INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

AERONAUTICAL ENGINEERING

QUESTION BANK

Course Title	**AEROSPACE STRUCTURAL DYNAMICS**				
Course Code	AAEC35				
Program	B.Tech				
Semester	VII	AE			
Course Type	Core				
Regulation	IARE	UG20			
Course Structure	Theory			Practical	
	Lecture	Tutorials	Credits	Laboratory	Credits
	3	1	4	-	-
Course Coordinator	Mr. K Arun Kumar, Assistant Professor				

COURSE OBJECTIVES:

The students will try to:

I	Formulate mathematical models of problems in vibrations using Newton's second law or energy principles.
II	Determine a complete solution to the modelled mechanical vibration problems.
III	design a mechanical system that has desirable vibrational behavior.
IV	Assess the underlying assumptions in the aeroelastic analysis of fixed wing and rotary wing aerospace vehicles/systems.

COURSE OUTCOMES:

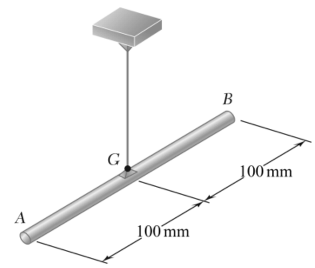
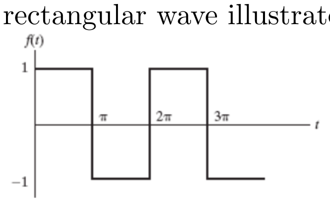
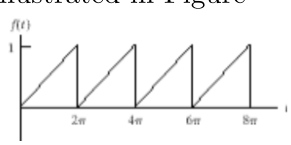
After successful completion of the course, students should be able to:

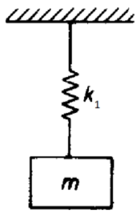
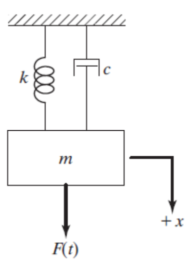
CO 1	**Apply** principles of mechanical vibrations such as Newton's second law, and the principle of conservation of energy to the mathematical models for obtaining their governing equations of motion.	Apply
CO 2	**Analyze** the mathematical modeling of the two degrees of freedom systems for determining the frequency of the spring-mass system.	Analyze
CO 3	**Solve** the natural frequencies and mode shapes of a multi degree of freedom system for the numerical solution of distributed parameter systems	Apply

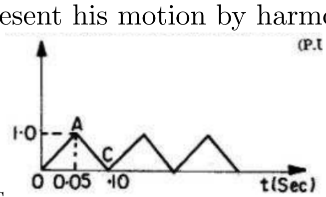
CO 4	**Apply** theoretical and numerical procedures for predicting the dynamic response of continuous structural systems under the most diverse loading conditions.	Apply
CO 5	**Formulate** the static aeroelasticity problems such as typical section and wing divergence problems; for their selection in real world applications.	Apply

QUESTION BANK:

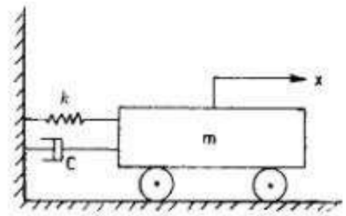
Q.No	QUESTION	Taxonomy	How does this subsume the level	CO's
		MODULE I		
		SINGLE-DEGREE-OF-FREEDOM LINEAR SYSTEMS		
		PART A-PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS		
1	A 2 kg block is supported as shown by a spring of constant k = 400 N/m, which can act in tension or compression. The block is in its equilibrium position when it is struck from below by a hammer, which imparts to the block an upward velocity of 2.5 m/s. Determine i) the time required for the block to move 100 mm upward, ii) the corresponding velocity and acceleration of the block	Apply	The learner will try to **recall** the function of spring-mass and then **explain** simplfy the frequency	CO 1
2	A block of mass 0.10kg is suspended from a spring having a stiffness of 25N/m. the block is displaced downwards from the equilibrium position through a distance of 2cm and released with an upward velocity of 3cm/sec. Determine (i) Natural Frequency (ii) Period of Oscillation (iii) Maximum Velocity (iv) Maximum Acceleration (v) Phase angle	Apply	The learner will try to **recall** damped and undamped frequency, Apply it in determining impulse	CO 1
3	Find the total response of a single degree of freedom system with mass= 10 kg, damping coefficient c= 20 N-s/m, Stiffness= 4000N/m, $x_0 = 0.001m$ and $\dot{x} = 0$ under an external force $F(t) = F_0 \cos \omega t$ acts on a system with $F_0 = 100N$ and $\omega = 10rad/s$	Apply	The learner will try to **recall** operation principle response of single degree of freedom.	CO 1

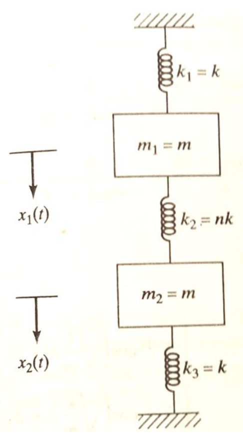
4	A 3-kg slender rod is suspended from a steel wire which is known to have a torsional spring constant K = 2 25 . N m/rad. If the rod is rotated through 180° about the vertical and released, determine (a) the period of oscillation, (b) the maximum velocity of end A of  the rod	Apply	The learner will try to **recall** the concept beams	CO 1
5	For a damped system, m, c, and k are known to be m = 1 kg, c = 2 kg/s, k = 10 N/m. Calculate the value of ζ and ωn. Is the system overdamped, underdamped, or critically damped?	Apply	The learner will try to **recall** the concept of response of single degree of freedom.	CO 1
6	Determine the Fourier series for the rectangular wave illustrated in Figure 	Apply	The learner will try to **recall** the response of single degree of freedom.	CO 1
7	Determine the Fourier series representation of the sawtooth curve illustrated in Figure 	Apply	The learner will try to **recall** the concepts of frequency and time period	CO 1
8	Solve the following system for the response x(t) using Laplace transforms: 100$\ddot{t}$ + 2000x(t) = 50δ(t) where the units are in Newtons and the initial conditions are both zero.	Apply	The learner will try to **recall** the concept beams	CO 1
9	Investigate the terms involved in the equations of motion of SDOF as given by $\ddot{x} + 3\dot{x} + 12x = 10\sin\omega t$	Apply	The learner will try to **recall** the concepts of frequency	CO 1

