INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

TUTORIAL QUESTION BANK

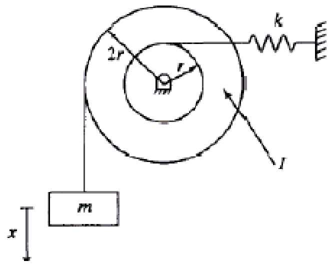
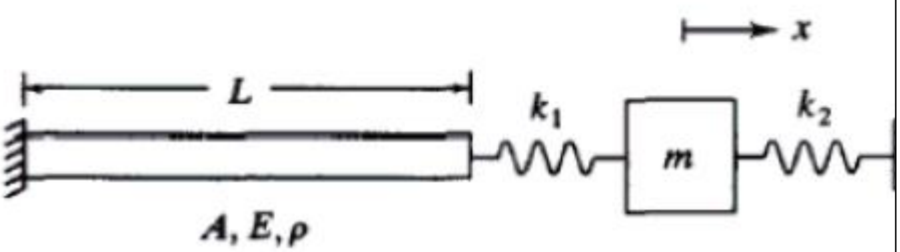
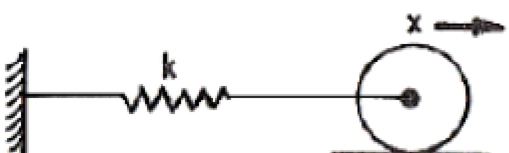
Course Name	:	**MECHANICAL VIBRATIONS**
Course Code	:	**A70346**
Class	:	IV B. Tech I Semester
Branch	:	MECHANICAL ENGINEERING
Year	:	2018 – 2019
Course Coordinator	:	Prof. VVSH Prasad, Professor, Department of Mechanical Engineering
Course Faculty	:	Prof. VVSH Prasad, Professor. Department of Mechanical Engineering

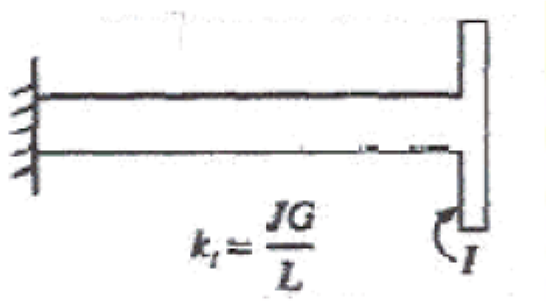
OBJECTIVES

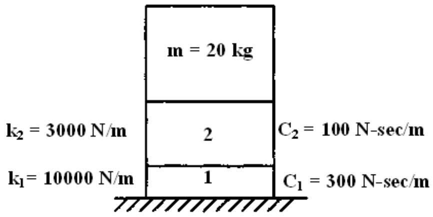
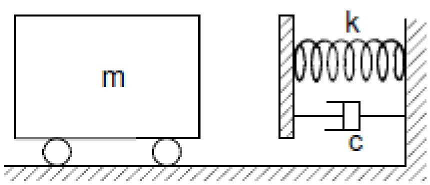
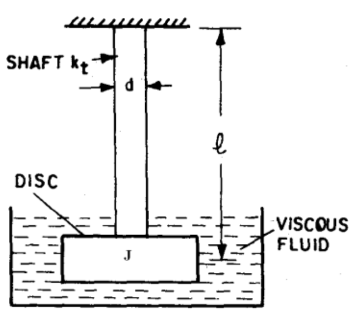
The course aims to teach basic concepts and recent developments related to mechanical vibrations, structural dynamics and vibration control. The Dynamics – Introduction to Mechanical Vibration course seeks to introduce students to the fundamentals of dynamics by providing an overview on mechanical vibration. Vibrations in machines and structures are typically undesirable as they produce stresses, energy losses and increased bearing loads. They contribute to structural wear and can lead to passenger discomfort in vehicles. This course covers the vibrations of discrete systems and continuous structures and introduces the computational dynamics of linear engineering systems. Learn how to derive equations of motion and design vibration isolation systems. Gain an understanding of the concepts of natural frequencies and mode shapes and their significance. Complete system modeling tasks and formulate equations to measure and ultimately minimize vibrations.

