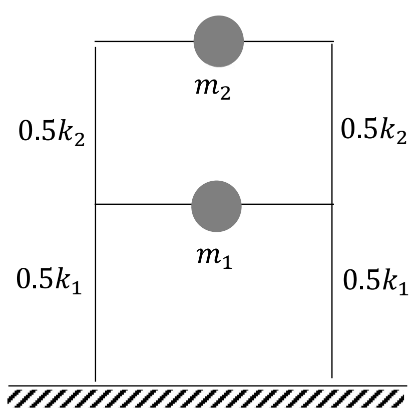
BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI
(END SEMESTER EXAMINATION)

CLASS: BTECH **SEMESTER: VI**
BRANCH: CIVIL AND ENVIRONMENTAL ENGINEERING **SESSION: SP/2025**

SUBJECT: CE412 STRUCTURAL DYNAMICS

TIME: 3 Hours **FULL MARKS: 50**

INSTRUCTIONS:
1. The question paper contains 5 questions each of 10 marks and total 50 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
4. Before attempting the question paper, be sure that you have got the correct question paper.
5. Tables/Data handbook/Graph paper etc. to be supplied to the candidates in the examination hall.

			CO	BL
Q.1(a)	Define degree of freedom and natural time period of a dynamic system. A SDOF system has the mass $m = 5\ kg$ and stiffness $k = 180\ N/m$. Determine the critical damping (C_{cr}) of the system. $\zeta = 1$	[5]	1	K1,K2,K3
Q.1(b)	Prove that the total energy (PE + KE) of an undamped SDOF system remains constant throughout the duration of oscillation.	[5]	1	K2
Q.2(a)	An under-damped SDOF system is subjected to harmonic excitation $P_0\ Sin(\omega_r t)$. The steady state displacement of the system is given by $$x(t) = \frac{P_0}{K\left[\left(1-\left(\frac{\omega_r}{\omega_n}\right)^2\right)^2 + \left(2\frac{\omega_r}{\omega_n}\zeta\right)^2\right]^{0.5}} Sin(\omega_r t - \phi)$$ Prove that the resonance frequency for displacement of the system is $\omega_r = \omega_n(1-2\zeta^2)^{0.5}$, where ω_n and ζ are the natural frequency and damping coefficient of the system respectively.	[5]	1	K2,K3
Q.2(b)	Discuss the half power band width method for determination of damping of a SDOF system.	[5]	2	K1,K2
Q.3(a)	What is Rayleigh Quotient? The matrix $A = \begin{bmatrix} 4 & -2 & 0 \\ -2 & 2 & -2 \\ 0 & -2 & 2 \end{bmatrix}$ has one Eigen vector $\phi = \begin{Bmatrix} -0.802 \\ -0.445 \\ 1.000 \end{Bmatrix}$. Determine the Eigen value (λ) corresponding to the Eigen vector ϕ	[5]	3	K1,K2,K3
Q.3(b)	Consider the matrix $A = \begin{bmatrix} 5 & -2 \\ -2 & 2 \end{bmatrix}$. Determine the Eigen values and Eigen Vectors of the matrix A^4	[5]	3	K2,K3,K4,K5
Q.4(a)		[10]	4	K3,K4,K5

Determine the base shear on the MDOF system as shown in the figure below by using response spectrum analysis. The properties of the MDOF is given as; $m_1 = 6000\ kg, m_2 = 4000\ kg, k_1 = k_2 = 12.0 \times 10^6 \frac{N}{m}$. Use the SRSS (square root of summation of square) combination rule for the modal superposition of the base shears. The response spectrum is given as

$$\frac{S_a}{g} = \begin{cases} 1 + 15T & for \quad 0 < T < 0.1\ s \\ 2.5 & for \quad 0.1\ s < T < 0.55\ s \\ \frac{1.36}{T} & for \quad 0.55\ s < T < 4.0\ s \\ 0.34 & for \quad T > 4.0\ s \end{cases}$$

Q.5(a) [10]

A damped SDF system has the following properties: $m = 0.2533$ kg, $k = 10$ N/m, and $\zeta = 0.05$. The SDF system is subjected to an external load of $P(t) = P_0 Sin\ (\bar{\omega}\ t);\ P_0 = 10\ kN, \bar{\omega} = 5.236 \frac{rad}{s}$. 5 K3,K4,K5

Determine the displacement ($u_{t=0.3}$) and velocity ($\dot{u}_{t=0.3\ s}$) of the SDF system at $t =\ 0.3\ s$. Use the central difference method with a time interval of $\Delta t = 0.1\ s$. The initial displacement and velocity are given as $u_{t=0} = 0$ and $\dot{u}_{t=0} = 0$.

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