INSTITUTEOFAERONAUTICALENGINEERING

(Autonomous)

Dundigal,Hyderabad-500043

CIVIL ENGINEERING

M. Tech (Structural Engineering)

QUESTION BANK

Course Name	:	**STRUCTURAL DYNAMICS**
Course Code	:	BST004
Class	:	I M. Tech II Semester
Branch	:	STRUCTURAL ENGINEERING
Year	:	2017 – 2018
Course Coordinator	:	Dr. J. S. R. Prasad, Professor, Department of Civil Engineering
Course Faculty	:	Dr. J. S. R. Prasad, Professor, Department of Civil Engineering

OBJECTIVES

The objectives of this course are to impart knowledge and abilities to the students to:

I. Understand the basic principles of dynamic analysis of structures and vibratory systems
II. Formulate the dynamic equations of motions for discretized and continuous systems
III. Analyse the dynamic free and forced responses of discretized and continuous systems
IV. Analyze the response of multi-storeyed buildings for various dynamic loads including earthquake loads.

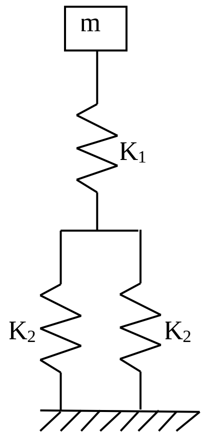
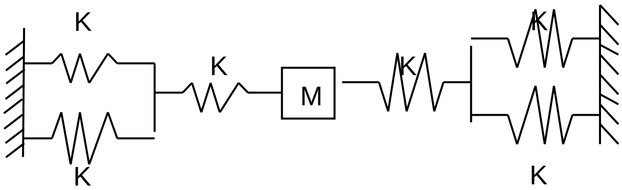
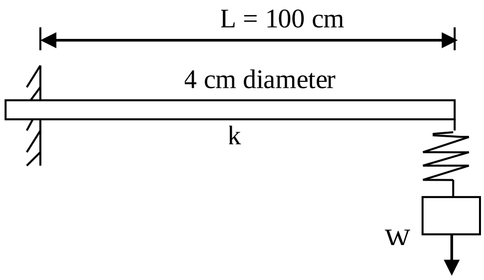
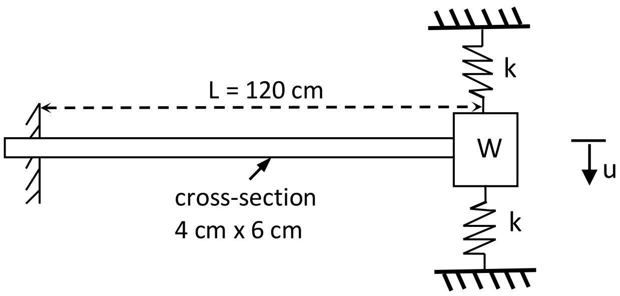
COURSE OUTCOMES

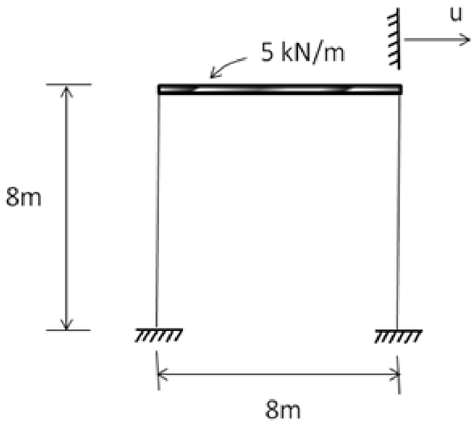
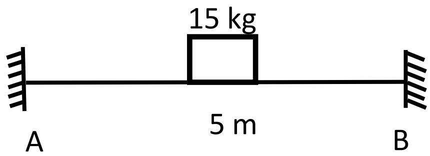
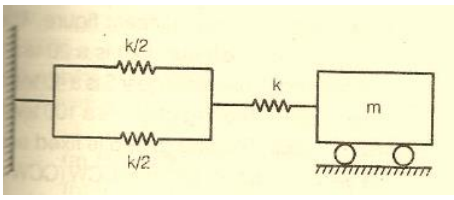
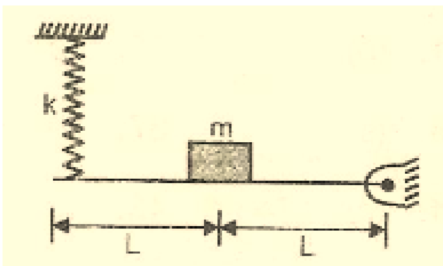
After completing this course, the student must demonstrate the knowledge and ability:

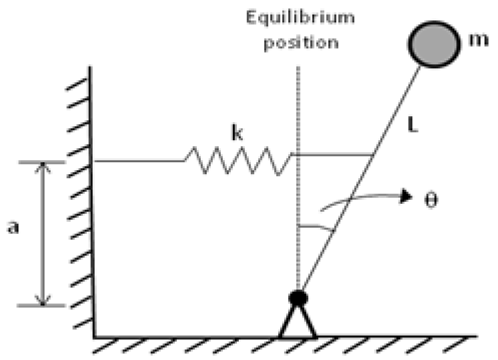
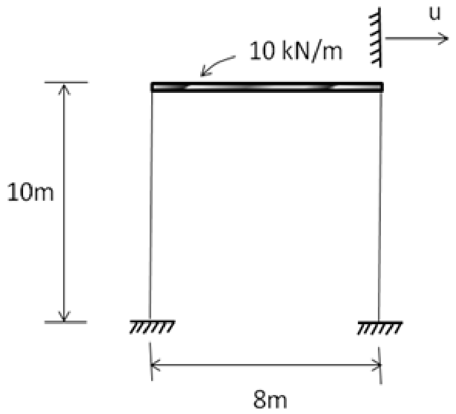
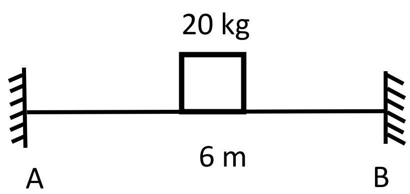
S. No.	Course Outcomes
CBST004.01	To understand the concepts on vibration system
CBST004.02	To understand the degrees of freedom
CBST004.03	To explain the function of the importance of damping
CBST004.04	To idealize the vibration motion system into lumped mass
CBST004.05	To model and analyse the differential equations of motion for SDOF and MDOF systems and analyze their solutions
CBST004.06	To enable the application of Virtual work to Structural Dynamics
CBST004.07	To apply the D' Alembert's principle in dynamic equilibrium of a vibratory body
CBST004.08	To formulate and solve of the equation of motion
CBST004.09	To evaluate the response to harmonic, periodic, impulsive loadings
CBST004.10	To understand the application of Duhamel Integral in Single Degree of Freedom Systems
CBST004.11	To be able to develop mathematical models for dynamic analysis of structures
CBST004.12	To evaluate Eigen values and Eigen vectors in a dynamic analysis
CBST004.13	To understand the orthogonality properties of normal mode shapes
CBST004.14	To learn the different methods to analyze forced vibration ofMDOF system
CBST004.15	To Find the stiffness and flexibility matrices for the system
CBST004.16	To be able to Explain Stodola method
CBST004.17	To understand Modal Superposition method
CBST004.18	To differentiate Stodola and Hozler methods

