STRUCTURAL DYNAMICS AND EARTHQUAKE ENGINEERING
(CIV3132)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) The Indian seismic zones are (Modified)
(a) Zone-I to Zone – V (b) Zone-II to Zone - V
(c) Zone-II to Zone – VI (d) Zone-I to Zone - VI.

(ii) The equivalent spring stiffness of two springs k1 and k2 in series is
(a) $k_{1+}k_2$ (b) $\frac{1}{k_1}+\frac{1}{k_2}$ (c) $\frac{k_1+k_2}{k_1k_2}$ (d) $\frac{k_1k_2}{k_1+k_2}$

(iii) One useful definition of the critically damped condition is that
(a) it is a damping for which the responses are delayed Exponentially.
(b) It is the smallest amount of damping for which no oscillation occurs in the free response
(c) It is the largest amount of damping for which no oscillation occurs in the free response
(d) none of these.

(iv) The maximum displacement of a linear elastic system for a constant force applied suddenly is
(a) 2 δst (b) δst (c) 3 δst (d) 0·5 δst.

(v) In a single degree of freedom damped forced vibration, magnification factor μ is given by (if r=frequency ratio and ε=damping ratio)
(a) $\frac{1}{\sqrt{(1-r^2)^2+4\epsilon^2r^2}}$ (b) $\frac{1}{\sqrt{(1-r)^2+4\epsilon r}}$
(c) $\frac{1}{\sqrt{(1-r^2)^2+4\epsilon r}}$ (d) none of these.

(vi) What is the main purpose of the Equivalent Static Method (ESM) in structural engineering?
(a) To perform a detailed dynamic analysis
(b) To simplify seismic load analysis by replacing dynamic loads with static loads
(c) To ignore seismic effects on structures
(d) To calculate wind loads on structures

(vii) What does the Response Spectrum Method primarily analyze in structural engineering?
(a) Static loads only
(b) Peak dynamic response of a structure to seismic excitation
(c) Wind pressure effects on buildings
(d) Thermal expansion effects

(viii) According to IS 1893:2016, a "soft storey" is defined as a storey where:
(a) Lateral stiffness is more than that of the storey above
(b) Lateral stiffness is less than 70% of that of the storey above or less than 80% of the average lateral stiffness of the three storeys above
(c) Only vertical loads are carried
(d) Storey has no lateral load resisting elements

(ix) What is the maximum allowed inter-storey drift ratio as prescribed by IS 1893:2016 to prevent soft storey collapse?
(a) 1% (b) 0.5% (c) 0.2% (d) 2%

(x) Tuned Mass Dampers (TMD) work by
(a) Increasing the natural frequency of the structure
(b) Converting the earthquake energy into heat directly
(c) Absorbing and dissipating vibrational energy to reduce structural movement
(d) Applying external forces opposite to the earthquake direction

Fill in the blanks with the correct word

(xi) The equation of motion for undamped free vibration is _____ .

(xii) For a full description of movement of a structure, the number of degrees of freedom is defined with_____ no. of variables.

(xiii) Logarithmic decrement (δ) is defined as where Y1 andY2 are the two consecutive peaks_____.

(xiv) In Equivalent Static Method, the total lateral seismic force is also known as the _____ shear.

(xv) A floating column is a column that transfers its load to a _____ rather than directly to the foundation.

Group - B

2. (a) What do you mean by d.o.f (degrees of freedom) of a system? Give examples of SDOF and MDOF systems. *[(CO2)(Understanding/LOCQ)]*
(b) Derive the equation of motion of a dynamic system from D'Alembert's principle. *[(CO2)(Applying/IOCQ)]*
6 + 6 = 12

3. (a) What do you mean by damping of a system? Discuss in brief critical damping. *[(CO2)(Remembering/LOCQ)]*
(b) A mass of 20 kg is suspended from a spring of stiffness 39240 N/m. A dashpot is fitted and it is found that the amplitude of vibration diminished from its initial

value of 25 mm to 6.25 mm in two complete oscillations. Find the resistance offered by the dashpot at a velocity of 0.3 m/s and the frequency of damped vibration. Compare this value with frequency of free vibration.