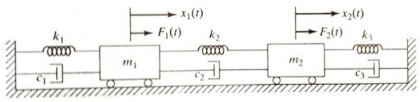
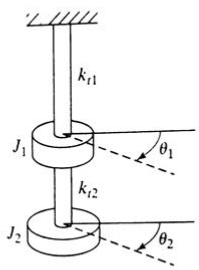
10	In a single degree damped vibrating system mass of 8kg makes 30 oscillations in 18 seconds. The amplitude decreases to 0.35 of the initial value after 5 oscillations. Determine the stifness of the spring, damping factor ζ and c	Apply	The learner will try to **recall** the concept of undamped frequency and critical damping	CO 1
11	A spring-mass system, k1 and m, has a natural frequency of f1. If a second spring k2 is added in series with the first spring, the natural frequency is lowered to 1/2 f1. Determine k2 in  terms of k1.	Apply	The learner will try to **recall** the concept of undamped frequency and critical damping	CO 1
	PART-B LONG ANSWER QUESTIONS			
1	Dervie the equation of motion for free vibration of an undamped system using Newton's second law of motion.	Apply	The learner will able to understand the concepts of free-undamped vibration.	CO 1
2	Derive the transfer function of a viscously damped single-degree-of-freedom system subjected to external force f(t) as shown in Fig. 	Apply	The learner will able to understand the concepts of undamped system under harmonic force.	CO 1
3	Discuss force-displacement relation for linearly elastic and inelastic systems	Apply	The learner will able to understand the concepts of damped system under harmonic force.	CO 1

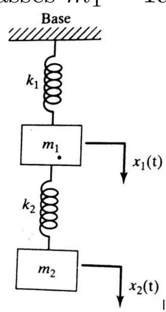
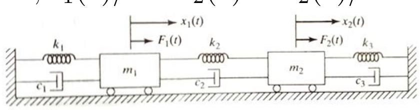
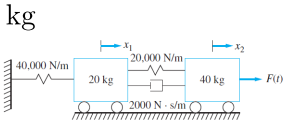
4	Derive expression for response of a SDOF system subjected to damped free vibration. Draw the plot showing response of the structure to damped free vibration explaining salient features involved.	Apply	The learner will try to **recall** operation principle response of single degree of freedom.	CO 1
5	Dervie the equation of motion of a spring-mass system in vertical position.	Apply	The learner will able to understand the concepts of free-undamped vibration.	CO 1
6	A harmonic motion is given by $x(t) = 10\sin(30t - \frac{\pi}{3})$ mm where tis in seconds and phase angle in radians. Find frequency and period of motion ii) Maximum displacement velocity and acceleration	Apply	The learner will try to understand the concept of impact excitation.	CO 1
7	Discuss the response to an impulse excitation of a single DOF vibrating body.	Apply	The learner will try to understand the concept of impulsive excitation.	CO 1
8	Derive the relation between logarithmic decrement and damping ratio. How is it useful in finding damping of a system?	Apply	The learner will try to **recall** the concepts under a periodic force of irregular form.	CO 1
9	Summarize the concepts of i) damping ratio and Critically damping constant and describe how damped systems are classified based on ddaamping ratio	Apply	The learner will able to understand the concepts of damped system under harmonic force.	CO 1
10	Dervie the equation of motion for free vibration of an undamped system using Principle of conservation of energy.	Apply	The learner will able to understand the concepts of free-undamped vibration.	CO 1
11	A periodic motion observed on the oscilloscope is illustrated in the figure Represent his motion by harmonic  series	Apply	The learner will able to understand the concepts of free-undamped vibration.	CO 1
12	What are the three elementary parts of a vibrating system?	Apply	The learner will able to understand the concepts of undamped system under harmonic force.	CO 1

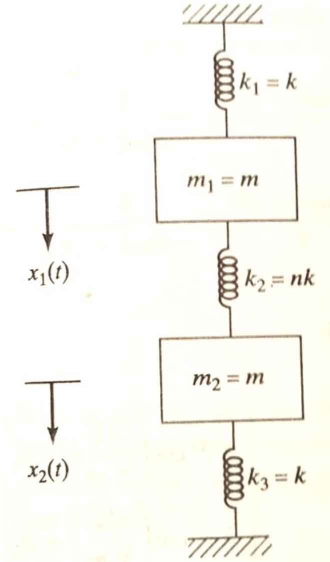
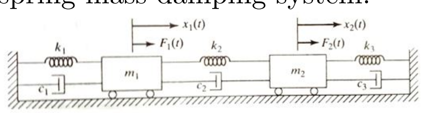
13	Consider a spring-mass system with k=4000N/m and m=10kg, with and subject to a harmonic force $F(t) = 400\cos 10t$ Find and plot the total response of the system under the following initial conditions: i) $x_0 = 0.1m, \dot{x_0} = 0m/s$ ii) $x_0 = 0m, \dot{x_0} = 10m/s$	Apply	The learner will able to understand the concepts of damped system under harmonic force.	CO 1
14	List four differences between the free vibrations of an underdamped system and a system with Coulomb damping.	Apply	The learner will try to **recall** operation principle response of single degree of freedom.	CO 1
15	Describe in detail the following terminologies w.r.t harmonic analysis. i) Cycle ii) Amplitude iii) Period of oscillation iv) Frequency of oscillation v) Phase angle vi) Natural frequency	Apply	The learner will able to understand the concepts of free-undamped vibration.	CO 1
16	Write a note on number of number of degrees of a vibrating system and illustrate three examples of single-degree-of-freedom systems, two degree-of-freedom systems and three -degree-of-freedom systems..	Apply	The learner will try to understand the concept of impact excitation.	CO 1
17	Interpret the following concepts with an example: i) Free and Forced Vibration ii) Undamped and Damped Vibration iii) Linear and Nonlinear Vibration iv)Deterministic and Random vibration	Apply	The learner will try to understand the concept of impulsive excitation.	CO 1
18	What is the difference between a discrete and a continuous system? How are the amplitude, frequency, and phase of a steady-state vibration related to those of the applied harmonic force for an undamped system?	Apply	The learner will try to **recall** the concepts under a periodic force of irregular form.	CO 1