CBST004.19	To understand differential equation governing the transverse vibrations of a beam, explaining the terms
CBST004.20	To evaluate the boundary conditions of bending moment and shear force to be applied at the simply supported end of a beam.
CBST004.21	To definezero period acceleration and understand its significance in Response Spectra Analysis
CBST004.22	To defineresponse spectra and understand its significance
CBST004.23	To explain briefly the effectof earthquake on different types of structures.
CBST004.24	To write the step by step procedure for seismic analysis of RC buildings as perIS1893:2002.

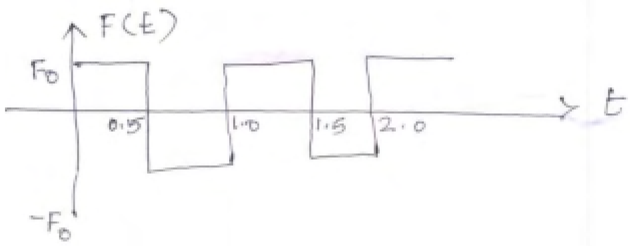
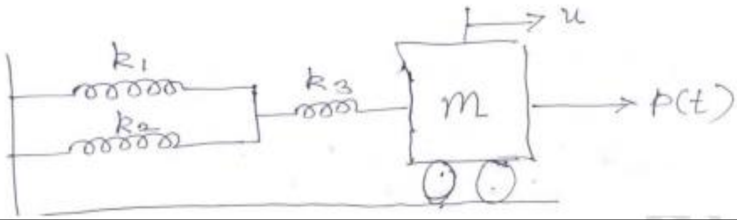
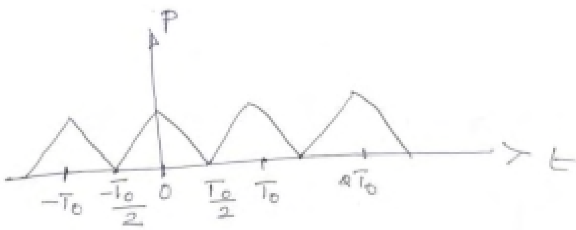
S. No.	QUESTION	Blooms taxonomy level	Course Outcomes
	UNIT-I **THEORY OF VIBRATIONS**		
Part - A (Short Answer Questions)			
1	What is meant by periodic motion of vibratory systems? Give two examples of periodic motion.	Remembering	CBST004.01
2	Define the terms (a) Time Period and (b) Frequency in relation to periodic motion of vibratory systems	Remembering	CBST004.01
3	Define simple harmonic motion. Give examples of simple harmonic motions	Remembering	CBST004.01
4	What do we mean by degree of freedom of a vibratory system? Illustrate by a spring mass model.	Remembering	CBST004.02
5	Sketch themathematical model of a single degree of freedom system	Remembering	CBST004.02
6	Distinguish between free vibrations and forced vibrations of a vibratory system.	Understanding	CBST004.02
7	Whatdo you understand by damping in a vibratory system?	Remembering	CBST004.03
8	What is meant by critical damping?	Remembering	CBST004.03
9	Distinguish between damping coefficient and damping ratio?	Understanding	CBST004.03
10	Distinguish between under-damped, critically damping and over-damped system.	Understanding	CBST004.03
Part - B (Long Answer Questions)			
1	A harmonic motion has an amplitude of 0.05 m and a frequency of 25 Hz. Find the time period, maximum velocity and maximum acceleration. Also find the average and RMS values of displacement, velocity and acceleration.	Applying	CBST004.01
2	A particle is simultaneously subjected to two motions given by $X_1 = 4\cos(wt + 10^o)$ and $X_2 = 6\sin(wt + 60^o)$. Find the solution of the combined motion by vectorial addition.	Applying	CBST004.01
3	Add the following motion vectors analytically and represent the final solution graphically: $X_1 = 8\sin(wt + 30^o)$ and $X_2 = 10\sin(wt - 60^o)$.	Applying	CBST004.01
4	Add the following motion vectors analytically and find the final amplitude and phase: $X_1 = 6\sin(wt + 60^o)$ and $X_2 = 8\cos(wt - 30^o)$.	Applying	CBST004.01
5	Split up the harmonic motion $x = 10\sin(wt + 30^o)$ into two harmonic motions , one having a phase angle of zero and the other of 45^o.	Applying	CBST004.02
6	Split up the harmonic motion $x = 8\cos(wt + 45^o)$ into two harmonic motions , one having a phase angle of zero and the other of 60^o.	Applying	CBST004.02
7	Split up the harmonic motion $x = 8\sin(wt + 45^o)$ into two harmonic motions , one having a amplitude of 10 and phase difference of zero.	Applying	CBST004.02
8	A body is subjected to two harmonic motions as given below: $X_1 = 15\cos(wt + 30^o)$ and $X_2 = 8\cos(wt + 60^o)$. What extra harmonic motion should be given to the body to bring it to static equilibrium?	Applying	CBST004.03

