INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

TUTORIAL QUESTION BANK

Course Title	MECHANICAL VIBRATIONS				
Course Code	AME524				
Programme	B.Tech				
Semester	VII	ME			
Course Type	Elective				
Regulation	**IARE - R16**				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Mr. VVSH Prasad, Associate Professor.				
Course Faculty	Mr. VVSH Prasad, Associate Professor.				

COURSE OBJECTIVES:

I	Understand basic concepts of mechanical vibrations and phenomena of transmissibility.
II	Analyze mechanical systems with or without damping for single and multi degrees of freedom environment.
III	Application of vibration measuring instruments and machine monitoring systems.
IV	Develop competency in analytical methods in solving problems of vibrations along with mode shapes.

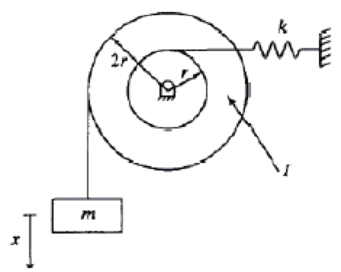
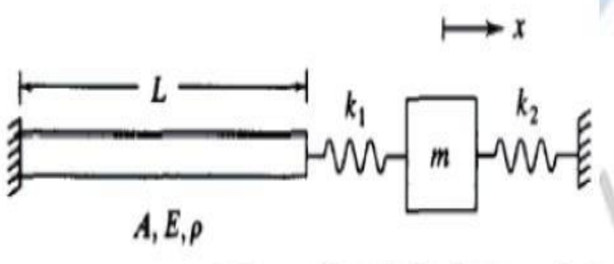
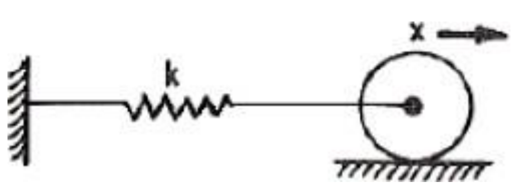
COURSE OUTCOMES (COs):

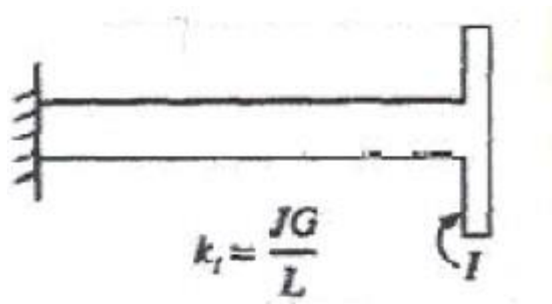
CO1	Understand the equations of motion of single degree of freedom systems.
CO2	Understand the equations of motion of two degree of freedom systems.
CO3	Understand the equations of motion of multi degree of freedom systems.
CO4	Explore the concept of frequency domain of vibration analysis.
CO5	Explore the natural frequencies by using numerical methods.

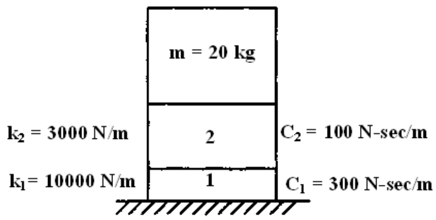
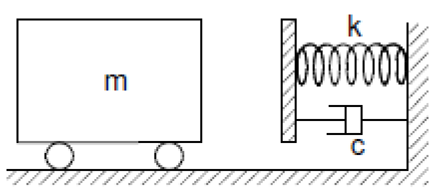
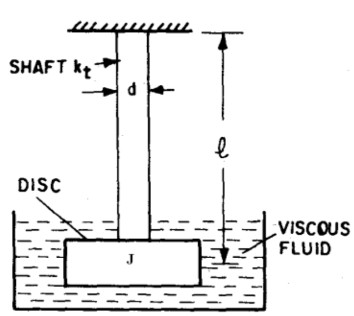
COURSE LEARNING OUTCOMES:

AME524.01	Understand the degree of freedom of systems.
AME524.02	Understand the simple harmonic motion of various systems.
AME524.03	Understand the undamped and damped free vibrations.
AME524.04	Understand the forced vibrations and columb damping.
AME524.05	Understand the vibration isolation and transmissibility.
AME524.06	Compute the natural frequency of single degree of freedom systems.
AME524.07	Understand the non periodic excitations.
AME524.08	Understand the two degree of freedom systems.
AME524.09	Determine the mode shapes of two degree of freedom systems.
AME524.10	Understand the multi degree of freedom systems.
AME524.11	Determine the Eigen values.
AME524.12	Determine the normal modes and their properties.
AME524.13	Determine the free and forced vibration by Modal analysis.
AME524.14	Understand the vibration measuring instruments.
AME524.15	Understand the frequency domain vibration analysis.
AME524.16	Understand the trending analysis of various systems.
AME524.17	Understand the Raleigh‟s method of multi degree of freedom system.
AME524.18	Understand the matrix iteration method of multi degree of freedom system.
AME524.19	Understand the Raleigh‟s Ritz method of multi degree of freedom system.
AME524.20	Understand the Holzerd‟s method of multi degree of freedom system.

UNIT – I				
SINGLE DEGREE OF FREEDOM SYSTEMS				
PART - A (SHORT ANSWER QUESTIONS)				
S No	**QUESTION**	**Blooms Taxonomy Level**	**Course Outcomes**	**Course Learning Outcomes**
1	What is Vibration?	Remember	CO1	AME524.01
2	Define natural frequency. Why is it important to determine the natural frequency of a vibrating system?	Understand	CO1	AME524.01
3	Define the following terms: Free, undamped, damped and forced vibrations.	Understand	CO1	AME524.01
4	Define the following terms: Resonance, phase difference, periodic motion, time period, amplitude and degree of freedom.	Understand	CO1	AME524.01
5	Distinguish between free and forced vibrations	Understand	CO1	AME524.01
6	Distinguish between damped and undamped vibrations	Remember	CO1	AME524.01
7	Distinguish between Rectilinear and torsional system	Remember	CO1	AME524.01
8	What are the various elements of a vibratory system?	Remember	CO1	AME524.01
9	Define longitudinal, transverse and torsional vibrations.	Remember	CO1	AME524.02
10	What is Forced Vibration? Give one example	Remember	CO1	AME524.03
11	Write equation of motion for simple vibration system	Understand	CO1	AME524.02
12	What is damping ratio?	Remember	CO1	AME524.2
13	Define damping	Remember	CO1	AME524.01
14	What is the difference between a vibration isolator and a vibration absorber?	Remember	CO1	AME524.01
15	What is the function of a vibration isolator?	Remember	CO1	AME524.01
16	What is a vibration absorber?	Remember	CO1	AME524.01
17	Define the transmissibility. Write the expression for motion transmissibility	Remember	CO1	AME524.01
18	What happens to the response of an undamped system at resonance?	Understand	CO1	AME524.01
19	What is meant by logarithmic decrement?	Remember	CO1	AME524.01
20	Define the term magnification factor	Remember	CO1	AME524.01
21	Indicate some methods for finding the response of a system under non periodic forces.	Remember	CO1	AME524.02
22	What is a response spectrum? And what are engineering applications?	Remember	CO1	AME524.03
23	How is the Laplace transformation of a function x(t) defined and advantages of this transformation method.	Understand	CO1	AME524.02
24	Define unit impulse, unit step and unit ramp functions?	Remember	CO1	AME524.01
Part - B (Long Answer Questions)				
1	Discuss the response of under damped , critically damped and over damped systems using respective response equations and curves	Remember	CO1	AME524.01
2	A machine part of mass 2.5Kg vibrates in a viscous medium. A harmonic exiting force of 30N acts on the part and causes resonant amplitude of 14mm with a period of 0.22 sec. Find the damping coefficient if the frequency of the exciting force is changed to 4Hz. Determine the increase in the amplitude of forced vibration upon removal of the damper.	Understand	CO1	AME524.01
3	A damped system has following elements: Mass = 4 kg; k = 1 kN/m; C = 40 N-sec/m. Determine: (a) Damping factor & natural frequency of damped oscillation. (b) Logarithmic decrement and number of cycles after which the original amplitude is reduced to 20.	Remember	CO1	AME524.01
4	In a particular case of a large canon, the gun barrel and recoil mechanism have a mass of 500kg with recoil spring stiffness	Understand	CO1	AME524.01