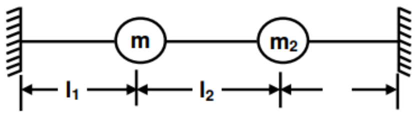
19	Find the equation of motion for the system shown in Figure when i) $\epsilon = 0.3$ ii) $\epsilon = 0.2$ iii) $\epsilon = 2.0$, if the mass m is displaced by a distance of 3cm and released. 	Apply	The learner will able to understand the concepts of damped system under harmonic force.	CO 1
20	Explain in detail variouus types of damping used in mechanical systems and write the displacement equations	Apply	The learner will able to understand the concepts of free-undamped vibration.	CO 1
PART-C SHORT ANSWER QUESTIONS				
1	What is Vibration?	Understand	The learner will try to **recall** the definition of vibration	CO 1
2	Define natural frequency. Why is it important ?	Remember		CO 1
3	Define Free vibrations.	Remember	–	CO 1
4	Define forced vibrations.	Remember	–	CO 1
5	Define Resonance with example.	Understand	The learner will try to recall basics of vibrations.	CO 1
6	Define damped vibrations.	Understand	The learner will try to understand the difference of damped and undamped.	CO 1
7	State the parameters corresponding to m, c, k, and x for a torsional system.	Remember		CO 1
8	What effect does a decrease in mass have on the frequency of a system?	Remember		CO 1
9	What effect does a decrease in the stiffness of the system have on the natural period?	Remember		CO 1
10	Why does the amplitude of free vibration gradually diminish in practical systems?	Remember		CO 1
11	Can the energy method be used to find the differential equation of motion of all singledegree- of-freedom systems?	Remember		CO 1

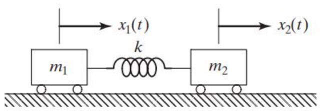
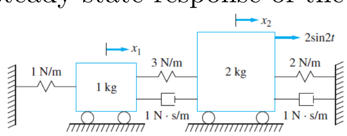
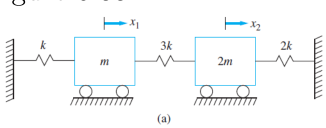
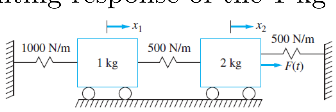
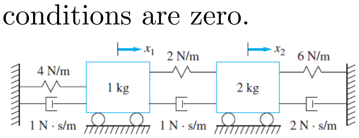
12	What assumptions are made in finding the natural frequency of a single-degree-offreedom system using the energy method?	Remember		CO 1
13	What methods are available for solving the governing equations of a vibration problem?	Remember		CO 1
14	How do you connect several springs to increase the overall stiffness?	Remember		CO 1
15	Define spring stiffness and damping constant.	Remember		CO 1
16	What are the common types of damping?	Remember		CO 1
17	State three different ways of expressing a periodic function in terms of its harmonics	Remember		CO 1
18	What will be the frequency of the applied force with respect to the natural frequency of the system if the magnification factor is less than unity?	Remember		CO 1
19	What happens to the response of an undamped system at resonance?	Remember		CO 1
20	What is the difference between the peak amplitude and the resonant amplitude?	Remember		CO 1
MODULE II				
TWO-DEGREE-OF-FREEDOM SYSTEMS				
PART-A PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS				
1	Find the natural frequencies and mode shapes of a spring-mass system, shown in Figure, which is constrained to move in the vertical direction only.  Take n=1	Apply	The learner will try to **recall** natural frequencies of spring-mass system.	CO 2

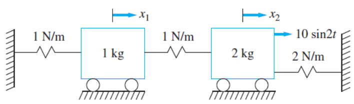
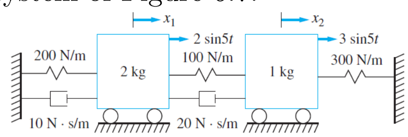
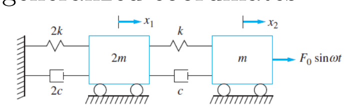
2	Find the free vibration response of the system shown in figure with $k_1 = 30, k_2 = 5, k_3 = 0, m_1 = 10, m_2 = 1, and c_1 = c_2 = c_3 = 0$ for the initial conditions $x_1(0) = 1, x_1(0)/t = x_2(0) = x_2(0)/t = 0$. 	Apply	The learner will try to **recall** the free vibration response of two DOF.	CO 2
3	Find the natural frequencies and mode shapes for the torsional system shown in figure for $J_1 = J_0 = 2J_0$, and  $k_{t1} = k_{t2} = k_t$.	Apply	The learner will try to **recall** the natural frequencies of a torsional system.	CO 2
4	Consider the two-degree-of-freedom system described by $\begin{Bmatrix} 1 & 0 \\ 0 & 1 \end{Bmatrix} \begin{Bmatrix} \ddot{x_1} \\ \ddot{x_2} \end{Bmatrix} + \begin{Bmatrix} 0 & 0 \\ 0 & c \end{Bmatrix} \begin{Bmatrix} \dot{x_1} \\ \dot{x_2} \end{Bmatrix} + \begin{Bmatrix} 2 & -1 \\ -1 & 2 \end{Bmatrix} \begin{Bmatrix} x_1 \\ x_2 \end{Bmatrix} = \begin{Bmatrix} f_0 \sin \omega t \\ 0 \end{Bmatrix}$ and calculate the transfer function —X/F— as a function of the damping parameter c.	Apply	The learner will try to **recall** the mode shape of a torsional system.	CO 2
5	Formulate the equation of motion for two degree of freedom system for damped free vibration.	Apply	The learner will try to **recall** the response under impulse using Laplace transform method.	CO 2