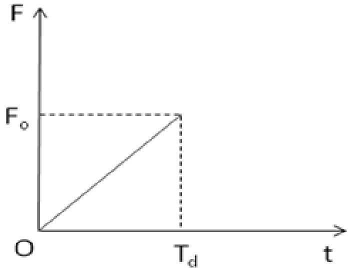
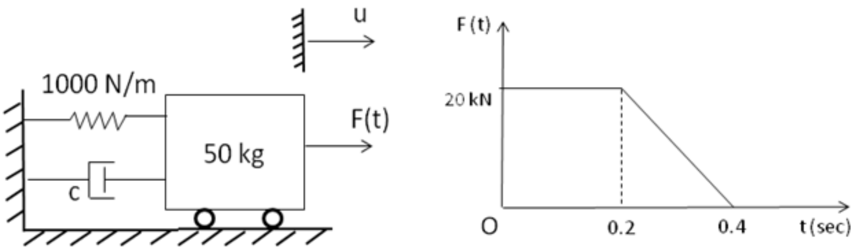
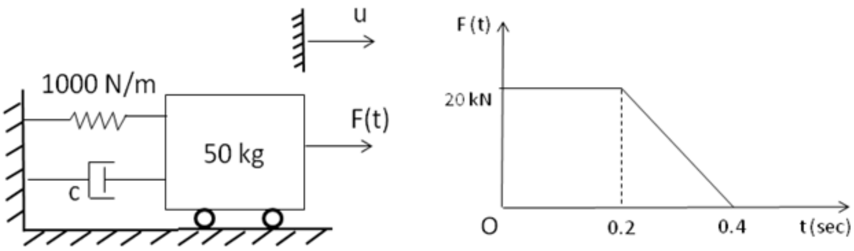
<table>
<tr><td>9</td><td>What is equivalent stiffness and the natural frequency for the system illustrated in Figure below?

</td><td>Applying</td><td>CBST004.02</td></tr>
<tr><td>10</td><td>What is equivalent stiffness and the natural frequency for the system illustrated in Figure below?

</td><td>Applying</td><td>CBST004.05</td></tr>
<tr><td colspan="4">Part - C (Problem Solving and Critical Thinking Questions)</td></tr>
<tr><td>1</td><td>Determine the natural frequency of motion of the weight W = 10 N suspended from a spring at the free end of a circular cantilever steel beam shown in Figure below. Take Young's modulus for steel, E = 2.05 x 10^{11} N/m^2 and spring stiffness, k = 30 kN/m. Neglect the mass of the beam and spring.

</td><td>Evaluating</td><td>CBST004.01</td></tr>
<tr><td>2</td><td>Determine the natural frequency of motion of the weight W = 20 N suspended from a spring at the free end of a rectangular cantilever steel beam shown in Figure below. Take Young's modulus for steel, E = 2.1 x 10^{11} N/m^2 and spring stiffness, k = 20 kN/m. Neglect the mass of the beam and spring.

</td><td>Evaluating</td><td>CBST004.02</td></tr>
</table>

3	Calculate the natural frequency in the horizontal mode of vibration for the frame shown below, where the horizontal member is considered rigid. The cross-section of the columns is 200 X 200 mm^2. The Young's modulus for the material of the members is E = 180 GPa. 	Evaluating	CBST004.03
4	Determine the natural frequency of vibration of the mass on the fixed beam shown in the figure carrying the concentrated load on the mid-span. The cross-section of the beam is 150 x 300 mm^2 and E = 120 GPa. 	Evaluating	CBST004.04
5	Determine the natural frequency of the vibration system shown below and its free vibration response, if initial displacement and initial velocity are zero. 	Evaluating	CBST004.05
6	A concentrated mass m is attached at the centre of a rod of length 2L as shown in the figure. The rod is kept in a horizontal equilibrium position by a spring of stiffness k. For very small amplitude of vibration, neglecting the weights of the rod and spring, find the undamped natural frequency of the system. 	Evaluating	CBST004.01

<table>
<tr><td>7</td><td>Determine the differential equation of motion for the inverted pendulum shown in the figure. Assuming small oscillations and negligible mass of the rod, also determine the natural frequency of the system.

</td><td>Evaluating</td><td>CBST004.02</td></tr>
<tr><td>8</td><td>Formulate the differential equation for the horizontal mode of vibration for the frame shown below, where the horizontal member is considered rigid. The cross-section of the columns is 250 X 250 mm^2. The Young's modulus for the material of the members is E = 150 GPa.

</td><td>Evaluating</td><td>CBST004.03</td></tr>
<tr><td>9</td><td>Determine the differential equation governing the vibration of the mass bonded on the fixed beam shown in the figure carrying the concentrated load on the mid-span. The cross-section of the beam is 180 x 240 mm^2 and E = 150 GPa. Give the general solution for the undamped vibration response.

</td><td>Evaluating</td><td>CBST004.04</td></tr>
<tr><td>10</td><td>Show that the displacement response of an undamped SDOF system subjected earthquake acceleration, $\ddot{x}(t) = \ddot{x}_o e^{-\alpha t}$ is given by
$$x(t) = -\frac{\ddot{x}_0}{a^2+\omega_0^2}\left[\frac{a}{\omega_0}\sin\omega_0 t - \cos\omega_0 t + e^{-at}\right]$$
where, w_o = natural frequency of the SDOF system; and a = parameter having the same unit as that of w_o.</td><td>Evaluating</td><td>CBST004.05</td></tr>
<tr><td colspan="4">UNIT-II
SINGLE DEGREE OF FREEDOM SYSTEMS</td></tr>
<tr><td colspan="4">Part - A (Short Answer Questions)</td></tr>
<tr><td>1</td><td>Give the explanation onvirtual work and its application to Structural Dynamics</td><td>Remembering</td><td>CBST004.06</td></tr>
</table>

