

STRUCTURAL DYNAMICS AND EARTHQUAKE ENGINEERING

QUESTION BANK

UNIT- 1 THEORY OF VIBRATIONS

Difference between static loading and dynamic loading – Degree of freedom – idealisation of structure as single degree of freedom system – Formulation of Equations of motion of SDOF system - D'Alembert's principles – effect of damping – free and forced vibration of damped and undamped structures – Response to harmonic and periodic forces.

PART – A

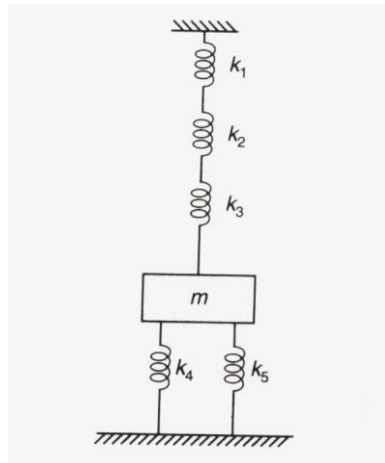
1. State the consequences of vibration in a structure.
2. Define damping.
3. Define Degrees of freedom and list the types.
4. Brief critical damping.
5. Define logarithmic decrement.
6. Define resonance and natural frequency.
7. Summarize critically damped, under damped and over damped system.
8. Explain Damping ratio.
9. Describe D'Alembert's principle.
10. Mention the types of damping.
11. Classify the types of vibration.
12. Illustrate magnification factor.
13. A harmonic motion has a time period of 0.2 s and amplitude of 0.4 cm. Calculate the maximum velocity and acceleration.
14. Distinguish Viscous damping and negative damping.
15. Difference between static and dynamic loading.
16. Compare forced vibration and free vibration.
17. A cantilever beam 3 m long supports a mass of 500 kg at its upper end. Evaluate the natural period and natural frequency.
18. Evaluate harmonic and periodic loading.
19. Write about transient vibration.
20. Write the mathematical equation for equivalent stiffness for springs in parallel and springs in series.

PART – B

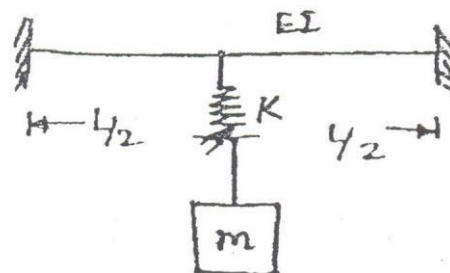
1. A mass of 2 kg is suspended by a spring having a stiffness at 700 N/m. The mass is displaced downward from its equilibrium position by a distance of 0.02 m. Estimate equation of motion, natural frequency, the response of the system and total energy.
2. A machine foundation weighs 60 KN. The spring constant is 11000 KN/m

and dash pot constant (C) = 200 KN-s/m. Explain

- Whether the system is over damped, under tamped or critically damped.
 - Determine Logarithmic decrement
 - Determine Ratio of two successive amplitudes
 - Determine If the initial displacement is 10 mm and initial velocity is zero displacement at $t = 0.1s$
3.
 - i. Briefly explain the types of vibration (10 marks)
 - ii. A harmonic motion has a maximum velocity of 6 m/s and it has a frequency of 12cps. Determine its amplitude and maximum acceleration. (6 marks)
 4. Consider the system shown in figure. If $k_1 = 2000$ N/m, $k_2 = 1500$ N/m, $k_3 = 3000$ N/m, $k_4 = k_5 = 500$ N/m, Calculate the mass if the natural frequency of the system is 10 Hz.



5. Derive the equation of motion for viscous damping.
6. A single degree of freedom system having a mass of 2.5 m is set into motion with a viscous damping and allowed to oscillate freely. The frequency of oscillation is found to be 20 Hz, and measure of the amplitude of vibration shows two successive amplitude to be 6 mm and 5.5 mm. Estimate the viscous damping co-efficient.
7. A damper offers resistance 0.08 N at a constant velocity 0.06 m/s. the damper is used with a spring of stiffness equal to 12 N/m. Estimate the damping ratio and frequency of the system when the mass of the system is 0.3 kg.
8. A mass 'm' is suspended from a beam shown in figure. The beam is of negligible mass and has a uniform flexural rigidity 'EI'. Examine the natural frequency of the system.



