal to 0.035 cm. Neglect the weight of the beam and assume that the damping is equivalent to a force acting at the middle of the beam proportional to the velocity and equal to 500 N at a velocity of 2.5 cm/sec.

5. Find the angular natural frequency, time period and the spring constant of the system as shown below. The mass of the beam may be neglected. $E = 2 \times 10^5$ N/m.





6. The steel frame as shown below. Supports a rotating machine which exerts a horizontal force at the girder level, $f(t) = 1000 \sin 5t$ N. Assuming damping ratio of 0.15 determine (a) the steady-state amplitude of vibration and (b) the maximum dynamic stress in the columns. Assume that the girder is rigid.



GROUP C
(Long Answer Type Questions)

Answer any *three* questions. 3×15 = 45

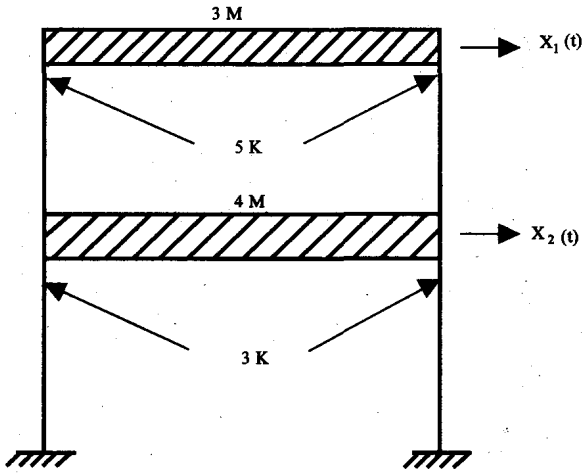
7. A platform of mass m = 3000 kN is being supported by four columns of equal height. Experimentally, it was determined that a static force F = 450 kg causes a deformation of $\Delta = 0.025\ m$. The damping ratio of the structure is estimated to be $\xi = 0.05$.
Find the following:
(i) Undamped natural frequency
(ii) Damped natural frequency
(iii) Damping coefficient C
(iv) Logarithmic decrement over a cycle
(v) If the system is excited by a force 1000 sin(300t)N, find out the Dynamic Magnification Factor
(vi) Dynamic Magnification Factor in case of resonance
(vii) Maximum possible value of Dynamic Magnification Factor.

8. A vertical single-cylinder direct engine of 600 kg mass is mounted on a spring with K = 200 kN/m and damper with $\zeta = 0.22$. The rotating parts are well balanced. The mass of equivalent reciprocating part is 10 kg and stroke is 200 mm. Find the dynamic amplitude of the vertical motion, transmissibility and the force transmitted to the foundation, if the engine is operated at 200 rpm.

9. A five storied RCC framed building will be constructed in Kolkata in medium soil. Floor to floor height = 3 m. It is a square building of plan size 16 m × 16 m. Columns are space @ 4 m c/c in both directions. Live load on floor = 3 kN/m^2 has to be considered. Thickness of floor and roof slab = 125 mm. The size of beam may be considered 250 × 450 mm^2 and column may be considered 350 × 350 mm^2. Determine the base shear and its distribution along height as per IS 1893-2002.

10. Determine the magnification factor of forced vibration produced by an oscillator, fixed at the middle of the beam at a speed of 550 rpm. The weight concentrated at the middle of the beam is 5000 N and produces a statistical deflection of the beam = 0.020 cm. Assume that damping is equivalent to a force acting at the middle of the beam which is proportional to the velocity and equal to 450 N at a velocity of 2.5 cm/sec. Neglect the weight of the beam.

11. Consider a two storey building frame as below:



(a) Derive the mass and stiffness matrices for the building and write down the governing equation for free vibration.
(b) Calculate its natural periods and mode shapes.