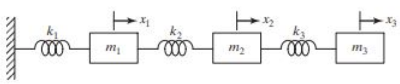
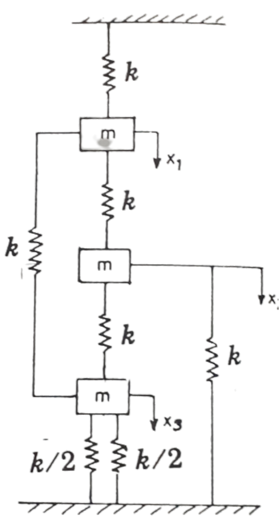
6	Find the natural frequencies of the system shown in figure, with $m_1 = m, m_2 = 2m, k_1 = k$, and $k_2 = 2k$. Determine the response of the system when k=1000 N/m, m=20kg, and the initial values of the displacement of the masses $m_1 = 1$and  $m_2 = -1$ respectively.	Apply	The learner will try to **recall** the response of spring-mass system	CO 2
7	Find the free vibration response of the spring-mass-damper system shown in figure with $k_1 = 40, k_2 = 10, k_3 = 2, m_1 = 9, m_2 = 12, and c_1 = 1, c_2 = c_3 = 0$ for the initial conditions $x_1(0) = 1.5, x_1(0)/t = x_2(0) = x_2(0)/t = 0.5$. 	Apply	The learner will try to **recall** the free vibration response of two DOF.	CO 2
8	The stiffness matrix and mass matrix of a two degree fredom system are given by K=$\begin{Bmatrix} 4 & 2 \\ 2 & 4 \end{Bmatrix}$ and m= $\begin{Bmatrix} 1 & 0 \\ 0 & 1 \end{Bmatrix}$ Determine the natural frequencies and modes of vibration normalized w.r.t matrix such that $x^T mx = 1$	Apply	The learner will try to apply the concepts of two DOF for practicle problems.	CO 2
9	Determine the transfer function for the 20 kg block of the system in Figure 6.10 due to a force applied to the 20 kg  block.	Apply	The learner will try to **recall** the response of spring-mass system	CO 2

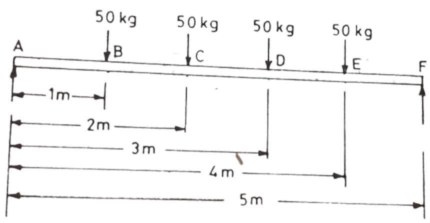
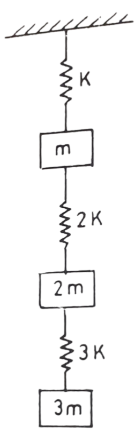
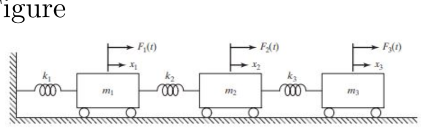
10	Find the natural frequencies of a spring-mass system, shown in Figure, for $k_1 = 300N/m, k_2 = 500N/m, k_3 = 200N/m, m_1 = 2kg$ and $m_2 = 1kg$. 	Apply	The learner will try to **recall** natural frequencies of spring-mass system.	CO 2
	PART-B LONG ANSWER QUESTIONS			
1	Derive the equation of motion for forced vibration of spring-mass-damping system. 	Apply	The learner will try to **recall** natural frequencies of spring-mass system.	CO 2
2	Derive the frequency equation for free vibration analysis of an undamped system.	Apply	The learner will able to **recall** the experssion of free vibration analysis of an undamped system.	CO 2
3	Derive equation of motion of multi degree freedom systems by (i) Newton's equation of motion (ii) Mass spring damper system (iii) Dynamic equilibrium	Apply	The learner will able to **recall** the experssion of free vibration analysis of an undamped system.	CO 2
4	Describe the experssions for the free vibrational analysis for torsional system.	Understand	The learner will try to **recall** the free vibrational analysis for torsional system.	CO 2

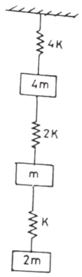
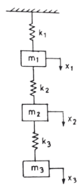
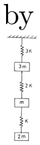
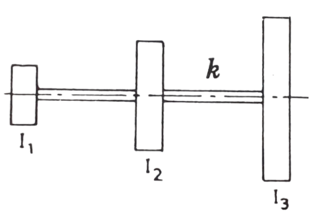
5	Derive the equation of motion of the system shown in Figure . Assume that the initial tension 'T' in the string is too large and remains constants for small amplitudes. Determine the natural frequencies, the ratio of amplitudes and locate the nodes for each mode of vibrations when m1 = m2 = m and l1= l2 = l3 = l. 	Apply	The learner will try to **recall** natural frequencies of spring-mass system.	CO 2
6	Derive the equation of motion for two degree of freedom under external forces.	Apply	The learner will try to **recall** the two degree of freedom under external forces.	CO 2
7	What is meant by static and dynamic coupling? How can you eliminate coupling of the equations of motion	Apply	The learner will try to apply the concepts of two DOF for practicle problems.	CO 2
8	The transfer function for one generalized coordinate of a two degree-of-freedom system is $G(s) = \dfrac{1}{s^4 + 3s^2 + 2}$ i) Calculate G(3i). ii) What are the natural frequencies of the system? iii) If this system were excited by a force equal to 5 sin3t, what is the steady-state response of the generalized coordinate?	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the transfer function for different mechanical systems	CO 2
9	Derive the frequency experssion for un-restrained systems with diagram.	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 2