9. A mass of 10 kg is supported by a steel wire 1 m in dia and 3 m long. The system is made to move upwards with a uniform velocity of 10 cm/sec when the upper end is suddenly stopped. Construct the frequency and the amplitude of the resulting vibrations of the mass and the maximum stress on the wire.
10. A vibrating system consists of a mass of 5 kg, spring of stiffness 120 N/m and a damper with a damping co-efficient of 5 N-s/m. Calculate
 - a. Damping factor
 - b. Natural frequency of the system
 - c. Logarithmic decrement
 - d. The ratio of two successive amplitude
 - e. The number of cycles after which the initial amplitude reduces to 25%
11. Describe the mathematical modeling of an SDOF system.
12.
 - i. State and elaborate D'Alemberts Principle. (8marks)
 - ii. Describe the solution of equation of motion. (8marks)
13.
 - i. Explain the important points from transmissibility curves. Draw neat curve. (8marks)
 - ii. An SDOF system consists of a mass of 20 kg, a spring of stiffness 2.2 KN/m and a dash pot with a damping co-efficient of 60 N-s/m is subjected to a harmonic excitation of $F = (200 \sin 5t)$ N. show the complete solution of the equation of motion. (8marks)
14. Examine whether the log – decrement is also given by the equation $\lambda = 1/n \log (U_0/ U_n)$ represents the amplitude after n cycles have elapsed.

UNIT II MULTIPLE DEGREE OF FREEDOM SYSTEM

Two degree of freedom system – modes of vibrations – formulation of equations of motion of multi degree of freedom (MDOF) system - Eigen values and Eigen vectors – Response to free and forced vibrations - damped and undamped MDOF system – Modal superposition methods.

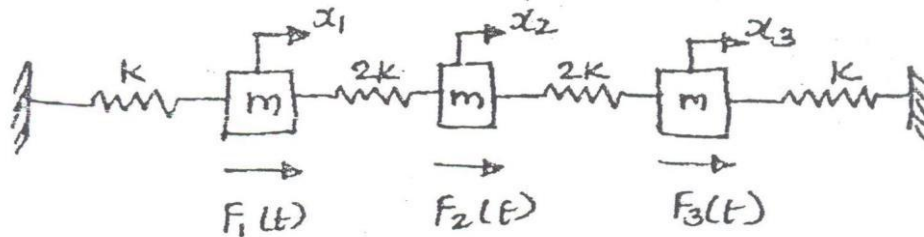
PART - A

1. Define flexibility matrix.
2. What is fundamental frequency and fundamental mode?
3. Define natural period.
4. Enumerate orthogonality and normality principles.
5. What do you mean by equivalent stiffness of a spring.
6. Define Eigen vectors.
7. Write any two point of assumptions made in the concept of shear building.
8. Describe briefly the modal super position method.
9. Discuss about multi degree of freedom system.
10. Comment on mode shape.
11. Examine the steps to be followed for the dynamic analysis of structure.
12. Illustrate model analysis.
13. Examine mass matrix.
14. Explain two degrees of freedom system.
15. Enumerate damping force and Damping force matrix.
16. Write the characteristic equation for free vibration of undamped system.
17. Generalize decoupling equation.

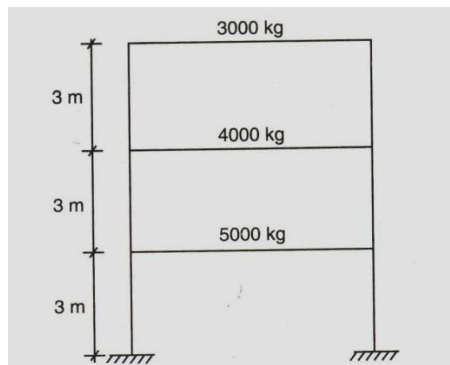
18. Examine first and second mode of vibration.
19. Assess the equation of motion for an damped two degree of freedom system.
20. Write short note on free vibration analysis

PART - B

1. In a two storey building frame, the mass $M_1 = M_2 = 1000$ Kg and stiffness are $k_1 = k_2 = 1$ MN/m. If a horizontal force of 20 kN is applied at The top of ground storey level, Estimate the displacement of the masses M_1, M_2 .
2. A three spring mass system is shown on figure. All the masses are subjected to dynamic forces. Develop the equation of motion in terms of displacements x_1, x_2, x_3 of the masses along the axis of the springs.