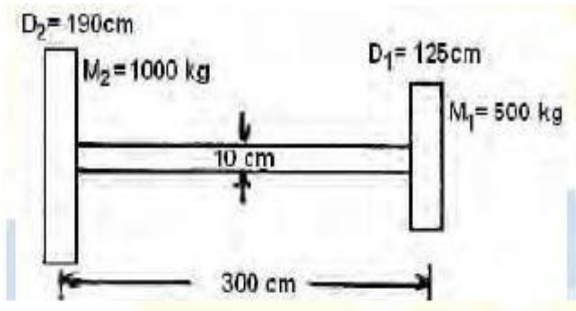
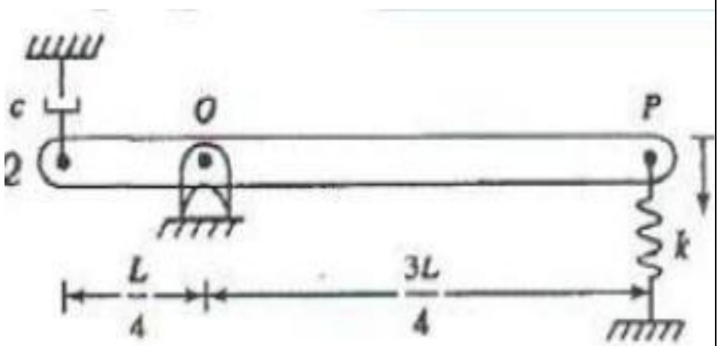
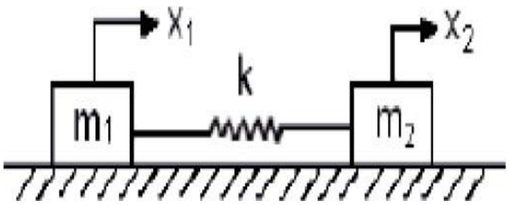
	10,000N/m. The gun recoils 0.4m upon firing. Find i) Critical damping co efficient of the damper. (ii) Initial recoil velocity of the gun.			
5	Derive an expression for the transmissibility and transmitted force for a spring - mass-damper system subjected to external excitation. Draw the vector diagram for the forces.	Understand	CO1	AME524.01
6	A metal block, placed on a rough surface, is attached to a spring and is given an initial displacement of 10cmfrom its equilibrium position. After five cycles of oscillation in 2s, the final position of the metal block found to be 1cm from its equilibrium positions. Find the coefficient of friction between the surface and the metal block.	Remember	CO1	AME524.01
7	Determine the frequency of oscillations for the system shown in fig. Also determine the time period if m = 4 kg and r = 80 mm 	Remember	CO1	AME524.02
8	.Find the equivalent stiffness, frequency and time period for the system shown in figure below. If K_1=200 N/m, K_2= 100N/m, m= 20Kg, L= 2000mm, A= 100m^2, density is 7200kg/mm^3 	Remember	CO1	AME524.03
9	A circular cylinder of mass m and radius r is connected by a spring of stiffness k as shown in fig. If it is free to roll on the rough surface which is horizontal without slipping, determine the natural frequency. 	Remember	CO1	AME524.02

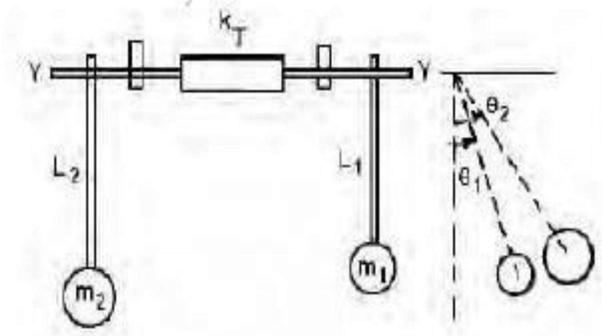
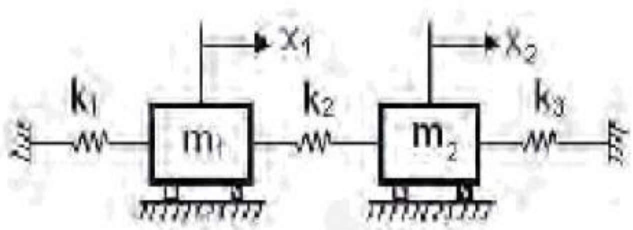
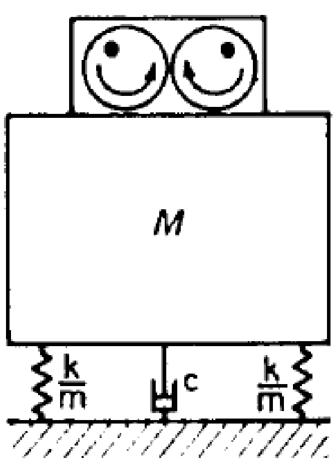
10	A wheel is mounted on a steel shaft ($G = 83 * 10^{9}$ N/m2) of length 1.5m and 0.80 cm. The wheel is rotated 5o and released. The period of oscillation is observed as 2.3s. Determine the mass moment of inertia of the wheel. 	Remember	CO1	AME524.03
11	Derive the convolution integral for a single degree of freedom subjected to an impulse.	Understand	CO1	AME524.02
12	In the vibration testing of a structure, an impact hammer with a load cell to measure the impact force is used to cause excitation. Assuming m=5kg, k=2000n/m, c=10Ns/m and F=20 N. Find the response of the system.	Remember	CO1	AME524.03
13	Explain the terms generalized impedance and admittance of a system.	Remember	CO1	AME524.02
14	Find the undamped response spectrum for the sinusoidal pulse force using initial conditions x(0)=0,dx/dt (0)=0	Remember	CO1	AME524.03
15	A compacting machine modelled as a single d.o.f system. the force on the mass m due to a sudden application of pressure can be idealized as a step force. Determine the response of the system.	Remember	CO1	AME524.01
16	Use the convolution integral to determine the response of an undamped 1- degree-of-freedom system of natural frequency ω_n and *m* when subject to a constant force of magnitude F_0. The system is at rest in equilibrium at t=0.	Remember	CO1	AME524.01
17	Use the convolution integral to determine the response of an undamped 1- degree-of-freedom system of natural frequency ω_n, damping ratio ζ and mass *m* when subject to a constant force of magnitude F_0. The system is at rest in equilibrium at t=0.	Remember	CO1	AME524.01
18	Use the convolution integral to determine the response of an undamped 1- degree-of-freedom system of natural frequency ω_n and mass *m* when subject to a time-dependent excitation of the form $F(t)=F_0e^{-\alpha t}$. The system is at rest in equilibrium at $t=0$.	Understand	CO1	AME524.01
19	Use the convolution integral to determine the response of an undamped 1- degree-of-freedom system of natural frequency ω_n and mass *m* when subject to a harmonic excitation of the form $F(t)=F_0 \sin \omega t$ with $\omega \neq \omega_n$	Remember	CO1	AME524.01
20	Use the Laplace transform method to determine the response of an under damped 1 DOF system of damping ratio ζ, natural frequency ω_n, mass *m*, initially at rest in equilibrium and subject to a series of applied impulses each of magnitude I, beginning at t=0 and each a time t_0 apart.	Remember	CO1	AME524.01
Part - C (Problem Solving and Critical Thinking Questions)				
1	The mass of a spring-mass-dashpot system is given an initial velocity $5\omega_n$, where ω_n is the undamped natural frequency of the system. Find the equation of motion for the system, when (i)ζ= 2.0, (ii) ζ= 1.0, (i) ζ= 0.2.	Remember	CO1	AME524.01