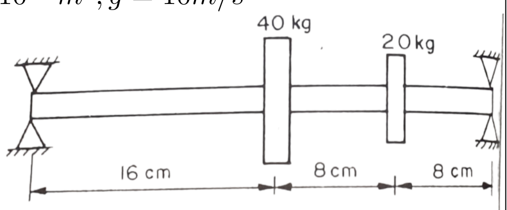
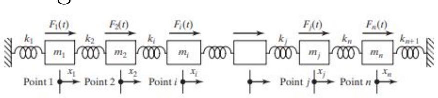
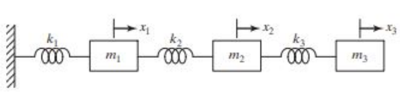
10	Find the free-vibration solution of the unrestrained system shown in figure for the following data: $k = 200N/m, m_1 = 1kg, m_2 = 2kg, and c_1 = 1, c_2 = c_3 = 0$ for the initial conditions $x_1(0) = 0.1m, x_2(0)/t = x_2(0)/t = 0.$.  	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 2
11	The two degree-of-freedom system shown in Figure 6.34 is subject to the periodic force shown. Determine the steady-state response of the system.  	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 2
12	Determine the natural frequencies and mode shapes for the two degree-of-freedom system shown in Figure 6.33.  	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 2
13	The system of Figure 6.9 is at rest in equilibrium when a unit impulse is applied to the 2 kg block. Determine the resulting response of the 1 kg  block.	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 2
14	Determine the response of the system of Figure 6.5 when using x_1 and x_2 as generalized coordinates when $\dot{x_2} - 2m/s$ and all other initial conditions are zero.  	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 2

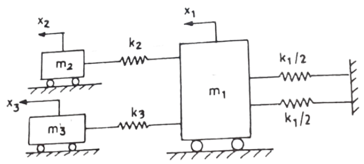
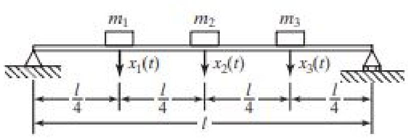
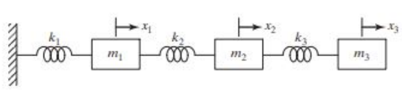
15	Consider the two degree-of-freedom system of Figure 6.6. Determine the steady-state response of the system. 	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 2
16	Find the steady-state response for the system of Figure 6.7. 	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 2
17	Derive the differential equations governing the damped two degree-of-freedom system shown in Figure P6.6 using x1 and x2 as generalized coordinates 	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 2
PART-C SHORT ANSWER QUESTIONS				
1	Define the two DOF with suitable figure.	Remember	–	CO 2
2	Define semidefinite systems with example.	Remember	–	CO 2
3	What are static couplings?	Remember	–	CO 2
4	Define generlized coordinates in vibration.	Remember	–	CO 2
5	Define Principal coordinates.	Remember	–	CO 2
6	What are dynamic couplings?	Remember	–	CO 2
7	Write a short note on torsional vibration for two DOF with example.	Remember	–	CO 2
8	Define elasticity coupling.	Remember	–	CO 2
9	Define the sinusoidal transfer function.	Remember	–	CO 2
10	Write the differential equations for the principal coordinates of free undamped vibrations of a two degree-of-freedom system with natural frequencies $\omega 1$ and $\omega 2$.	Remember	–	CO 2

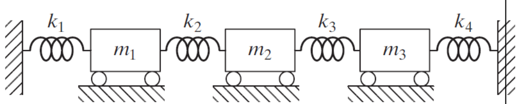
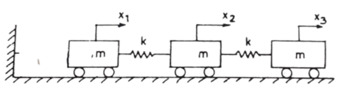
11	A two degree-of-freedom system has a mode with a modal fraction equal to zero. What does this imply?	Remember	–	CO 2
12	A two degree-of-freedom system has a mode with a modal fraction equal to one. What does this imply?	Remember	–	CO 2
13	How many nodes are there for the mode corresponding to the lowest natural frequency of a two degree-of-freedom system?	Remember	–	CO 2
MODULE III				
MULTI-DEGREE-OF-FREEDOM LINEAR SYSTEMS				
PART A-PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS				
1	The vibrations of a cantilever are given by $y = y_l(1 - \cos\frac{\pi x}{2l})$ Calculate the frequency with the following data for the cantilever using Rayleigh method. Modulus of amterial is $2 \times 10^{11} n?m^2$ Second moment of inertia about bending axis is $0.02m^4$ $Mass = 6 \times 10^4 kg\ length = 30m$ 	Apply	The learner will try to **recall** the concepts of stiffness influence coefficients.	CO 3
2	Determine the naatural frequency of multidegree of freedom spring mass system shown in figure 	Apply	The learner will try to **recall** the concepts of flexibility influence coefficients.	CO 3

<table>
<tr><td>3</td><td>A shaft of negligable weight 6cm diasmeter and 5m long is simply supported at the ends and carries four weights 50kg each at equal distance over the length of the shaft. Find the frequency of vibrations using Dunkerly method. Take $E = 2 \times 10^6 kg/cm^2$

</td><td>Apply</td><td>The learner will try to recall the concepts of flexibility influence coefficients.</td><td>CO 3</td></tr>
<tr><td>4</td><td>Find the natural frequency of transverse vibrations for a uniformly distributed system shown in Figure using Dunkerly method

</td><td>Apply</td><td>The learner will try to recall the concepts of inertia influence coefficients.</td><td>CO 3</td></tr>
<tr><td>5</td><td>Find the natural frequency and mode shapes by using influence coefficients for the mechanical system shown in Figure