2	State the D' Alembert's principle used in dynamic equilibrium of a vibratory body.	Remembering	CBST004.06
3	What is meant by damping in vibratory systems? Give the different types of damping models generally used in structural dynamics.	Remembering	CBST004.06
4	Give the differential equation of motion governing the undamped free vibrations of a single degree of freedom system.	Remembering	CBST004.06
5	Give the differential equation of motion governing the damped free vibrations of a single degree of freedom system.	Remembering	CBST004.07
6	Give the differential equation of motion governing the undamped forced vibrations of a single degree of freedom system.	Remembering	CBST004.07
7	Give the differential equation of motion governing the damped forced vibrations of a single degree of freedom system.	Remembering	CBST004.07
8	Sketch a typical undamped free vibration response of a single degree of freedom system.	Remembering	CBST004.07
9	Sketch a typical damped free vibration response of a single degree of freedom system.	Remembering	CBST004.07
10	Explain what is meant by Dynamic Magnification Factor in forced response of a vibratory system. Use sketch if required.	Understanding	CBST004.08
Part - B (Long Answer Questions)			
1	Derive the governing equation of motion of a damped single degree of freedom subjected to a dynamic forcing function.	Applying	CBST004.06
2	Explain the concepts of (a) lumped mass idealization and (b) discretization used in the dynamic analysis of structures.	Applying	CBST004.06
3	Derive the general solutionofundamped free vibrations of a singledegreeof freedomsystem.	Applying	CBST004.07
4	Derive the general solutionofdamped free vibrations of a singledegreeof freedomsystem.	Applying	CBST004.07
5	Derive the general solutionofundamped forced vibrations of a singledegreeof freedomsystem subjected to a harmonic forcing function, $F(t) = A \sin\omega t$.	Applying	CBST004.07
6	Explain the method of estimating the damping of a system from logarithmic decrement derived from the damped vibration response.	Applying	CBST004.07
7	An SDOF system consists of a mass of 20kg, and a spring of stiffness 2200kN/m and dashpot with a damping coefficient of 60Ns/m and is subjected to a force of F=200sin5t.Finditssteadystate response and peak amplitude.	Applying	CBST004.07
8	A SDOF system with a mass of 50kg and stiffness 20N/mm with damping 150Ns/m is initially at rest. If theinitial velocity is 100mm/s, (i) Determinethe expression for subsequent displacement. (ii) Find its displacement and velocity at T= 1.5sec.	Applying	CBST004.08
9	Estimate the damping in a single degree of freedom system that is excited by a harmonic force. The peak displacement amplitude at resonance was measured equal to 3 cm and equal to 0.2 cm at one-tenth of the natural frequency of the system.	Applying	CBST004.08
10	Determine the damping in a system in which during a vibration test under a harmonic force it was observed that at a frequency 10% higher than the resonant frequency, the displacement amplitude was exactly one-half of the resonant amplitude.	Applying	CBST004.08
Part - C (Problem Solving and Critical Thinking Questions)			

<table>
<tr><td>1</td><td>Derive the response to a single degree of freedom system with the periodic force function applied as shown below. Force is in Newtons and time is in sections.
</td><td>Evaluating</td><td>CBST004.07</td></tr>
<tr><td>2</td><td>a) Developtheeffectivestiffnessofthecombinedspringsystemshownin figure and write the equation ofmotion for the spring mass system
b) Derive the solution for undampedsingle degree of freedom system
</td><td>Evaluating</td><td>CBST004.07</td></tr>
<tr><td>3</td><td>An SDOF system with natural period T_n and damping ratio 3 is subjected to a periodic force as shownin figure, with an amplitude $P_0$and period T_0.
(i) Evaluate the forcing function in its Fourier series.
(ii) Determine the steady state responseofan un-damped system
</td><td>Evaluating</td><td>CBST004.07</td></tr>
<tr><td>4</td><td>The damped natural frequency of a system as obtained from a free vibration test is 9.8 Hz. During the forced vibration test with constant exciting force on the same system, the maximum amplitude of vibration is found to be at 9,6 Hz. Find the damping factor for the system and its natural frequency.</td><td>Evaluating</td><td>CBST004.08</td></tr>
<tr><td>5</td><td>A system of beams supports a motor of mass 1200 kg. The motor has an unbalanced mass of 1 kg located at 6.0 cm radius. It is known that the resonance occurs at 2210 r.p.m. What amplitude of vibration can be expected at the motor's operating speed of 1440 r.p.m. if damping factor is assumed to be less than 0.1?</td><td>Evaluating</td><td>CBST004.08</td></tr>
<tr><td>6</td><td>A 1000 kg machine is mounted on four identical springs of total spring constant k and having negligible damping. The machine is subjected to a harmonic external force of amplitude 490 N and frequency 180 R.P.M. Determine
the amplitude of motion of the machine and maximum force transmitted to the foundation because of the unbalanced force when $k = 1.96 \times 10^6$ N/m.</td><td>Evaluating</td><td>CBST004.08</td></tr>
<tr><td>7</td><td>Use Duhamel's integral to obtain the response of a damped simple oscillator of stiffness k, mass m, and damping ratio ξ, subjected to a suddenly applied force of magnitude F_o. Assume initial displacement and initial velocity to be equal to zero.</td><td>Evaluating</td><td>CBST004.08</td></tr>
</table>

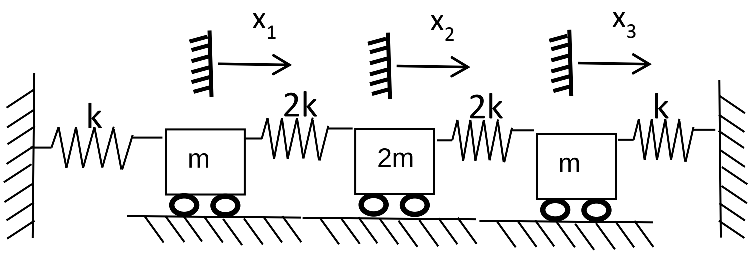
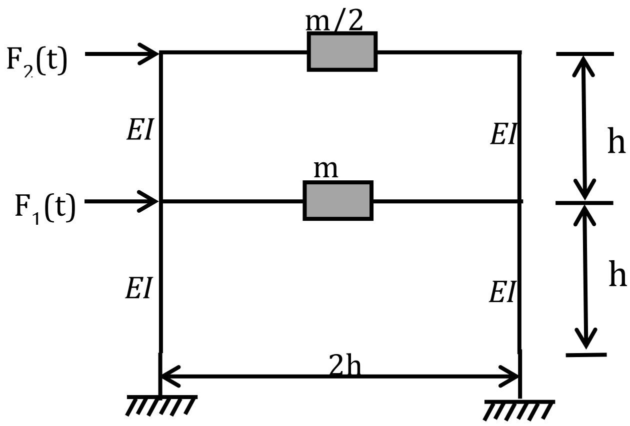
8	Determine the response of an undampedSDoF system to a ramp force of maximum magnitude F_0 and duration T_d starting with zero initial conditions of displacement and velocity.  	Evaluating	CBST004.08
9	For the dynamic system shown in the following figure below determine and plot the displacement as a function of time for the interval $0 \le t \le 0.5$ sec. Neglect damping.  	Evaluating	CBST004.08
10	For the dynamic system shown in the following figure below determine and plot the displacement as a function of time for the interval $0 \le t \le 0.5$ sec. Assume 10% critical damping.  	Evaluating	CBST004.09