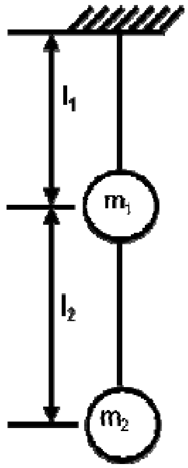
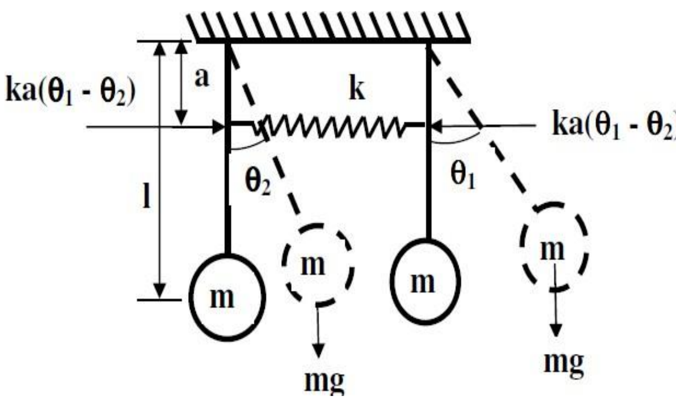
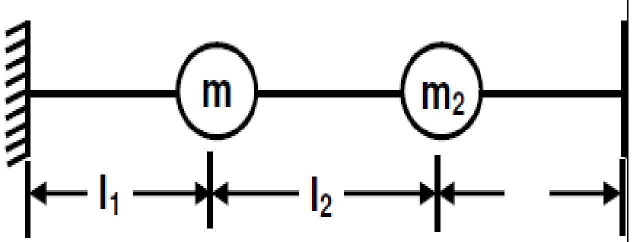
2	A mass of 20kg is supported on two isolators as shown in fig below. Determine the undamped and damped natural frequencies of the system, neglecting the mass of the Isolators.  **Fig Q (2)**	Remember	CO1	AME524.01
3	A gun barrel of mass 500kg has a recoil spring of stiffness 3,00,000 N/m. If the barrel recoils 1.2 meters on firing, determine, (a) initial velocity of the barrel (b) critical damping coefficient of the dashpot which is engaged at the end of the recoil stroke (c) time required for the barrel to return to a position 50mm from the initial Position.	Understand	CO1	AME524.01
4	A 25 kg mass is resting on a spring of 4900 N/m and dashpot of 147 N-se/m in Parallel. If a velocity of 0.10 m/sec is applied to the mass at the rest position, what will be its displacement from the equilibrium position at the end of first second?	Understand	CO1	AME524.01
5	A rail road bumper is designed as a spring in parallel with a viscous damper. What is the bumper"s damping coefficient such that the system has a damping ratio of 1.25, when the bumper is engaged by a rail car of 20000 kg mass. The stiffness of the spring is 2E5 N/m. If the rail car engages the bumper, while traveling at a speed of 20m/s, what is the maximum deflection of the bumper?  	Understand	CO1	AME524.01
6	A disc of a torsional pendulum has a moment of inertia of 6E-2 kg-m2 and is immersed in a viscous fluid. The shaft attached to it is 0.4m long and 0.1m in diameter. When the pendulum is oscillating, the observed amplitudes on the same side of the mean position for successive cycles are 90, 60 and 40. Determine (i) logarithmic decrement (ii) damping torque per unit velocity and (iii) the periodic time of vibration. Assume G = 4.4E10 N/m2, for the shaft material.  	Remember	CO1	AME524.01

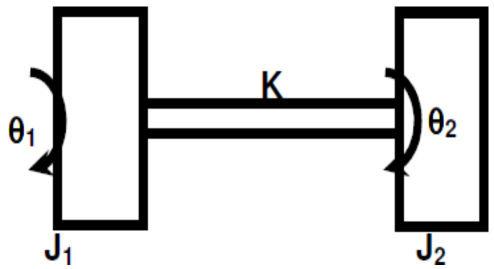
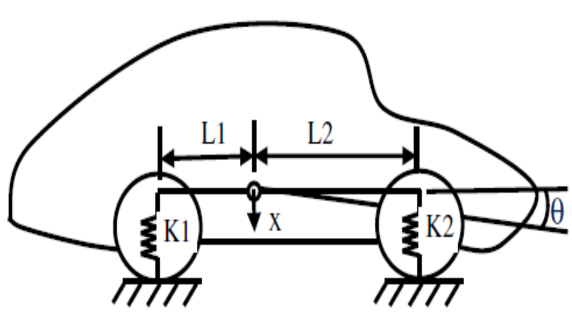
7	A mass of 1 kg is to be supported on a spring having a stiffness of 9800 N/m. The Damping coefficient is 5.9 N-sec/m. Determine the natural frequency of the system. Find also the logarithmic decrement and the amplitude after three cycles if the Initial displacement is 0.003m.	Remember	CO1	AME524.01
8	The damped vibration record of a spring-mass-dashpot system shows the Following data. Amplitude on second cycle = 0.012m; Amplitude on third cycle = 0.0105m; Spring constant k = 7840 N/m; Mass m = 2kg. Determine the damping constant, Assuming it to be viscous.	Remember	CO1	AME524.01
9	A mass of 2kg is supported on an isolator having a spring scale of 2940 N/m and viscous damping. If the amplitude of free vibration of the mass falls to one half its original value in 1.5 seconds, determine the damping coefficient of the isolator**.**	Remember	CO1	AME524.01
10	A system of beam supports a mass of 1200 kg. The motor has an unbalanced mass of 1 kg located at 6 cm radius. It is known that the resonance occurs at 2210 rpm. What amplitude of vibration can be expected at the motors operating speed of 1440 rpm if the damping factor is assumed to be less than 0.1?	Remember	CO1	AME524.01
11	An eccentric mass exciter is used to determine the vibratory characteristics of a structure of mass 200 kg. At a speed of 1000 rpm a stroboscope showed the eccentric mass to be at the bottom position at the instant the structure was moving downward through its static equilibrium position and the corresponding amplitude was 20 mm. If the unbalance of the eccentric is 0.05 kg-m, determine, (a) un damped natural frequency of the system (b) the damping factor of the structure (c) the angular position of the eccentric at 1300 rpm at the instant when the structure is moving downward through its equilibrium position.	Remember	CO1	AME524.01
12	A 40 kg machine is supported by four springs each of stiffness 250 N/m. The rotor is unbalanced such that the unbalance effect is equivalent to a mass of 5 kg located at 50mm from the axis of rotation. Find the amplitude of vibration when the rotor rotates at 1000 rpm and 60 rpm. Assume damping coefficient to be 0.15.	Understand	CO1	AME524.01
13	A vertical single stage air compressor having a mass of 500 kg is mounted on springs having a stiffness of 1.96×105 N/m and a damping coefficient of 0.2. The rotating parts are completely balanced and the equivalent reciprocating parts have a mass of 20 kg. The stroke is 0.2 m. Determine the dynamic amplitude of vertical motion and the phase difference between the motion and excitation force if the compressor is operated at 200 rpm.	Remember	CO1	AME524.01
14	The support of a spring mass system is vibrating with amplitude of 5 mm and a frequency of 1150 cpm. If the mass is 0.9 kg and the stiffness of springs is 1960 N/m, Determine the amplitude of vibration of mass. What amplitude will result if a damping factor of 0.2 is included in the system?	Remember	CO1	AME524.01
15	The springs of an automobile trailer are compressed 0.1 m under its own weight. Find the critical speed when the trailer is travelling over a road with a profile approximated by a sine wave of amplitude 0.08 m and a wavelength of 14 m. What will be the amplitude of vibration at 60 km/hr.	Remember	CO1	AME524.02
16	A heavy machine of 3000 N, is supported on a resilient foundation. The static deflection of the foundation due to the weight of the machine is found to be 7.5 cm. It is observed that the machine vibrates with an amplitude of 1 cm when the base of the machine is subjected to harmonic oscillations at the	Remember	CO1	AME524.03

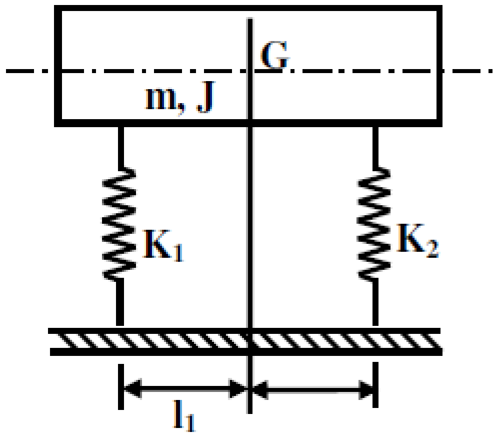
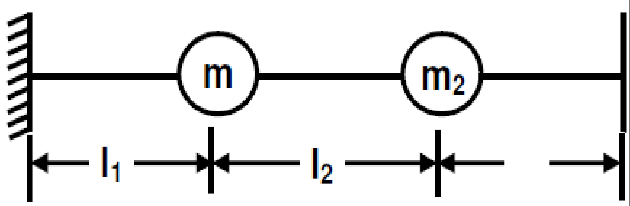
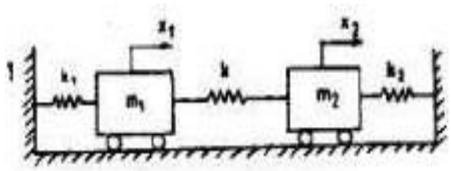
	undamped natural frequency of the system with an amplitude of 0.25 cm. Find (a) the damping constant of the foundation (b) the dynamic force amplitude on the base (c) the amplitude of the displacement of the machine relative to the base.			
17	The time of free vibration of a mass hung from the end of a helical spring is 0.8 s. When the mass is stationary, the upper end is made to move upwards with displacement *y* mm given by *y* = 18 sin 2πt, where t is time in seconds measured from the beginning of the motion. Neglecting the mass of spring and damping effect, determine the vertical distance through which the mass is moved in the first 0.3 seconds.	Understand	CO1	AME524.01
	UNIT – II			
	TWO DEGREE OF FREEDOM SYSTEMS			
	PART - A (SHORT ANSWER QUESTIONS)			
1	Write the frequency equation for the two DOF spring mass system	Remember	CO2	AME524.01
2	Write the frequency equation for the two DOF torsional system	Remember	CO2	AME524.01
3	What is the main disadvantage of a dynamic vibration absorber?	Understand	CO2	AME524.01
4	What is coordinate coupling?	Remember	CO2	AME524.01
5	What are static and dynamic couplings?	Remember	CO2	AME524.01
6	Define mass coupling	Remember	CO2	AME524.02
7	Define velocity coupling	Understand	CO2	AME524.03
8	Define elasticity coupling	Remember	CO2	AME524.02
9	What is semi definite system	Remember	CO2	AME524.03
10	Write a short note on principal mode of vibration	Remember	CO2	AME524.02
11	What are generalized coordinates?	Understand	CO2	AME524.03
12	What are principle coordinates?		CO2	AME524.02
13	Write a short note on Orthogonality principle as applied to two degree freedom system	Remember	CO2	AME524.03
14	What is the basic working principle of a dynamic vibration absorber?	Remember	CO2	AME524.01
15	How can we make system vibrate in one of its natural modes?	Remember	CO2	AME524.04
16	In a two D.O.F spring mass system, explain how Dynamic coupling exists.	Understand	CO2	AME524.05
17	What are principal co-ordinates when the system h subjected to linear as well as angular displacement?	Remember	CO2	AME524.04
18	Under what conditions a tuned absorber exists?	Understand	CO2	AME524.05
19	Explain conditions that are to be satisfied for a Ring tensional vibration absorber	Remember	CO2	AME524.04
20	What in the principle of working in a Houdille unturned damper?	Remember	CO2	AME524.05
	Part - B (Long Answer Questions)			
1	Obtain the frequency equation for the two DOF spring mass system. Also determine the natural frequencies and mode shapes. Assume m_1 ,m_2 ,k_1 and k_2 for governing equations.	Understand	CO2	AME524.05
2	Obtain the frequency equation for the two DOF torsional system. Also determine the natural frequencies and mode shapes. Assume J_1 ,J_2 ,kt_1 and kt_2 for governing equations	Understand	CO2	AME524.04
3	A diesel engine, weighing 3000 N is supported on a pedestal mount. It has been observed that the engine induces vibration into the surrounding area through its pedestal mount at an operating speed of 6000rpm. Determine the parameters of the vibration absorber that will reduce the vibration when mounted on the pedestal. The magnitude of the exciting force is 250 N and the amplitude of the auxiliary mass is to be limited to 2mm.	Remember	CO2	AME524.06
4	What is meant by static and dynamic coupling? How can coupling of the equations of motion be eliminated? Derive the	Understand	CO2	AME524.07