</td><td>Apply</td><td>The learner will try to recall the working principle and classification of engine cycles and then explain the differences between them and then compare their merits</td><td>CO 4</td></tr>
</table>

6	Find the natural frequency of vibration for the system shown in figure by Rayleigh method. 	Apply	The learner will try to **recall** the concept of Mono propellant and Bi propellant and then **explain**s the advantages over the other	CO 4
7	Write equations of motion and determine first mode shape of the system given in Figure using eigen values and eigen vectors 	Apply	The learner will try to apply the concepts of two DOF for practicle problems.	CO6
8	Find the natural frequency of the spring mass system shown in Figure by matrix method 	Apply	The learner will try to **recall** the natural frequencies of a torsional system.	CO 4
9	A steel shaft of diameter 10cm is carrying three masses 5kg, 7.5kg and 14kg respectively. The distances between the rotors are 0.70m. Determine the natural frequencies of torsional vibrations. The radius of gyrations of three rotors are 0.20, 0.20, 0.40. Take $G = 9 \times 10^8 N/m^2$ 	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 4

10	Find the free-vibration solution of the unrestrained system shown in figure for the following data: $k = 200N/m, m_1 = 1kg, m_2 = 2kg, and c_1 = 1, c_2 = c_3 = 0$ for the initial conditions $x_1(0) = 0.1m, x_2(0)/t = x_2(0)/t = 0.$.	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 4
PART-B LONG ANSWER QUESTIONS				
1	Discuss the procedure that can be adopted to derive the equation of motion of a multi degree of freedom.	Understand	The learner will try to **recall** concepts of multi degree of freedom.	CO 3
2	Estimate the lowest natural frequency transverse vibration for the system shown in Figure by using Rayleigh method. Take $E - 2 \times 10^{11} N/m^2, I = 10^{-6} m^4, g = 10m/s^2$ 	Apply	The learner will try to **recall** concepts of stiffness matrix.	CO 3
3	Dervie the equation of motion of the spring-mass-damper system shown in the figure. 	Apply	The learner will try to understand the derivation of multi DOF.	CO 4
4	What are the aspects that influence the stiffness coefficients for multi degree vibrating system?	Apply	The learner will try to identify the influence factors of stiffness.	CO 4
5	What are the aspects that influence the flexibility coefficients for multi degree vibrating system?	Apply	The learner will try to identify the influence factors of flexibility.	CO 4
6	An undamped vibration pickup having a natural frequency of 1Hz is used to measure a harmonic vibration of 4Hz. If the amplitude recorded is 0.52mm, what is the correct amplitude?	Apply	The learner will try to **recall** the concept of Mono propellant and Bi propellant and then **explain**s the advantages over the other	CO 4
1	Find the stiffness influence coefficients of the system shown in the figure. 	Apply	The learner will try to **recall** the concepts of stiffness influence coefficients.	CO 3

8	Find the lowest natural frequency of the mechanical system shown in Figure 	Apply	The learner will try to **recall** the natural frequencies of a torsional system.	CO 4
9	Derive the frequency experssion for un-restrained systems with diagram.	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 4
10	Find the free-vibration solution of the unrestrained system shown in figure for the following data: $k = 200N/m, m_1 = 1kg, m_2 = 2kg, andc_1 = 1, c_2 = c_3 = 0$ for the initial conditions $x_1(0) = 0.1m, x_2(0)/t = x_2(0)/t = 0$..	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 4
11	Derive the flexibility matrix of the weightless beam shown in Figure. The beam is simply supported at both ends, and the three masses are placed at equal intervals. Assume the beam to be uniform with stiffness EI. 	Apply	The learner will try to **recall** the natural frequencies of a torsional system.	CO 4
12	Find the flexibility coefficients influence coefficients of the system shown in the figure. 	Apply	The learner will try to **recall** the natural frequencies of a torsional system.	CO 4
13	Explain the coupling of coordinates in MDOF system. How will you obtain the type of coupling present by the help of matrices and energy expressions	Apply	The learner will try to **recall** the natural frequencies of a torsional system.	CO 4

14	Find the equations of motion of a multidegree-of-freedom system in matrix form using a. the flexibility matrix and b. the stiffness matrix.	Apply	The learner will try to **recall** the natural frequencies of a torsional system.	CO 4
15	Determine the eigenvalues and eigenvectors of the system shown in Fig. 6.29, taking $k_1 = k_2 = k_3 = k_4 = k$, $m_1 = 2m\ m_2 = 3m\ m_3 = 5m$ 	Apply	The learner will try to **recall** the natural frequencies of a torsional system.	CO 4
16	Three rail bogies are connected by two springs of stiffness $40 \times 10^6 n/m$ each. The mass of each bogey is $20 \times 10^3 kg$ Determine the frequecies of vibration Neglect wheels and rails 	Apply	The learner will try to **recall** the natural frequencies of a torsional system.	CO 4
PART-C SHORT ANSWER QUESTIONS				
1	Define multi degree of freedom with example.	Remember	–	CO 3
2	Define unrestrained systems.	Remember	–	CO 3
3	Write short notes on modal analysis.	Remember	–	CO 3
4	What is a mode shape?	Remember	–	CO 3
5	Write the steps to derive the equation of motion of multi DOF system using Newton's second law.	Remember	–	CO 3
6	What is the need for vibration measuring instruments?	Remember	–	CO 3
7	Draw the sketch of a seismic instrument and label the parts.	Remember	–	CO 3
8	State Lagrange s equations.		–	CO 2
9	What is an eigenvalue problem?		–	CO 2
10	What is a mode shape? How is it computed?		–	CO 2
11	How many distinct natural frequencies can exist for an n-degree-of-freedom system?		–	CO 2
12	What is a dynamical matrix? What is its use?		–	CO 2