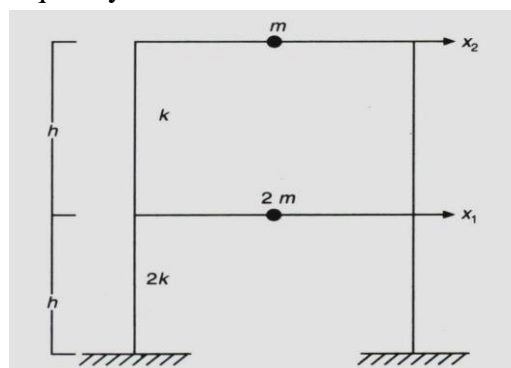
3. State and prove orthogonality property of mode shapes.
4. Calculate the natural frequency and mode shape for the MDOF system. $EI = 4.5 \times 10^6$ N-m² for all columns.



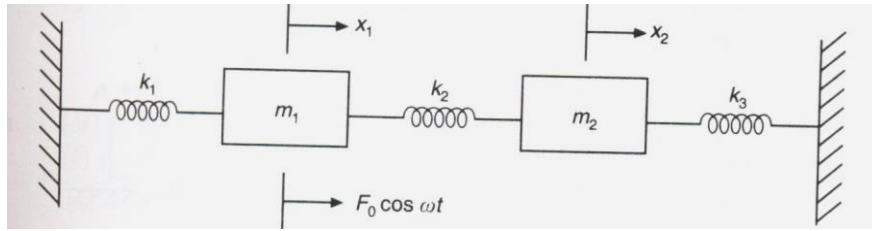
5. Predict the natural frequency and mode shapes of a MDF system. The mass and the stiffness matrix of a MDF system is given by

$$[M] = m \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 2 \end{bmatrix}, [K] = K \begin{bmatrix} 2 & -1 & 0 \\ -1 & 3 & -2 \\ 0 & -2 & 2 \end{bmatrix}$$

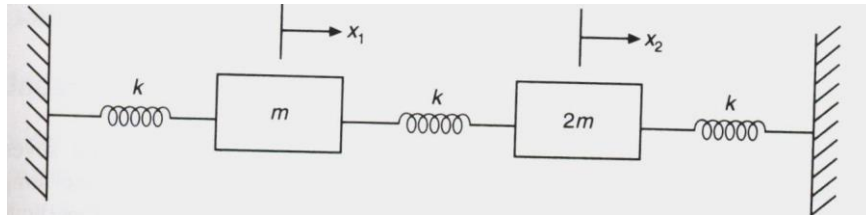
6. Solve the natural frequency and mode of vibration of the system



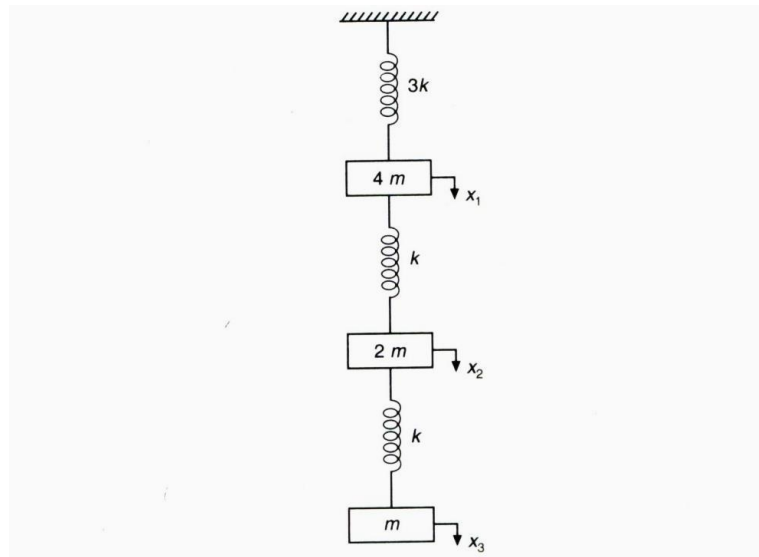
7. Define steady state response and determine the steady state response of the system.



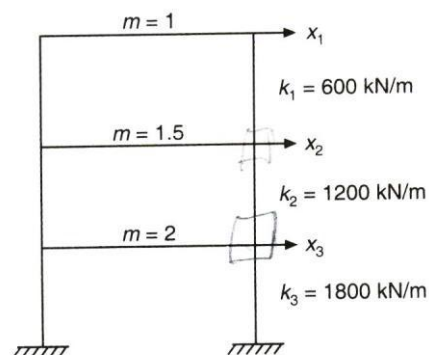
8. Identify the natural frequency and mode of vibration for the system shown.