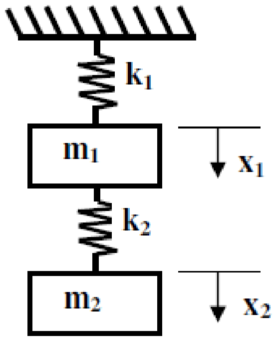
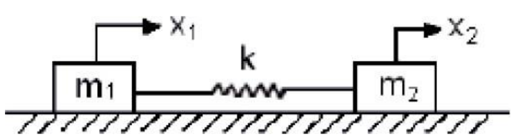
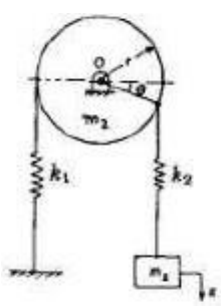
	governing equations through Lagrange energy approach.			
5	Determine the natural frequency of torsional vibrations of a shaft with two circularises of uniform thickness at the ends. The masses of the discs are M1= 500 kg andM2 = 1000 kg and their outer diameters are D1 = 125 cm and D2 = 190 cm. The length of the shaft is l = 300 cm and its diameter d = 10 cm as shown in fig. G = 0.83 x 10^{11}N/m^2 	Understand	CO2	AME524.06
6	A slender rod of length L and mass m is pinned at O as shown in figure below. A spring of stiffness K is connected to the rod at point P while a dashpot of damping coefficient c is connected to the rod at point Q. Assuming small displacements; Derive a linear differential equation governing the free vibration of this system. Use the displacement of the point P, measured from the systems equilibrium position as the generalized coordinate. 	Understand	CO2	AME524.07
7	Solve the problem shown in figure. m1=10kg, m2=15kg and k = 320 N/m. 	Remember	CO2	AME524.06

8	Two pendulums of different lengths are free to rotate y-y axis and coupled together by a rubber hose of torsional stiffness 7.35 X 103 Nm / rad as shown in figure. Determine the natural frequencies of the system if masses m1 = 3kg, m2 = 4kg, L1 = 0.30 m, L2 = 0.35 m. 	Understand	CO2	AME524.07
9	Determine the modes of vibrations for the system shown in figure 	Remember	CO2	AME524.06
10	A counter rotating eccentric weight exciter is used to produce the forced oscillation of a spring-supported mass as shown in Fig. By varying the speed of rotation, resonant amplitude of 0.60 cm was recorded. When the speed of rotation was increase considerably beyond the resonant frequency, the amplitude appeared to approach a fixed value of 0.08 cm. Determine the damping factor of the system. 	Understand	CO2	AME524.07

11	Derive the frequency equation for a double pendulum shown in figure. Determine the natural frequency and mode shapes of the double pendulum when $m_1=m_2=m$, $l_1=l_2=l$. 	Understand	CO2	AME524.04
12	Determine the natural frequencies of the coupled pendulum shown in the figure. Assume that the light spring of stiffness „k" is un-stretched and the pendulums are vertical in the equilibrium position. 	Remember	CO2	AME524.05
13	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 $m_1 = m_2 = m$ and $l_1 = l_2 = l_3 = l$. 	Remember	CO2	AME524.04

14	Derive the equation of motion of a torsional system shown in figure  Figure Two Rotor System	Remember	CO2	AME524.05
15	For the system shown in fig find the two natural frequencies when m_1=m_2=9.8 kg K_1=K_3=8820N/m, K_2=3430N\m. Find out the resultant motions of m_1 and m_2 for the following cases. The displacements mentioned below are from the equilibrium positions of the respective masses. Both masses are displaced 5mm in the downward direction and released simultaneously both masses are displaced 5mm, in the downward direction and in the upward direction and released simultaneously.	Remember	CO2	AME524.04
16	Explain the working principle of Bifilar Suspension absorber with a neat diagram.	Remember	CO2	AME524.05
17	A diesel Engine weighing 3000N, supported on a pedestal mount. It has been observed that the engine induces vibration into the surrounding area through L"ts pedestal mount at an operating speed of 6000rpm. Determine the parameters of the exciting force in 250N and amplitude of the motion of the auxiliary mass in limited to 2mm	Remember	CO2	AME524.04
18	With a neat sketch, derive the governing equation of the Ring Tensional absorber.	Remember	CO2	AME524.05
19	Explain the absorber principle in the case of centrifugal pendulum absorber from the first principles.	Remember	CO2	AME524.04
20	Draw and explain the amplitude and phase plots in a dynamic Vibration absorber .	Remember	CO2	AME524.06
Part – C (Problem Solving and Critical Thinking)				
1	Determine the normal mode of vibration of an automobile shown in figure. simulated by a simplified two degree of freedom system with the following numerical values m = 1460 kg, L1 = 1.35m, L2 = 2.65 m, K1 = 4.2x105N/m, K2 = 4.55x105 N/m and J=mr2 where r= 1.22 m 	Understand	CO2	AME524.06

2	Determine the natural frequencies and mode shape of un-damped coordinate coupling system with two degrees of freedom 	Understand	CO2	AME524.07
3	Determine the natural frequencies of undamped dynamic vibration absorber	Remember	CO2	AME524.06
4	Determine the frequencies and the location of oscillation centres of an automobile with the following data: m= 1000kg, r_g=0.9m, distance between the front axle and centre of gravity=1m, distance between the rear axle and centre of gravity =1.5m. Front spring stiffness, k_1=8 K/m, rear sprig stiffness k_2= 22KN/m.	Remember	CO2	AME524.07
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 $m_1 = m_2 = m$ and l_1=l, l_2 = 2l, l_3 =3l. 	Understand	CO2	AME524.06
6	Determine the natural frequencies, the ratio of amplitudes and locate the nodes for each mode of vibrations when $m_1 = m_2 = m$ 	Remember	CO2	AME524.07

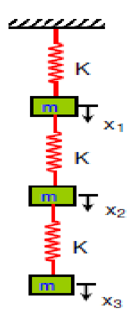
7	Figure shows a vibrating system having two DOF. Determine the two natural frequencies of vibrations and the ratio of amplitudes of the motion of m1 and m2for the two modes of vibrations 	Understand	CO2	AME524.04
8	Solve the problem shown in figure. m_1= 20kg, m_2= 35kg and k= 360 N/m 	Remember	CO2	AME524.05
9	Find the natural frequencies of the system shown in figure. Assume that there is no slip between the cord and cylinder. K_1= 40 N/m, k_2= 60N/m, m_1= 2kg, m_2= 10kg 	Understand	CO2	AME524.04
10	For the system shown in fig find the two natural frequencies when m_1=m_2=9.8 kg K_1=K_3=8820N/m, K_2=3430N\m. Find out the resultant motions of m_1 and m_2 for the following cases. The displacements mentioned below are from the equilibrium positions of the respective masses. mass m1 displaced 5mm downward and mass m2 is displaced 7.5mm downwards both masses are released simultaneously. mass m1 displaced 5mm upward while m2 is held fixed. Both masses are then released simultaneously.	Understand	CO2	AME524.05