13	How is the frequency equation derived for a multidegree-of-freedom system?		–	CO 2
14	What is meant by the orthogonality of normal modes? What are orthonormal modal vectors?		–	CO 2
15	What is a basis in n-dimensional space?		–	CO 2
16	What is the expansion theorem? What is its importance?		–	CO 2
17	Explain the modal analysis proceduce.		–	CO 2
18	What is a rigid-body mode? How is it determined?		–	CO 2
19	What is a degenerate system?		–	CO 2
20	How can we find the response of a multidegree-of-freedom system using the first few modes only?		–	CO 2
21	Define Rayleigh s dissipation function.		–	CO 2
22	Define these terms: proportional damping, modal damping ratio, modal participation factor.		–	CO 2
23	When do we get complex eigenvalues?		–	CO 2
24	What is the difference between generalized coordinates and Cartesian coordinates?		–	CO 2
MODULE IV				
DYNAMICS OF CONTINUOUS ELASTIC BODIES				
PART A- PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS				
1	Explain the consequences of misalignment and pre loaded shafts on the performance of the machine assembly with plots.	Analyze	The learner will try to **recall** RCS and payload fraction and **explain**s its importance and application of RCS	CO 5
2	Explain the procedure to find out natural frequency of vibrations by Dunker leys method for simple supported beam subjected to three point loads at equidistance along the span	Analyze	The learner will try to **recall** the importance of staging of rocket and then **explain**s the different mechanism's that are used for staging of rocket	CO 5

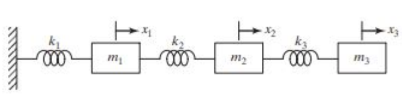
3	A shaft of negligible weight 6 cm diameter and 5 meters long is simply supported at the ends and carries four weights 50 kg each at equal distance over the length of the shaft as shown in Figure. Find the frequency of vibration by Dunkerley's method. Take E = 2 x 106 kg / cm2 if the ends of the fixed.	Analyze	The learner will try to **recall** the importance of staging of rocket and then **explain** the concept of rocket dispersion	CO 5
4	What conclusion can be drawn during condition monitoring of mechanical systems using failure mode analysis? and **explain** the function of gyroscope and accelerometer	Analyze	The learner will try to **recall** the concept of Inertial guidance systems and **explain** the working of gyroscope and accelerometer in	CO 5
5	Explain different types of data acquisition systems with compression to merits and demerits of each other.	Analyze	The learner will try to **recall** the concept of Wing configuration of missile and then **explain** the concept of wing and canard configuration with a neat sketch	CO 5
6	Explain signature analysis of a mechanical system subjected to forced vibration.	Analyze	The learner will try to **recall** the importance of staging of rocket and then **explain**s the advantages of multi-staging over a single stage rocket	CO 5
7	Root cause analysis is very essential for introducing to implement using fishbone chart. Explain.	Analyze	The learner will try to **recall** the concept of Wing configuration of missile and then **explain**s the concept of wing and canard configuration with a neat sketch	CO 5
8	Turbo engine connected to a propeller through gears shown in figure. The mass moments of inertia of the flywheel, engine, gear 1, gear 2 and the propeller are 10000, 1500, 200, and 2500 $(kg - m^2)$ respectively. Find the natural frequencies of the system in torsional vibration.	Apply	The learner will try to **recall** the natural frequencies of a torsional system.	CO 5

9	Derive the frequency experssion for un-restrained systems with diagram.	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 5
10	Find the free-vibration solution of the unrestrained system shown in figure for the following data: $k = 200N/m, m_1 = 1kg, m_2 = 2kg, andc_1 = 1, c_2 = c_3 = 0$ for the initial conditions $x_1(0) = 0.1m, x_2(0)/t = x_2(0)/t = 0$..	Apply	The learner will try to recall the concept of natural frequency and understand the equations of motion for MDOF and determine the the natural frequency for different mechanical systems	CO 5
PART-B LONG ANSWER QUESTIONS				
1	Explain trending analysis.	Understand	The learner will try to **recall** the concept of Wing configuration of missile and then **explain** the concept of wing and canard configuration with a neat sketch	CO 5
2	Explain failure node analysis.	Understand	The learner will try to **recall** the concept of wing aerodynamics and then **explain** the concept of upwash and downwash with neat sketches	CO 5
3	Explain root cause analysis.	Understand	The learner will try to **recall** the concept of guidance systems in rocket and missiles and **explain** the purpose of using the guidance system	CO 5
4	Explain signature analysis.	Understand	The learner will try to **recall** the operation of missile and then **explain** guidance phases of missiles	CO 5
5	Explain machine monitoring parameters.	Understand	The learner will try to **recall** the concept of guidance systems in rocket and missiles and **explain** the classification with neat sketches	CO 5

6	Explain vibration data acquisition.	Understand	The learner will try to **recall** the working principle of homing guidance systems and then **explain** the different homing guidance systems	CO 5
7	Explain briefly frequency domain analysis.	Understand	The learner will try to **recall** the importance of staging of rocket and then **explain**s the advantages of parallel staging over tandem staging	CO 5
8	Explain bode plots for amplitude and phase to represent the seismic and accelerometer range.	Remember	–	CO 5
9	Explain what is a seismic Instrument and frequency range?	Understand	The learner will try to **recall** the importance of staging of rocket and then **explain**s the vehicle optimization procedure for an launch vehicle	CO 5
10	Explain what is the advantage of experimental modes Analysis?	Understand	The learner will try to **recall** the concept of multistage rocket and then **explain** its parameters	CO 5
PART-C SHORT ANSWER QUESTIONS				
1	Why vibration analysis is important to monitor the condition of machine?	Remember	—	CO 5
2	Write a short note on fast Fourier transform Theory?	Understand	—	CO 5
3	What is complex fast Fourier transform theory	Remember	—	CO 5
4	Name some signal measurement and display units?	Remember	—	CO 5
5	Name few vibration and acoustic measurement sensors.	Remember	—	CO 5
6	Name sources of vibrations in mechanical systems.	Remember	—	CO 5
7	Explain the vibration phenomenon due to mechanical motion and force.	Remember	—	CO 5
8	Explain flow induced vibrations in mechanical systems.	Remember	—	CO 5
9	Write a short note on computer based instrumentation system.	Remember	–	CO 5