9. Analyze the natural frequency and mode of the system.



10. Evaluate the natural frequency and draw the mode shape for the shear building.



11. Describe damped systems.
 12. Elaborate undamped system with an example.
 13. Explain the concept of shear building.
 14. Define the natural frequencies and mode of vibration of the given system.

UNIT III ELEMENTS OF SEISMOLOGY

Elements of Engineering Seismology - Causes of Earthquake – Plate Tectonic theory – Elastic rebound Theory – Characteristic of earthquake – Estimation of earthquake parameters - Magnitude and intensity of earthquakes – Spectral Acceleration.

PART - A

1. Write short notes on elastic rebound theory.
2. Explain modified mercalli intensity scale.
3. Define focus and epicenter.
4. Describe about the seismogram.
5. Differentiate between Epicenter and Hypocenter.
6. Differentiate between seismograph and seismogram.
7. List out the causes of Earthquake
8. Define hypocenter.
9. Give brief note on focal depth and Epicentral distance.
10. Compare: magnitude and intensity of an earthquake.
11. Write a note on Tsunami.
12. Classify the types of earthquake.
13. List out some disastrous earthquakes occurred in past history in India.
14. Define fault and list its types.
15. Write short note on magnitude.
16. How will u develop an Iseismal map.
17. Describe about the characteristics of earthquake.
18. How will you evaluate strong ground motion.
19. How will you assess the types of seismic waves.
20. Write note on intensity.

PART – B

1. List out the causes of earthquake and explain it briefly.
2.
 - i. Explain the seismic waves with neat sketch.
 - ii. Discuss about the elastic rebound theory.
3. Write in detail about the plate tectonic theory and lithospheric plates.
4.
 - i. Explain the types of geological faults.
 - ii. Discuss about the classification of earthquake.
5.
 - i. Differentiate magnitude and intensity.
 - ii. How will you measure magnitude and intensity. Explain the methods

- briefly.
6. Describe about the characteristics of strong ground motion with neat graph.
 7. How will you estimate the measurement of earthquakes using
 - i. Seismograph
 - ii. Seismogram
 with neat sketches.
 8.
 - i. List out the two approaches followed for the prediction of earthquakes and explain it.
 - ii. Name the major plates of the earth.
 9. On what is the assignment of an earthquake magnitude based? Is magnitude the same as intensity? Explain
 10. Explain about some recent earthquakes and give information on some disastrous earthquakes.
 11. Define focus and epicenter of an earthquake. Name the kinds of body waves and explain it with neat sketch.
 12. Define Richter scale and MMI scale and explain it briefly.
 13. Write short notes on
 - i. Tsunami
 - ii. Spectral acceleration .
 14. Write in detail about the internal structure of the earth.

UNIT IV RESPONSE OF STRUCTURES TO EARTHQUAKE

Effect of earthquake on different type of structures – Behaviour of Reinforced Cement Concrete, Steel and Prestressed Concrete Structure under earthquake loading – Pinching effect – Bouchinger Effects – Evaluation of earthquake forces as per IS:1893 – 2002 - Response Spectra – Lessons learnt from past earthquakes.

PART – A

1. Define zero period acceleration.
2. Define response spectra.
3. List out the code based methods for seismic design.
4. Define the term base shear.
5. List out the methods of dynamic analysis.
6. List the different types of irregularities found on RC buildings during earthquake.
7. Explain the term storey drift.
8. Discuss about the major damages occur in the RC structures during earthquake.
9. Discuss about peak ground acceleration (PGA).
10. Explain the term Response reduction factor
11. Write short notes on soft storey failure.
12. Write note on the lessons learnt from past earthquake.
13. Write note on bouchinger effect.
14. How mass irregularities differ from plane irregularities. Explain.
15. Explain about the pinching effect.
16. Differentiate between rigid diaphragm and flexible diaphragm.
17. How will you evaluate the distribution of design base shear along the height of the building.
18. Predict some of the exterior wall damages during earthquake.

- 19 Formulate the expression for time period as per codal provision IS 1893:2002.
- 20 Write short note on pounding effect in buildings.