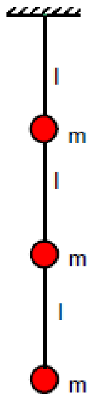
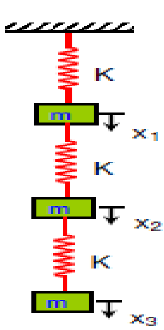
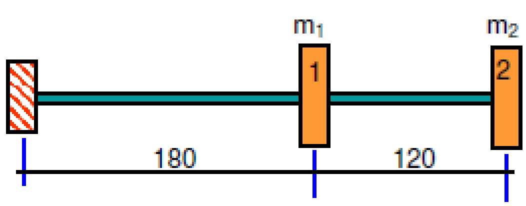
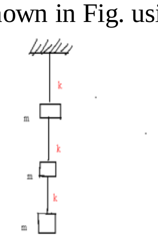
UNIT-III

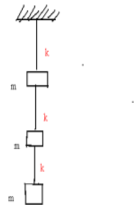
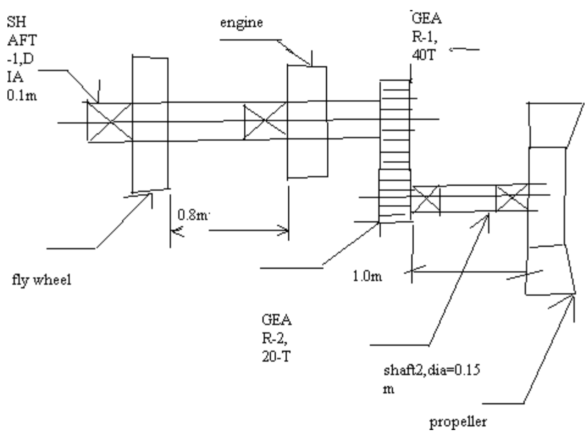
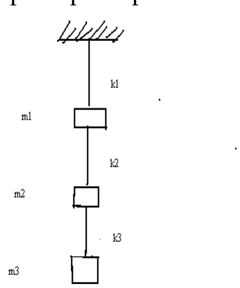
MULTI DEGREE FREEDOM SYSTEM

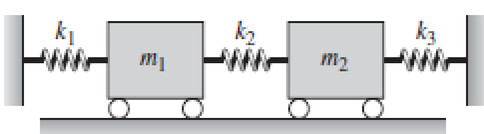
Part - A (Short Answer Questions)

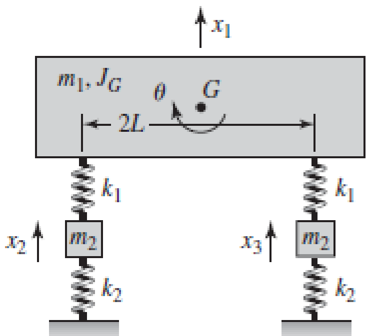
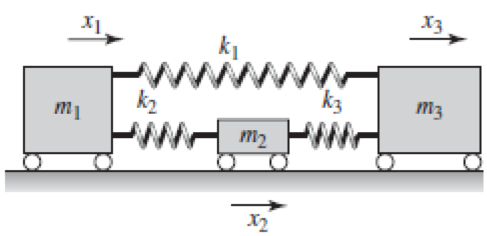
1	How can we make a system to vibrate in one of its natural made?	Remember	CO3	AME524.04
2	Name a few methods for finding the fundamental natural frequency of a multi degree of freedom system	Understand	CO3	AME524.05
3	What is the matrix iteration method?	Understand	CO3	AME524.04
4	Can we use any trial vector in the matrix iteration method to find the largest natural frequency?	Understand	CO3	AME524.06
5	What is the difference between the matrix iteration method and Jacobi‟s method?	Understand	CO3	AME524.07

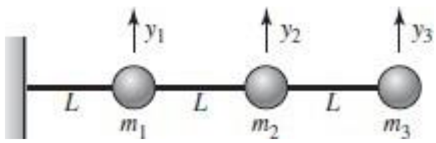
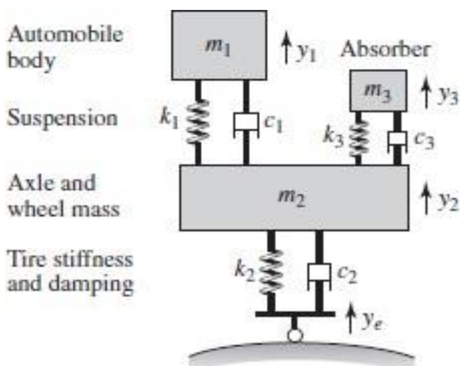
6	Using the matrix iteration method, how do you find the intermediate natural frequencies?	Understand	CO3	AME524.06
7	What are the different methods by which a vibrating system having several degrees of freedom can be analysed?	Remember	CO3	AME524.07
8	State Maxwell reciprocal theorem.	Remember	CO3	AME524.06
9	Distinguish between flexibility influence coefficient and stiffness coefficient.	Understand	CO3	AME524.07
10	Define stiffness influence coefficient as applicable to multi degree freedom vibrations.	Remember	CO3	AME524.06
MID-II				
11	Write a short notes on matrix iteration method as applied to multi degree freedom	Understand	CO3	AME524.06
12	Write a short notes on orthogonality principle	Understand	CO3	AME524.07
13	What is mode shape?	Remember	CO3	AME524.06
14	State orthogonality principle in case of multi degree freedom system.	Understand	CO3	AME524.06
15	What is the difference between vibiometer and Velometer?	Understand	CO3	AME524.06
16	What is the need for vibration measuring instruments?	Understand	CO3	AME524.06
17	Draw the sketch of a seismic instrument and label the parts	Understand	CO3	AME524.07
18	Write the governing equation for the instrument we the low natural frequency and Name the instrument	Understand	CO3	AME524.06
29	An instrument having high fundamental frequency. What is the governing equation and name of the instrument?	Understand	CO3	AME524.07
Part - B (Long Answer Questions)				
1	A seismic instrument is fitted to measure the vibration characteristics of a machine running at 120rpm. If the natural frequency of the instrument is 5Hz and if it shows 0.004cm. Determine the displacement, velocity and acceleration assuming no damping.	Understand	CO3	AME524.07
2	A vibrometre having a natural frequency of 4 rad/s and ζ =0.2 is attached to a structure performs a harmonic motion. If the difference between the maximum and minimum recorded values is 8mm, find the amplitude of motion of the vibrating structure when its frequency is 40 rad/s.	Remember	CO3	AME524.06
3	A simple model of a motor vehicle can vibrate in the vertical direction while travelling over a rough road. The vehicle has a mass of 1200kg.The suspension system has a spring constant of 400KN/m and a damping ratio of ζ=0.5.If the vehicle speed is 20km/hr, determine the displacement amplitude of the vehicle mounted with vibrometre. The road surface varies sinusoidal with amplitude Y=0.05 and wave length of 6m.	Remember	CO3	AME524.07
4	Obtain the approximate fundamental natural frequency of the linear spring system shown in Fig. using matrix method 	Understand	CO3	AME524.06

5	Obtain of the Flexibility influence coefficients of the pendulum system shown in the Fig 	Understand	CO3	AME524.04
6	Obtain the stiffness coefficients of the system shown in Fig 	Understand	CO3	AME524.05
7	Find the lowest natural frequency of the cantilever rotor system shown in Figure by matrix method. Take m1=100 kg, m2=50 kg 	Understand	CO3	AME524.04
8	Obtain natural frequency equation in matrix form for system shown in Fig. using Eigen value method 2. 	Understand	CO3	AME524.04