UNIT-III

MULTI-DEGREE OF FREEDOM SYSTEMS

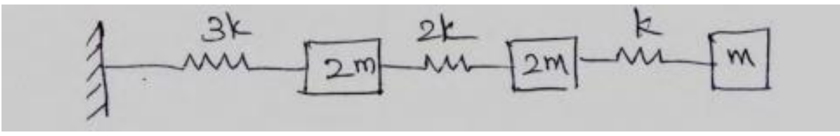
Part - A (Short Answer Questions)

1	Draw a mathematical model for dynamic analysis of a 4 storey building frame.	Remembering	CBST004.11
2	Draw the mathematical model of a 3DOFsystem including damping.	Remembering	CBST004.11
3	Give lumped mass matrix for a 3 DOF system?	Remembering	CBST004.11
4	Statethe orthogonality properties of normal mode shapes.	Remembering	CBST004.12
5	Give stiffness matrix for a 3 DOF system?	Remembering	CBST004.12
6	What are Eigen values and Eigen vectors in a dynamic analysis?	Remembering	CBST004.12
7	Write the equation of motion of an undamped MDOF system with free vibration for a 3 DOF system.	Remembering	CBST004.12
8	Write the equation of motion of undamped MDOF system with forcedvibration for a 3 DOF system.	Remembering	CBST004.11

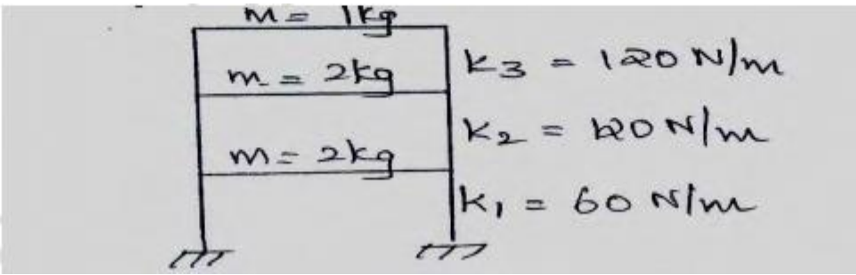
9	Explain what is meant by natural frequencies and mode shapes.	Understanding	CBST004.12
10	What are the different methods to analyze forced vibration of MDOF system?	Understanding	CBST004.13
Part - B (Long Answer Questions)			
1	(i) Explain how mathematical modelling can be done for a multi-degreefreedomsystem. (ii) Derive the governing differential equation and undamped free vibration solution for a three storey shear building frame modelled as oscillators.	Applying	CBST004.11
2	Evaluate the natural frequencies and modes of vibration of a two degree of freedom spring – mass oscillators, with equal masses of 10 kg and equal spring stiffness of 100 N/m.	Applying	CBST004.11
3	Evaluate the eigen values and eigen vectors for a simple pendulum with three masses each of 10 kg. Neglect weight of the connectors.	Applying	CBST004.12
4	Prove the orthogonality property of the normalized mode shapes vectors.	Applying	CBST004.12
5	Determine the three natural frequencies for the system shown below.  	Applying	CBST004.12
6	Formulate the equations of motion for the two-story shear frame with lumped masses as shown in the figure. Beams are considered fully rigid and the flexural rigidity of the columns is EI. Neglect axial deformations in all elements.  	Applying	CBST004.12
7	Consider the uniform shear building in which the mass of each floor is *m* and the stiffness of each storey is *k*. Determine the general form of the system of differential equations for a uniform shear building of *N* storeys.	Applying	CBST004.12
Part - C (Problem Solving and Critical Thinking Questions)			

<table>
<tr><td>1</td><td>The Stiffness and mass matrices of a vibrating system is given below. Determineits fundamental frequency and Mode shapes.

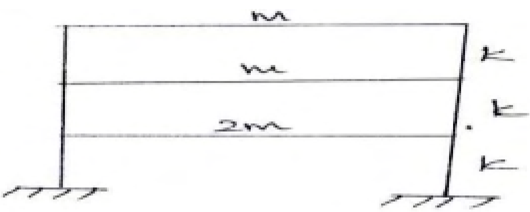
$$[m] = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1.5 & 0 \\ 0 & 0 & 2 \end{bmatrix} \qquad [k] = \begin{bmatrix} 600 & -600 & 0 \\ -600 & 1800 & -1200 \\ 0 & -1200 & 3000 \end{bmatrix}$$
</td><td>Evaluating</td><td>CBST004.12</td></tr>
<tr><td>2</td><td>Evaluate the natural frequencies and the mode shapes for the system shown below:



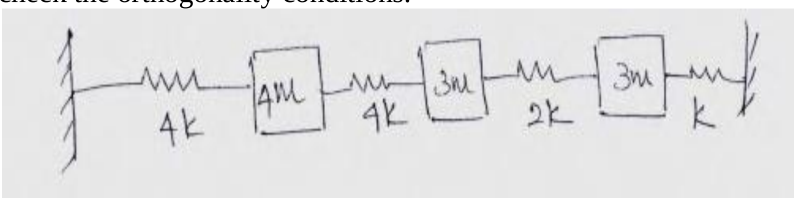
</td><td>Evaluating</td><td>CBST004.13</td></tr>
<tr><td>3</td><td>Analyse the natural frequencies and the mode shapes for the shear building as shown below:



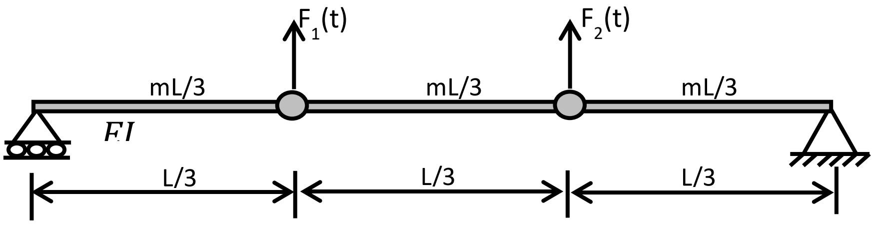
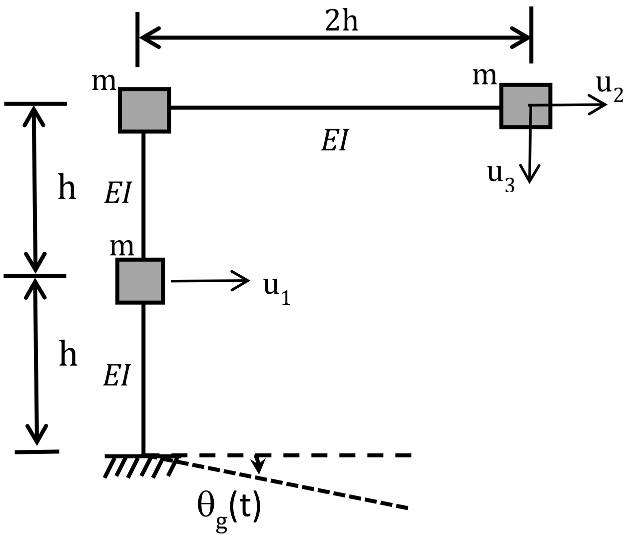
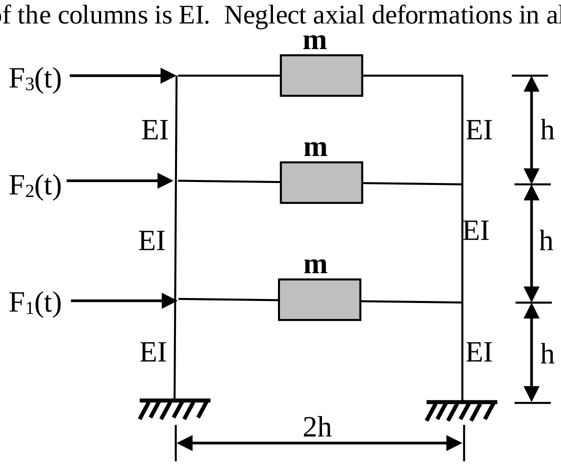
</td><td>Evaluating</td><td>CBST004.13</td></tr>
<tr><td>4</td><td>(a) Calculate the natural frequencies for the given frame.
(b) Also prove the orthogonality property of mode shapes.

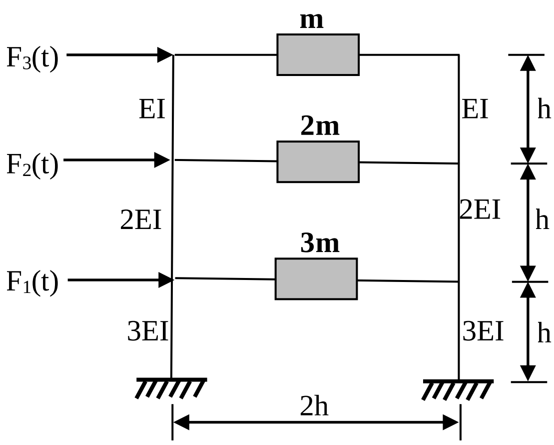


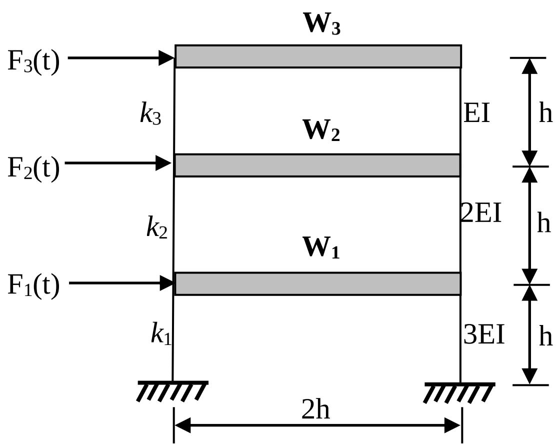
</td><td>Evaluating</td><td>CBST004.13</td></tr>
<tr><td>5</td><td>Analyze the natural frequencies and mode shape for the given system and check the orthogonality conditions.



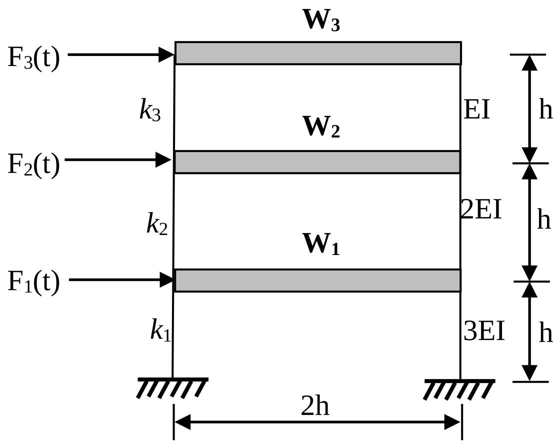
</td><td>Evaluating</td><td>CBST004.13</td></tr>
</table>