[(CO2)(Evaluating /HOCQ)]

4 + 8 = 12

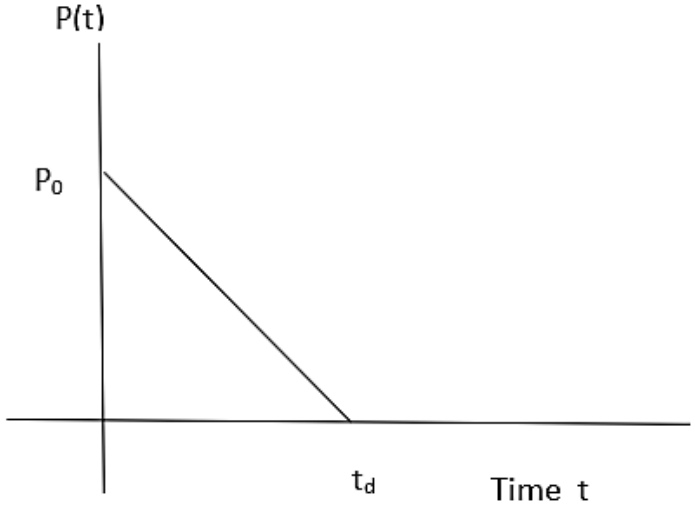
Group - C

4. (a) What do you mean by forced vibration ? Derive the solution for the steady state condition of the SDOF system of $m\ddot{x} + c\dot{x} + kx = Fcos\ pt$ where notations have their usual meanings. *[(CO2)(Applying/IOCQ)]*

   (b) What is Resonance? A machine part weighing 5 kg vibrates in a viscous medium. Determine the damping coefficient when a harmonic force of 36 N results in 15 mm resonant amplitude with a period of 0.32s. *[(CO2)(Applying /IOCQ)]*

6 + 6 = 12

5. (a) An undamped SDOF system is subjected to a down ramp impulse as shown in fig. Find its steady state response in the forced and free vibration states. Determine the maximum response if peak load is 50 kN and duration of the impulse is 0.16 sec, stiffness k=4000 kN/m and natural frequency of vibration is 4.5 Hz. Also determine the maximum spring force. The dynamic magnification factor is 1.40.



Down ramp impulse

[(CO2) (applying/IOCQ)]

   (b) Plot curves showing variation of phase angle with frequency ratio, for different values of critical damping ratio. *[(CO2)(Applying/IOCQ)]*

6 + 6 = 12

Group - D

6. Calculate the design base shear for a 10-story residential building located in seismic zone IV with a total seismic weight of 2000 kN, natural period of 0.5 seconds, and soil type II. Use the equivalent static method as per IS 1893-2016. *[(CO3)(Applying/IOCQ)]*

12

7. Compare and contrast the Response Spectrum Method with the Equivalent Static Method in terms of applicability, accuracy, and complexity. Under what conditions is the

Response Spectrum Method preferred over static analysis, particularly for buildings in high seismic zones? *[(CO3)(Understanding/LOCQ)]*

12

Group - E

8. (a) What is the role of energy dissipation devices in seismic protection? Compare hysteretic, viscous, and friction dampers based on working mechanism and application? *[(CO6)(Remembering /LOCQ)]*

   (b) Explain the theory and design considerations of tuned mass dampers (TMDs) for seismic vibration control in tall structures? *[(CO6)(Understanding /IOCQ)]*

6 + 6 = 12

9. (a) Explain the ductile detailing requirements for columns under IS 13920-2016, including longitudinal and transverse reinforcement criteria. *[(CO4)(Understanding/LOCQ)]*

   (b) Discuss the special confining reinforcement provisions in beam-column joints as per IS 13920-2016. Why is confinement important, and how is it achieved. *[(CO4)(Understanding /LOCQ)]*

6 + 6 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	42	50	8