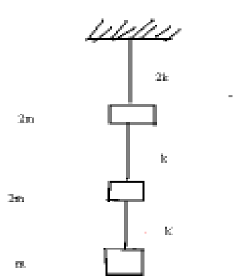
9	Find modal vectors and mode shapes of the system shown using Eigen value method 3  	Remember	CO3	AME524.05
10	The schematic diagram of a marine engine connected to a propeller thro gears as shown in fig. The moment of inertia of the flywheel =9000kg-m^2,engine=1000kg-m^2,gear1=250 kg-m^2,gear2=150 kgm^2,propeller=2000kg-m^2.find the natural frequencies and mode shapes of the system in torsional vibration. Considering inertia of the gears Considering inertia of the gears.  	Remember	CO3	AME524.04
MID-II				
11	Explain principle of orthogonality of modal vectors  	Understand	CO3	AME524.04
12	A commercial type vibration pick up has a natural frequency of 6cps and a damping factor ζ=0.6.calculate the relative displacement amplitude if the instrument is subject to motion x=0.08sin 20t.	Understand	CO3	AME524.05
13	A seismic instrument is mounted on a machine running at 1000 rpm. The natural frequency of the seismic instrument is 20 rad/sec. The instrument records relative amplitude of 0.5 mm. Compute the displacement, velocity and acceleration of the machine. Damping in seismic instrument is neglected.	Understand	CO3	AME524.04

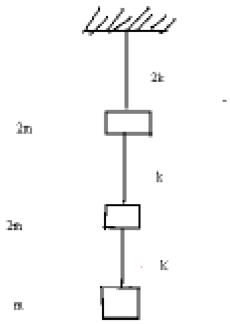
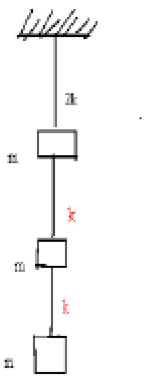
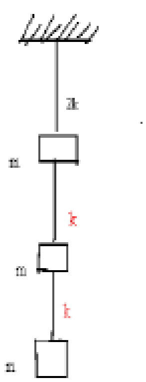
14	Seismic instrument has natural frequency of 6 Hz. What is the lowest frequency beyond which the amplitude can be measured within 2% error? Neglect damping.	Understand	CO3	AME524.05
15	Seismic instrument has natural frequency of 6 Hz. What is the lowest frequency beyond which the amplitude can be measured within 2% error?	Understand	CO3	AME524.04
16	A vibrometer with a natural frequency of 2 Hz and with negligible damping is attached to a vibrating system which performs a harmonic motion. Assuming the difference between the maximum and minimum recorded value as 0.6mm, determine the amplitude of motion of the vibrating system when its frequency is (i) 20Hz (ii) 4Hz.	Remember	CO3	AME524.06
17	An accelerometer having natural frequency of 1000cpm and a damping factor of 0.7 is attached to a vibrating system. Determine the maximum acceleration of the system when the recorded amplitude is $\omega^2 Z$=0.5m/s^2 when the system performs a harmonic motion at (i) 400 cpm (ii) 800cpm.	Understand	CO3	AME524.07
18	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?	Remember	CO3	AME524.06
19	A seismic instrument is mounted on a machine running at 1200 rpm. The natural frequency of the seismic instrument is 30 rad/sec. The instrument records relative amplitude of 0.7 mm. Compute the displacement, velocity and acceleration of the machine. Damping in seismic instrument is neglected.	Remember	CO3	AME524.07
20	A commercial type vibration pick up has a natural frequency of 6cps and a damping factor ζ=0.8.calculate the relative displacement amplitude if the instrument is subject to motion x=0.1sin 30t.	Understand	CO3	AME524.06
Part – C (Problem Solving and Critical Thinking)				
1	It is desired to measure maximum acceleration of a machine part, which vibrates violently with a frequency of 700cycles/min. An accelerometer with negligible damping, 0.5 kg mass and 18 KN/m spring constant is attached to it. The total travel of the indicator is found to be 8.2 mm, find the maximum amplitude and maximum acceleration of the part.	Understand	CO3	AME524.06
2	Determine the natural frequencies and mode shapes associated with the system shown in Figure for $m1$ = 10 kg, $m2$ = 20 kg, $k1$ = 100 N/m, $k2$ = 100 N/m, and $k3$ = 50 N/m. 	Remember	CO3	AME524.04
3	An elastically supported machine tool with a total mass of 4000 kg has a resonance frequency of 80 Hz. An 800 kg absorber system with a natural frequency of 80 Hz is attached to the machine tool. Determine the natural frequencies and mode shapes of this system.	Remember	CO3	AME524.05
4	One model that has been used to study the vibratory motion of motor vehicles is shown in Figure. The body of the vehicle has a mass $m1$ and a rotary inertia J_G about an axis through the center. The elasticity of the tires is represented by springs k_2, and the elasticity of the suspension by springs $k1$. The mass of the tire assemblies is m_2. a) Determine the matrix form for the governing equations of the	Understand	CO3	AME524.04

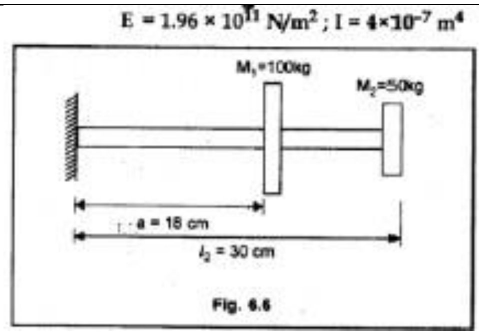
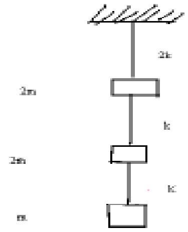
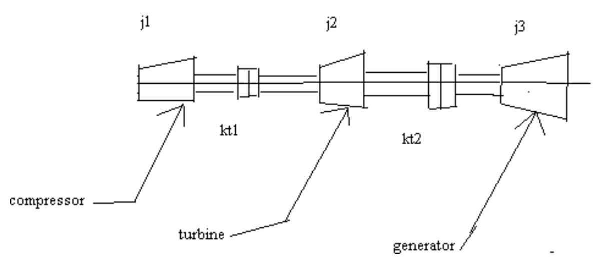
	system. b) Obtain the natural frequencies and mode shapes for the case where $m1$ = 800 kg, m_2 = 25 kg, k_1= 60 kN/m, k_2 =20 kN/m, L = 1.4 m, and J_G= 180 kg m2. 			
5	Determine the characteristic equation for the system shown in Figure .and solve this equation for the special case when $k1= k2= k3 = k$ and $m1 = m2 = m3 = m$. Determine if the system has any rigid-body modes. 	Understand	CO3	AME524.05
MID-II				
6	Determine the modal mass, modal stiffness, and modal damping factors associated with the system whose mass matrix, stiffness matrix, and damping matrix are given by the following: $$[M] = \begin{bmatrix} 1 & 0 \\ 0 & 2 \end{bmatrix}, \quad [K] = \begin{bmatrix} 1 & -1 \\ -1 & 2 \end{bmatrix},$$ $$[C] = \begin{bmatrix} 3 & -2 \\ -2 & 6 \end{bmatrix}$$	Remember	CO3	AME524.05
7	A device used to measure torsional acceleration consists of a ring having a moment of inertia of 0.049 Kg-m2 connected to a shaft by a spiral spring having a scale of 0.98N-m/rad, and a viscous damper having a constant of 0.11 N-m-s/rad. When the shaft vibrates with a frequency of 15cpm, the relative amplitude between the ring and the shaft is found to be 2 degree. What is the maximum acceleration of the shaft?	Remember	CO3	AME524.04
8	An instrument for measuring accelerations records 30 oscillation/sec. The natural frequency of the instrument is 800 cycles/sec. What is the acceleration of the machine part to which the instrument is attached if the amplitude recorded is 0.02mm? What is the amplitude of vibration of the machine part?	Understand	CO3	AME524.05
9	Consider the system shown in Figure E8.10 in which the three masses $m1$, $m2$, and $m3$ are located on a uniform cantilever beam with flexural rigidity EI. The inverse of the stiffness matrix for this system, which is called the flexibility matrix, is given by	Understand	CO3	AME524.04