PART – B

- 1 Explain briefly the effect of earthquake on different types of structures.
- 2 Discuss about the vertical irregularities that affect the performance of RC buildings during earthquake.
- 3 i. Write short notes on pinching effect.
 ii. Write short notes on bouchinger effect.
- 4 Write the step by step procedure for seismic analysis of RC buildings as per IS 1893:2002.
- 5 Examine the plan configuration problems that affect the performance of RC buildings during earthquake.
- 6 In what manner is the behaviour of a soft storey construction likely to be different from a regular construction in the event of an earthquake. Explain it.
- 7 Explain the behavior of prestressed concrete structures under earthquake loading.
- 8 List out the lessons learnt from the past earthquakes in India and explain it briefly.
- 9 Discuss in detail about the methods of seismic analysis.
- 10 Define Response spectra. Explain the concept and types of response spectra with neat sketch.
- 11 A three storeyed symmetrical RC school building situated at Bhuj with following data:
- | | |
|-------------------------------------|----------|
| Plan dimension | : 7 m |
| Storey height | : 3.5 m |
| Total weight of beams in a storey | : 130 kN |
| Total weight of slab in a storey | : 250 kN |
| Total weight of columns in a storey | : 50 kN |
| Total weight of walls in a storey | : 530 kN |
| Live load | : 130 kN |
| Weight of terrace floor | : 655 kN |
- The structure is resting on hard rock. Determine the total base shear and lateral loads at each floor level for 5% of damping using seismic coefficient method.
- 12 Write a step by step procedure to analyze a frame by equivalent static lateral load method.
- 13 Define the following terms and explain it:
- i. Smooth spectrum
- ii. Seismic demand diagrams.
- 14 A four storey reinforced concrete frame building as shown in fig: is situated at Roorkee. The height between the floors is 3 m and total height of building is 12 m. The dead load and live load is lumped at respective floor. The soil below the foundation is assumed to be hard rock. Assume building is intended to be used as a hospital. Determine the total base shear as per IS1893 (PART1) : 2002. Distribute the base shear along the height of the

building.

UNIT V DESIGN METHODOLOGY

Causes of damage – Planning considerations / Architectural concepts as per IS:4326 – 1993 – Guidelines for Earthquake resistant design – Earthquake resistant design for masonry and Reinforced Cement Concrete buildings – Later load analysis – Design and detailing as per IS:13920 – 1993.

PART – A

- 1 Define ductility
- 2 Define the term DBE, MCE and MMI.
- 3 Define diaphragm discontinuity.
- 4 List out the factors affecting ductility.
- 5 Define lateral load analysis of masonry buildings.
- 6 List out the methods of improving element level and Global level Ductility.
- 7 Discuss about the design philosophy adopted for earthquake resistant structure.
- 8 Explain two cases of design horizontal earthquake load.
- 9 Explain the concept of floating column.
- 10 Describe the design considerations made in masonry structures.
- 11 Write the IS 13920 provisions for flexural members.
- 12 Write a short note on curvature ductility.
- 13 Show the stress strain curve for brickwork in compression.
- 14 Explain the types of damages occur in masonry building during earthquakes.
- 15 Differentiate structural and non-structural damages in masonry building.
- 16 Explain the planning considerations as per IS 4326:1993.
- 17 How will you assess the causes of damage in RC and Masonry buildings.
- 18 What will happen if the rigidity modulus affects the masonry structure. Justify.
- 19 Write the principle for the design of infill walls.
- 20 Write the formula for modal mass.

PART – B

- 1 List out the codal provisions for architectural considerations and structural design considerations as per IS 4326:1993.
- 2 Write down the design principles involved in design of masonry structure.

- 3 Write down the various earthquake resistant features that can be introduced in masonry building to make it earthquake resistant.
- 4 Explain the principles and practice of earthquake resistant design of R.C.C buildings.
- 5 Classify the damages and non-damages occurred in masonry buildings during an earthquake with examples.
- 6 Write down the procedure for lateral load analysis of masonry buildings.
- 7 Explain the reinforcement detailing of flexural members as per IS 13920:1993.
- 8 Explain about the Earthquake design philosophy.
- 9 Compare and contrast earthquake design of masonry and RC structures.
- 10
 - i. Explain the factors affecting ductility.
 - ii. Describe the importance of ductility in earthquake resistant design.
- 11 Why ductility consideration is very important in earthquake resistant design of RC building? Explain the ductile detailing considerations in flexural members as per IS 13920-1993.
- 12 List out the causes of damages occurred in RC building during earthquake.
- 13
 - i. List out the design principles of earthquake resistant structure as per IS 1893-2002.
 - ii. Write in detail about the special confining reinforcement detailing as per IS 13920-1993.
- 14 Define the response behavior and explain the ductility demand in multistoried buildings with neat sketch.