6	(a) A uniform simply supported beam of length L, flexural rigidity EI, and mass m per unit length is idealized as a lumped-mass as shown in the figure. The applied forces are also shown. Neglect axial deformations (b) Identify the DOFs for representing the elastic properties and determine the stiffness matrix (c) Identity the DOFs for representing the inertial properties and determine the mass matrix (d) Formulate the equations governing the translational motion of the beam. 	Evaluating	CBST004.13
7	Formulate the governing equation of motion for the frame subjected to base rotatory acceleration $\ddot{\theta}_g(t)$ as shown in the figure. Evaluate the stiffness and mass matrices. 	Evaluating	CBST004.14
8	Formulate the equations of motion for the three-storey shear frame with lumped masses as shown in the figure. Beams are considered fully rigid and the flexural rigidity of the columns is EI. Neglect axial deformations in all elements. 	Evaluating	CBST004.14

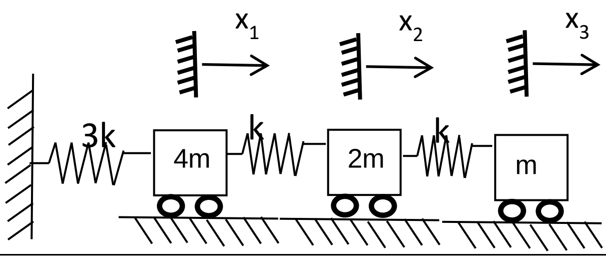
10	Find the natural frequencies and the mode shapes of the three-storey shear frame with lumped masses as shown in the figure. Beams are considered fully rigid and the flexural rigidity of the columns is as shown. Neglect axial deformations in all elements. Take m = 100 kN, h = 10 m and EI = 2 x 10^{11} N/m^2. 	Evaluating	CBST004.14
UNIT-IV **VIBRATION ANALYSIS**			
Part - A (Short Answer Questions)			
1	What is Stodola method used for? Explain in two or three sentences the principle involved in Stodola method?	Understanding	CBST004.16
2	What is Holzer method used for? Explain in two or three sentences the principle involved in Holzer method?	Understanding	CBST004.16
3	What is Modal Superposition method used for? Explain in two or three sentences the principle involved in Modal Superposition method?	Remembering	CBST004.17
4	Explain in two or three sentences the fundamental difference in approach of Stodola and Holzer methods?	Understanding	CBST004.17
5	What are generalized mass, stiffness and damping matrices? What is their significance in modal analysis?	Understanding	CBST004.17
	(A) Vibration of Continuous Systems		
6	Write the differential equation governing the transverse vibrations of a string, explaining the terms.	Understanding	CBST004.16
7	Write the differential equation governing the transverse vibrations of a beam, explaining the terms.	Understanding	CBST004.16
8	Draw and illustrate the first three modes of flexural vibration of a simply supported beam.	Understanding	CBST004.16
9	Draw and illustrate the first three modes of flexural vibration of a cantilever beam.	Understanding	CBST004.17
10	Give the boundary conditions of bending moment and shear force to be applied at the fixed end of a beam.	Understanding	CBST004.17
11	Give the boundary conditions of bending moment and shear force to be applied at the simply supported end of a beam.	Understanding	CBST004.17
12	Give the boundary conditions of bending moment and shear force to be applied at the free end of a beam.	Understanding	CBST004.17
Part - B (Long Answer Questions)			
(A) **Practical Vibration Analysis (Numerical methods)**			

1	In a summary form, list the steps involved in evaluating natural frequencies and mode shapes of a multi-degree of freedom system using Stodola method.	Understanding	CBST004.16
2	Summarize the steps involved in Holzer method to evaluate natural frequencies and mode shapes of a multi-degree of freedom.	Understanding	CBST004.16
3	Write the steps involved in the modal superposition method in evaluating mode shapes and natural frequencies.	Understanding	CBST004.17
4	Write the expression and explain what is the use of the mode-participation factor.	Understanding	CBST004.17
5	Explain the steps and formula used in finding the maximum response of vibration of multi-degree of freedom systems using square root of sum of squares (SRSS) method.	Understanding	CBST004.17
Vibration of Continuous Systems			
6	A uniform string of length *l* fixed at its ends has a large initial tension. It is plucked at x = *l*/2 through a distance of a_0 and released. Determine the equations of subsequent motion.	Applying	CBST004.17
7	A uniform string of length *l* fixed at its ends has a large initial tension. It is plucked at x = *l*/3 through a distance of a_0 and released. Determine the equations of subsequent motion.	Applying	CBST004.17
8	A uniform taut string of length *l* fixed at both ends has a large initial tension. It is struck in such a manner as to give an initial velocity to the string, which varies linearly from zero at the ends to V_0 at the centre. Determine the equations of subsequent motion.	Applying	CBST004.17
9	Derive the governing equation of flexural vibration of a beam with simply supported boundary conditions.	Applying	CBST004.17
10	Determine the frequency equation in transverse vibration for a uniform cantilever.	Applying	CBST004.17
Part - C (Problem Solving and Critical Thinking Questions)			
1	For a dynamic matrix A given below, calculate the mode shape vector and the eigen value of the first mode by Stodola method. $$A=\begin{bmatrix}1&1&1\\1&2&2\\1&2&3\end{bmatrix}$$	Analyze & evaluate	CBST004.16
2	For a three storey shear type structure as shown below the floor weight and the floor stiffness are given as follows: $W_1 = W_2 = W_3 = 490$ kN $k_1 = 50000$ kN/m, $k_2 = 45000$ kN/m, $k_3 = 40000$ kN/m. Calculate the mode shape vector and the eigen value of the first mode by Stodola method 	Analyze & evaluate	CBST004.16

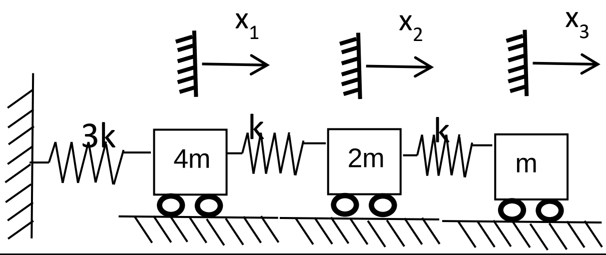
<table>
<tr><td>3</td><td>For a three storey shear type structure as shown below the floor weight and the floor stiffness are given as follows:
W_1 = W_2 = W_3 = 490 kN, k_1 = 50000 kN/m, k_2 = 45000 kN/m, k_3 = 40000 kN/m. Calculate the mode shape vector and the eigen value of the first mode by Holzer method.