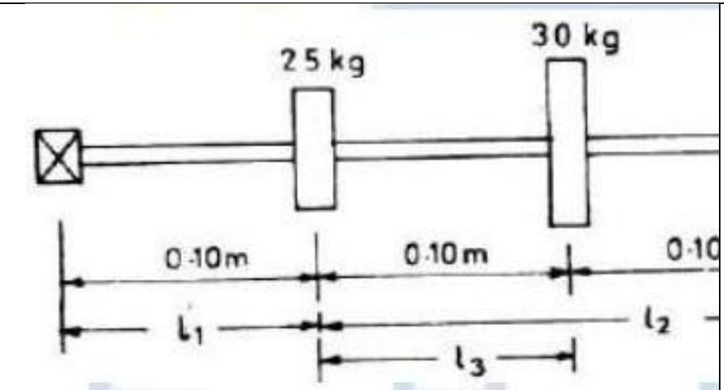
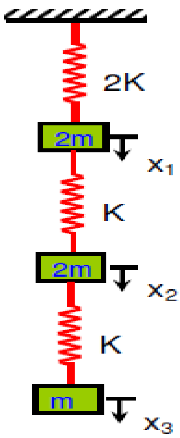
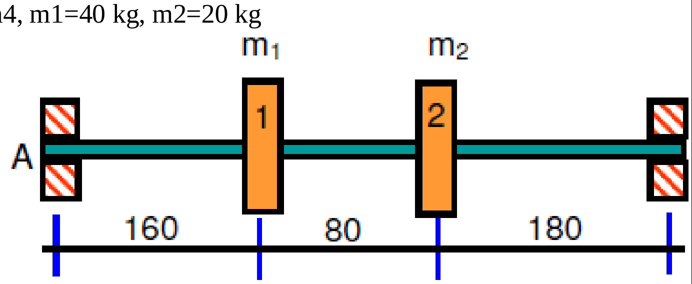
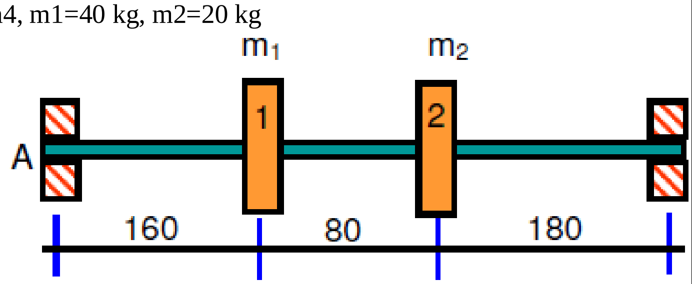
	$$[K]^{-1} = \frac{L^3}{3EI}\begin{bmatrix} 27 & 14 & 4 \\ 14 & 8 & 2.5 \\ 4 & 2.5 & 1 \end{bmatrix}$$ If the masses of the system are all identical; that is, $m_1 = m_2 = m_3 = m$, then determine the response of this system when it is forced sinusoidally at the location of mass m_2 with a forcing amplitude F_2 and an excitation frequency v. 			
10	Derive the equations of motion of the vehicle model shown in Figure 	Understand	CO3	AME524.06
UNIT-IV				
FREQUENCY DOMAIN VIBRATION ANALYSIS				
Part – A (Short Answer Questions)				
1	Why vibration analysis is important to monitor the condition of machine?	Understand	CO4	AME524.09
2	Write a short note on fast Fourier transform Theory?	Remember		AME524.10
3	What is complex fast Fourier transform theory?	Remember	CO4	AME524.11
4	Name some signal measurement and display units?	Remember	CO4	AME524.09
5	Name few vibration and acoustic measurement sensors	Remember	CO4	AME524.10
6	Name sources of vibrations in mechanical systems.	Remember	CO4	AME524.11
7	Explain the vibration phenomenon due to mechanical motion and force	Understand	CO4	AME524.09
8	Reciprocating linear motion machinery causes vibration why?	Understand	CO4	AME524.10
9	Write a short note on root cause analysis	Remember	CO4	AME524.11
10	Explain flow induced vibrations in mechanical systems.	Remember	CO4	AME524.09
11	Write a short note on machine train monitoring parameters	Understand	CO4	AME524.10
12	Monitoring the overall mechanical condition of machinery for more than 20 years. In this case what type system to be used for analysis?	Understand	CO4	AME524.11
13	What types of instrumentation systems are used for condition monitoring of machines?	Remember	CO4	AME524.09
14	Change in vibration amplitude in an indication of a compounding change in operating system. Name the type of analysis technique to be used and explain.	Remember	CO4	AME524.11

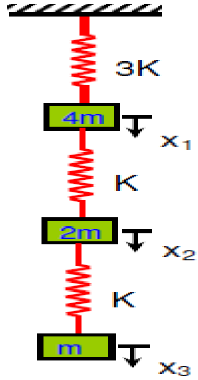
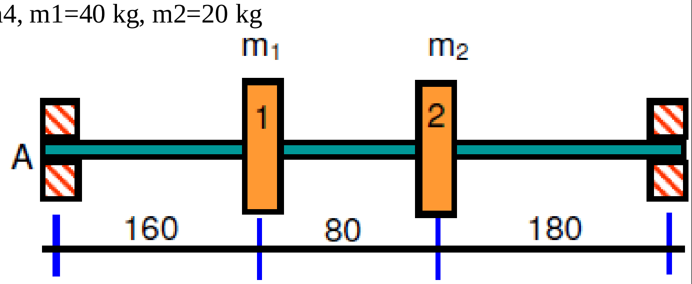
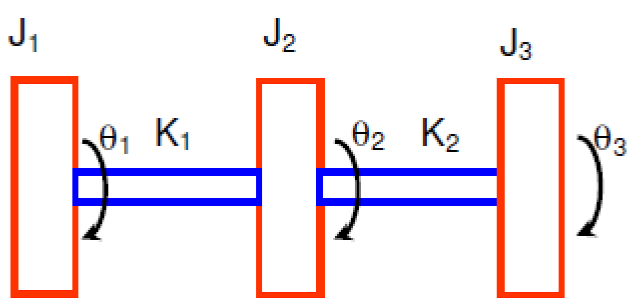
15	Name different types of data types acquired and displaced in a vibrating system.	Understand	CO4	AME524.12
16	Write a short note on computer based instrumentation system	Understand	CO4	AME524.13
17	What is the major limitation of the velocity transducer indicate the range.	Remember	CO4	AME524.11
18	Write a short notes on time domain analysis	Remember	CO4	AME524.12
19	What are the factors to be considered for acquiring data in a vibration system?	Remember	CO4	AME524.13
20	State three methods of representing frequency response data	Understand	CO4	AME524.11
Part – B (Long Answer Questions)				
1	Explain trending analysis	Remember	CO4	AME524.09
2	Explain failure node analysis	Understand	CO4	AME524.09
3	Explain root cause analysis	Remember	CO4	AME524.10
4	Explain signature analysis	Understand	CO4	AME524.11
5	Explain machine monitoring parameters	Remember	CO4	AME524.09
6	Explain vibration data acquisition	Remember	CO4	AME524.10
7	Explain briefly frequency domain analysis	Remember	CO4	AME524.11
8	Explain bode plots for amplitude and phase to represent the seismic and accelerometer range.	Understand	CO4	AME524.11
9	Explain what is a seismic Instrument and frequency range?	Remember	CO4	AME524.12
10	Explain what is the advantage of experimental modes Analysis?	Remember	CO4	AME524.13
11	Explain how are a bit used in machine diagnostics	Remember	CO4	AME524.09
12	Explain the principle of mode Superposition. What is its use in model Analysis.	Understand	CO4	AME524.10
13	Name two frequency measuring instruments. Explain any one instrument"s working principle.	Remember	CO4	AME524.11
14	State the three types of maintenance schemes used for machinery.	Understand	CO4	AME524.09
15	Time-domain wave farms can be used to detect dushate damages of the machinery. Explain.	Remember	CO4	AME524.10
16	A spectrum Analyser is a device that analyses a signal in the frequency domain. Explain in detail the working.	Remember	CO4	AME524.11
17	Compare theoretical and Real-time harmonic profiles of the vibrating systems with explanation.	Remember	CO4	AME524.09
18	Draw and explain working of accelerometer for vibration pickup in a mechanical system	Understand	CO4	AME524.10
19	Name the factors that must be considered for acquiring the data in a roto dynamic system.	Remember	CO4	AME524.11
20	How the vibration data measurement is carried a out for machine characterization?	Understand	CO4	AME524.09
Part – C (Problem Solving and Critical Thinking)				
1	Explain machine vibrations caused by shaft imbalance with bode plots.	Remember	CO4	AME524.11
2	Explain the consequences of misalignment and pre loaded shafts on the performance of the machine assembly with plots.	Understand	CO4	AME524.09
3	Explain faults in rolling element of the bearing	Remember	CO4	AME524.10
4	Explain faults in gears.	Understand	CO4	AME524.11
5	Explain rubs in rotor bearing system	Remember	CO4	AME524.09
6	Explain different types of data acquisition systems with compression to merits and demerits of each other.	Remember	CO4	AME524.11
7	Machine condition monitoring is very important. Explain thro trending analysis and its interpretation.	Understand	CO4	AME524.12
8	What conclusion can be drawn during condition monitoring of mechanical systems using failure mode analysis?	Remember	CO4	AME524.13
9	Explain signature analysis of a mechanical system subjected to forced vibration.	Understand	CO4	AME524.11