10	State three methods of representing frequency response data.	Remember	—	CO 5
MODULE V				
INTRODUCTION TO AEROELASTICITY				
PART A-PROBLEM SOLVING AND CRITICAL THINKING QUESTIONS)				
1	A steel wire of 2 mm diameter is fixed between two points located 2 m apart. The tensile force in the wire is 250N. Determine the fundamental natural frequency and the velocity of wave propagation in the wire.	Understand	—	CO 5
2	Find first natural frequency and modal vector of the system shown in the Fig. using Matrix iteration method. Use flexibility influence coefficient.	Understand	The learner will try to **recall** materials of SRM and then **explain** the mechanical and chemical properties of these materials	CO 5
3	Find the fundamental natural frequency and modal vector of a vibratory system shown in Fig. using Stodola's method.	Understand	The learner will try to summarize various performance parameters and **explain** various evaluation techniques	CO 5
4	When one end is fixed and other end in free derive from the first principles for obtaining natural frequency using Collar's method.	Analyze	The learner will try to **recall** the classification of solid rocket motor and then **explain** various loads acting on it.	CO 5
5	A cord of length l is made to vibrate in a viscous medium. Derive the equation of motion considering the viscous damping force.	Analyze	The learner will try to **recall** materials of liquid rocket engine and then **explain** the mechanical and chemical properties of these materials	CO 5
6	Explain vibration data acquisition.	Understand	The learner will try to **recall** the working principle of homing guidance systems and then **explain** the different homing guidance systems	CO 5
7	Explain briefly frequency domain analysis.	Understand	The learner will try to **recall** the importance of staging of rocket and then **explain**s the advantages of parallel staging over tandem staging	CO 5
8	Explain bode plots for amplitude and phase to represent the seismic and accelerometer range.	Remember	–	CO 5

9	Explain what is a seismic Instrument and frequency range?	Understand	The learner will try to **recall** the importance of staging of rocket and then **explain**s the vehicle optimization procedure for an launch vehicle	CO 5
10	Explain what is the advantage of experimental modes Analysis?	Understand	The learner will try to **recall** the concept of multistage rocket and then **explain** its parameters	CO 5
PART-B LONG ANSWER QUESTIONS				
1	Find the natural frequencies and the free vibration solution of a bar fixed at one end and free at the other.	Understand	The learner will try to **recall** the concept of composite materials and then **explain** the fiber wound reinforced plastic along with its properties	CO 5
2	Determine the natural frequencies of vibration of a uniform beam fixed at x=0 and simply supported at x=l.	Understand	The learner will try to **recall** the material selection in combustion chamber of SRM to withstand high temperatures and pressures	CO 5
3	Explain the Rayleigh Ritz method for vibration analysis?	Understand	The learner will try to **recall** the material selection in missiles and then **explain** the desirable properties of ceramic materials w.r.t missiles	CO 5
4	Find the natural frequencies of the tapered cantilever beam by using Rayleigh-Ritz method.	Analyze	The learner will try to **recall** materials used in aerospace and then **explain** the importance of structural properties	CO 5
5	Find the time it takes for a transverse wave to travel along a transmission line from one tower to another one 300 m away. Assume the horizontal component of the cable tension as 30,000N and the mass of the cable as 2Kg/m of length.	Analyze	The learner will try to **recall** materials for combustion chamber and **explain** the materials used in combustion chamber along with its properties	CO 5

6	Find the lowest natural frequency of transverse vibrations of the system shown in Fig. by holzer's method. E=196 GPa, I=10-6 m4, m1=40 kg, m2=20 kg	Analyze	The learner will try to **recall** materials for various rocket components and then **explain** the properties of these materials	CO 5
7	With suitable assumptions derive the Rayleigh's equation for determining the fundamental natural frequency of a multi mass system.	Analyze	The learner will try to **recall** the importance and the need of rocket testing	CO 5
8	Explain stodola's method to estimate the natural frequency and mode shapes of multi degree freedom system.	Analyze	The learner will try to **recall** materials used in aerospace and then **explain** the performance parameters and its selection criteria.	CO 5
9	Explain what is a seismic Instrument and frequency range?	Understand	The learner will try to **recall** the importance of staging of rocket and then **explain**s the vehicle optimization procedure for an launch vehicle	CO 5
10	Explain what is the advantage of experimental modes Analysis?	Understand	The learner will try to **recall** the concept of multistage rocket and then **explain** its parameters	CO 5
PART-C SHORT ANSWER QUESTIONS				
1	Write short notes on Stodola's method.	Remember	—	CO 5
2	Write short notes on Rayleigh-ritz method.	Remember	—	CO 5
3	Write short notes on Holzer's method.	Remember	—	CO 5
4	Write short notes on matrix iteration method.	Remember	—	CO 5
5	Which numerical method is particularly used for torsional vibrations of shafts?	Remember	—	CO 5
6	Which method is used to determine fundamental natural frequency of free undamped vibrating systems?	Remember		CO 5
7	Find the stiffness influence coefficients of the system shown in the figure. 	Apply	The learner will try to **recall** the concepts of stiffness influence coefficients.	CO 3

8	Write a short note on sweeping technique.	Remember	–	CO 5
9	Which method is most commonly used for determining fundamental frequency when the system me end in free and other end in fixed.	Understand	The learner will try to **recall** the various testing methods that are to be conducted before launching the rocket	CO 5
10	For solving beam problems, which numerical method is applied?	Understand	-	CO 5

Course Coordinator: **HOD, AE**

Mr. K Arun Kumar, Assistant Professor