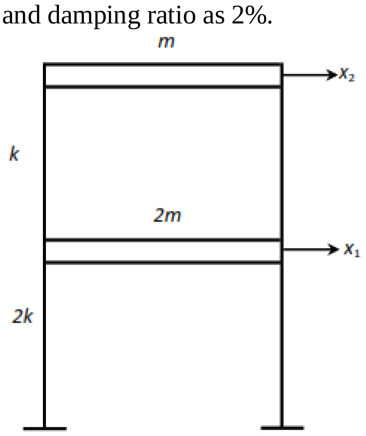
</td><td>Analyze & evaluate</td><td>CBST004.16</td></tr>
<tr><td>4</td><td>For the three degree of freedom system shown below, find the lowest natural frequency by Stodola's method.

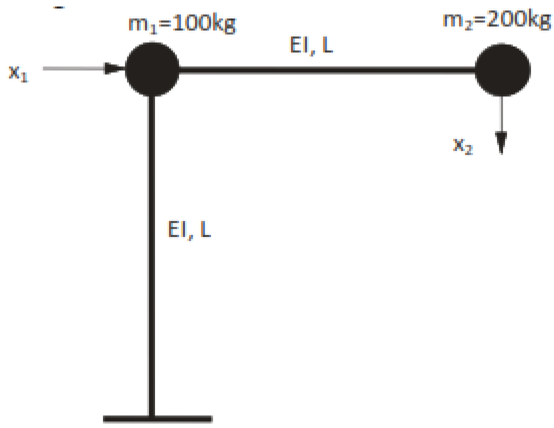


</td><td>Apply & evaluate</td><td>CBST004.17</td></tr>
<tr><td>5</td><td>For the three degree of freedom system shown below, find the lowest natural frequency by Holzer's method.



</td><td>Apply & evaluate</td><td>CBST004.17</td></tr>
<tr><td>6</td><td>A cantilever consists of a uniform bar of length l. At mid-point a force P which acts away from the fixed end is applied, and released at time t = 0, suddenly, Find the ensuing motion.</td><td>Analyze & evaluate</td><td>CBST004.17</td></tr>
<tr><td>7</td><td>A simply supported beam of length l is deflected by a force P applied at a point distance c from one end. Find the resulting transverse vibrations when the load is suddenly removed.</td><td>Analyze & evaluate</td><td>CBST004.17</td></tr>
<tr><td>8</td><td>Determine the frequency equation in transverse vibration for a free-free beam length l and having a uniform cross-section.</td><td>Analyze & evaluate</td><td>CBST004.17</td></tr>
<tr><td colspan="4" align="center">UNIT-V
EARTHQUAKE ANALYSIS</td></tr>
<tr><td colspan="4">Part - A (Short Answer Questions)</td></tr>
<tr><td>1</td><td>Give the differential equation of motion governing the undamped free vibrations of a single degree of freedom system subjected to base acceleration.</td><td>Remembering</td><td>CBST004.21</td></tr>
<tr><td>2</td><td>Give the differential equation of motion governing the damped free vibrations of a single degree of freedom system subjected to base acceleration.</td><td>Remembering</td><td>CBST004.21</td></tr>
</table>

3	Give the differential equation of motion governing the un-damped free vibrations of a three storey shear building subjected to base acceleration.	Remembering	CBST004.22
4	Give the differential equation of motion governing the damped free vibrations of a three storey shear building subjected to base acceleration.	Remembering	CBST004.22
5	Definezero period acceleration. What is its significance in Response Spectra Analysis?	Remembering	CBST004.22
6	Define response spectra. What does it signify?	Understanding	CBST004.22
7	What is the IS code used for seismic design? List out the IS code based methods for seismic design.	Remembering	CBST004.23
8	Definethe terms baseshear and base excitation.	Remembering	CBST004.23
Part - B (Long Answer Questions)			
1	Explain briefly the effectof earthquake on different types of structures.	Applying	CBST004.21
2	Discuss aboutthevertical irregularitiesthataffecttheperformanceof RC buildingsduringearthquake.	Applying	CBST004.21
3	Define Response spectra. Explain the conceptandtypesof response spectrawith neat sketch.	Applying	CBST004.22
4	Write the step by step procedure for seismic analysis of RC buildings as perIS1893:2002.	Applying	CBST004.23
5	Examine the plan configuration problems that affect the performanceof RC buildings duringearthquake.	Applying	CBST004.23
Part - C (Problem Solving and Critical Thinking Questions)			
1	Consider a SDOF system with mass, *m* = 2000 kg, stiffness, *k* = 60kN/m and damping, *c* = 0.44 kN.sec/m. Using the response spectra of El-Centro, 1940 earthquake, Compute (a) Maximum relative displacement, (b) Maximum base shear and (c) Maximum strain energy.	Applying	CBST004.21
2	Plot the pseudo acceleration response spectra for the earthquake acceleration expressed as $$\ddot{x}_g(t) = \ddot{x}_0 \sin(\bar{\omega} t) = 0.5g\ \sin(10t)$$	Applying	CBST004.21
3	Plot the pseudo acceleration response spectra of the ground motion given by $$\ddot{x}_g(t) = c_0 \delta(t-2)$$ where ‘d’ is Dirac delta function. Take duration of acceleration as 30 sec.	Applying	CBST004.21
4	A two-story building is modelled as 2-DOF system and rigid floors as shown in the Figure shown below. Determine the top floor maximum displacement and base shear due to El-Centro, 1940 earthquake ground motion using the response spectrum method. Take the inter-story stiffness, *k* =197.392 × 10^3 N/m and the floor mass, *m* = 2500 kg and damping ratio as 2%. 	Applying	CBST004.22

5	An industrial structure is modelled as 2-DOF system as shown in the Figure shown below. Determine the lateral displacement, base shear and base moment of the structure due to El-Centro, 1940earthquake ground motion using the response spectrum method. Take EI =80 × 10^3 Nm^2, L = 2 m, m_1= 100 kg; m_2= 200 kg.  	Applying	CBST004.23

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