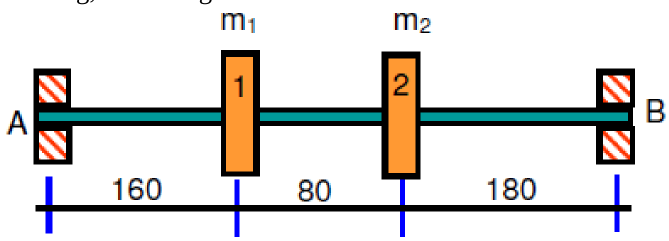
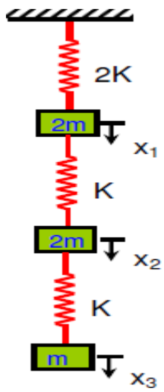
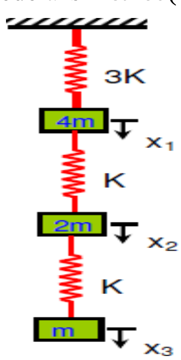
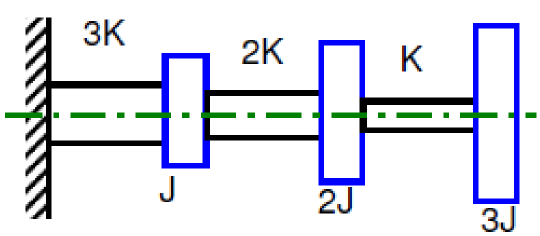
10	Root cause analysis is very essential for introducing to implement using fishbone chart. Explain	Remember	CO4	AME524.09
UNIT-V				
NUMERICAL METHODS				
Part - A (Short Answer Questions)				
1	Write a short notes on Stodola"s method	Understand	CO5	AME524.09
2	Write a short notes on Rayleigh-ritz method	Remember	CO5	AME524.10
3	Write a short notes on Holzer"s method	Remember	CO5	AME524.11
4	Write a short notes on matrix iteration method	Remember	CO5	AME524.09
5	Which numerical method is particularly used for torsional vibrations of shafts?	Remember	CO5	AME524.10
6	Which numerical method is usually applicable for solving for beam problems?	Understand	CO5	AME524.11
7	Which method is used to determine fundamental natural frequency of free undamped vibrating systems?	Remember	CO5	AME524.09
8	What are the disadvantages of stodola"s method?	Remember	CO5	AME524.10
9	Write a short note on sweeping technique.	Understand	CO5	AME524.11
10	Write equation of motion of a vibrating system of n DOF in matrix form	Remember	CO5	AME524.09
11	Write down the fundamental natural frequency equation for Rayleigh Energy method applied for "n" masses	Remember	CO5	AME524.11
12	Dum Kerly"s method used for determining natural frequency of 3 Rotor systems E X plain the procedure.	Understand	CO5	AME524.12
13	Distinguish between 3 to dole and Holzer methods.	Remember	CO5	AME524.13
14	Write any three numerical methods for obtaining fundamental frequency.	Remember	CO5	AME524.11
15	What are node points and mode shapes in case of matrix iferation method?	Remember	CO5	AME524.12
16	Which numerical method is used to finding torsional vibrations of shaft?	Understand	CO5	AME524.13
17	Write down the form in which frequencies are obtained using Rayleigh"s Energy method.	Remember	CO5	AME524.11
18	Which method is most commonly used for determining fundamentalfrequency when the system me end in free and other end in fixed.	Understand	CO5	AME524.11
19	For solving beam problems, which numerical method is applied?	Remember	CO5	AME524.09
20	Explain node points and mode shapes. What is its physical significance?	Remember	CO5	AME524.09
Part - B (Long Answer Questions)				
1	Find first natural frequency using matrix Iteration method (use flexibility influence co-efficient) 	Understand	CO5	AME524.11

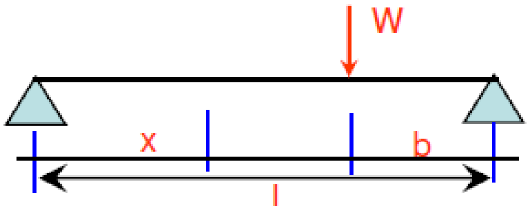
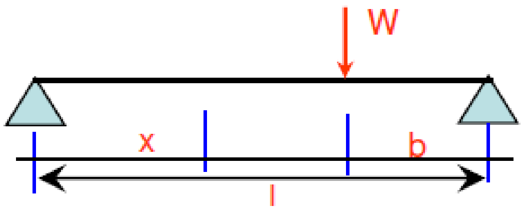
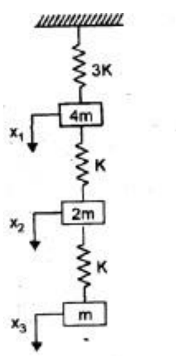
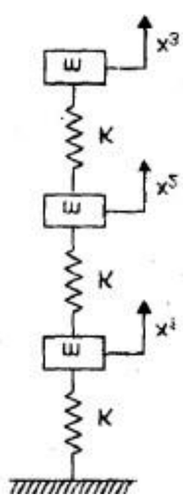
				
2	Estimate the approximate fundamental natural frequency of the system shown in Fig. using Rayleigh"s method. Take: m=1kg and K=1000 N/m.  	Understand	CO5	AME524.09
3	Explain the Rayleigh ritz method for vibration analysis?	Remember	CO5	AME524.10
4	Find the lowest natural frequency of vibration for the system shown in Fig. by Rayleigh"s method	Remember	CO5	AME524.11

	 Fig. 6.6			
5	For system shown in below fig, determine the lowest natural frequency by “stodolas” method.(carry out two iterations) 	Remember	CO5	AME524.11
6	Deduce the governing equation for semi definite torsional vibratory multi DOF System. Using Holzars method. Assume j1=j2=j3 =1, kt1=kt2 =1 (as shown below) 	Remember	CO5	AME524.12
7	Determine the frequency of vibrations for the system shown in figure using stodola method.	Understand	CO5	AME524.13

				
8	Estimate the approximate fundamental natural frequency of the system shown in Fig. Using Rayleigh"s method. Take: m=2kg and K=1000 N/m. 	Remember	CO5	AME524.13
9	Find the lowest natural frequency of transverse vibrations of the system shown in Fig. by Rayleigh"s method. E=196 GPa, I=10-6 m4, m1=40 kg, m2=20 kg 	Remember	CO5	AME524.11
10	Find the lowest natural frequency of transverse vibrations of the system shown in Fig. by stodola"s method. E=196 GPa, I=10-6 m4, m1=40 kg, m2=20 kg 	Remember	CO5	AME524.11

11	For the system shown in Fig. find the lowest natural frequency by holzer"s method(carryout two iterations) 	Understand	CO5	AME524.12
12	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 	Remember	CO5	AME524.13
13	With suitable assumptions derive the rayleigh"s equation for determining the fundamental natural frequency of a multi mass system.	Remember	CO5	AME524.11
14	Explain Holzer"s method of analysing multi degree freedom system.	Remember	CO5	AME524.11
15	Explain stodola"s method to estimate the natural frequency and mode shapes of multi degree freedom system.	Understand	CO5	AME524.12
16	For the system shown in the Fig, obtain natural frequencies using Holzar"s method**.** 	Remember	CO5	AME524.13
17	Derive the equation of Dunkerly"s method for "n" number of masses in a systems	Remember	CO5	AME524.11
18	Derive the equation of Rayleigh"s Energy method for determining the natural frequency of "n" masses of a system.	Remember	CO5	AME524.12
19	Derive the governing equation of the Holzer"s method when both ends of the system are free	Understand	CO5	AME524.11
20	When both ends of the rotor system are fixed, use Holzer method for determining the natural frequency.	Remember	CO5	AME524.13

Part – C (Problem Solving and Critical Thinking)				
1	Find the lowest natural frequency of transverse vibrations of the system shown in Fig. by matrix iteration method. E=196 GPa, I=10-6 m4, m1=40 kg, m2=20 kg 	Remember	CO5	AME524.11
2	Estimate the approximate fundamental natural frequency of the system shown in Fig. Using stodola‟s method. Take: m=2kg and K=1000 N/m. 	Understand	CO5	AME524.12
3	For the system shown in Fig. find the lowest natural frequency by Stodola‟s method(carryout two iterations) 	Remember	CO5	AME524.13
4	For the system shown in the figure estimate natural frequencies using Holzar‟s Method. 	Remember	CO5	AME524.11
5	Find first natural frequency and modal vector of the system shown in the Fig. using Matrix iteration method. Use flexibility influence coefficient.	Remember	CO5	AME524.12

				
6	Find the fundamental natural frequency and modal vector of a vibratory system shown in Fig. using Stodola‟s method. 	Understand	CO5	AME524.11
7	Determine the fundamental frequency and first mode of the system shown in Fig. using matrix Iteration method 	Remember	CO5	AME524.12
8	Determine the natural frequencies of the system shown in Fig using hozler‟s method. 	Understand	CO5	AME524.13

9	When one end is fixed and other end in free derive from the first principles for obtaining natural frequency using Holzer method.	Remember	CO5	AME524.11
10	Determine the fundamental natural frequency for a three spring mass systems using the Dunkerley‟s method we the following data. m_1=10kg k_1=500N-m m_2=10kg k_2=500N-m m_3=10kg k_3=500N-m	Remember	CO5	AME524.15

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