S No	QUESTION	Blooms Taxonomy Level	Course Outcomes
UNIT – I SINGLE DEGREE OF FREEDOM SYSTEMS			
Part - A (Short Answer Questions)			
1	What is Vibration?	Remember	1
2	Define natural frequency. Why is it important to determine the natural frequency of a vibrating system?	Understand	1
3	Define the following terms: Free, undamped, damped and forced vibrations.	Understand	1
4	Define the following terms: Resonance, phase difference, periodic motion, time period, amplitude and degree of freedom.	Understand	3
5	Distinguish between free and forced vibrations	Understand	2
6	Distinguish between damped and undamped vibrations	Remember	1
7	Distinguish between Rectilinear and torsional system	Remember	2
8	What are the various elements of a vibratory system?	Remember	2
9	Define longitudinal, transverse and torsional vibrations.	Remember	2
10	What is Forced Vibration? Give one example	Remember	2
11	Write equation of motion for simple vibration system	Understand	2

12	What is damping ratio?	Remember	2
13	Define damping	Remember	1
14	What is the difference between a vibration isolator and a vibration absorber?	Remember	2
15	What is the function of a vibration isolator?	Remember	3
16	What is a vibration absorber?	Remember	3
17	Define the transmissibility. Write the expression for motion transmissibility	Remember	2
18	What happens to the response of an undamped system at resonance?	Understand	3
19	What is meant by logarithmic decrement?	Remember	2
20	Define the term magnification factor	Remember	3
21	Indicate some methods for finding the response of a system under non periodic forces.	Remember	3
22	What is a response spectrum? And what are engineering applications?	Remember	3
23	How is the Laplace transformation of a function x(t) defined and advantages of this transformation method.	Understand	2
24	Define unit impulse, unit step and unit ramp functions?	Remember	3
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	1
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	1
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	2
4	In a particular case of a large canon, the gun barrel and recoil mechanism have a mass of 500kg with recoil spring stiffness 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.	Understand	2
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	1
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	1

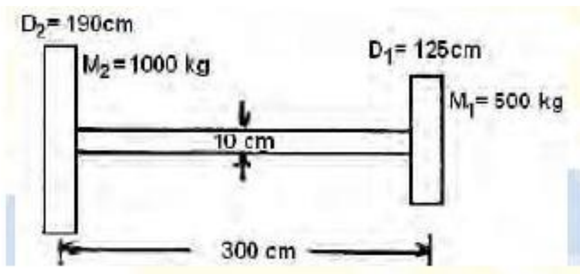
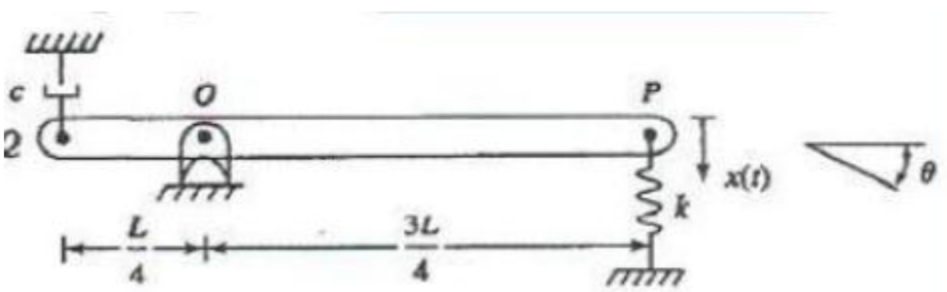
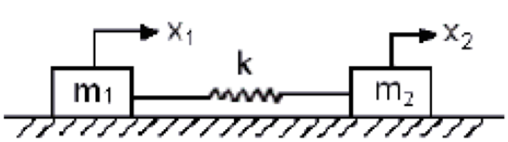
7	Determine the frequency of oscillations for the system shown in fig. Also determine the time period if m = 4 kg and r = 80 mm 	Remember	3
8	. Find the equivalent stiffness, frequency and time period for the system shown in figure below. If K_1=200 N/m, K_2= 100N/m, m= 20Kg, L= 2000mm, A= 100m^2, density is 7200kg/mm^3 	Remember	2
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	1

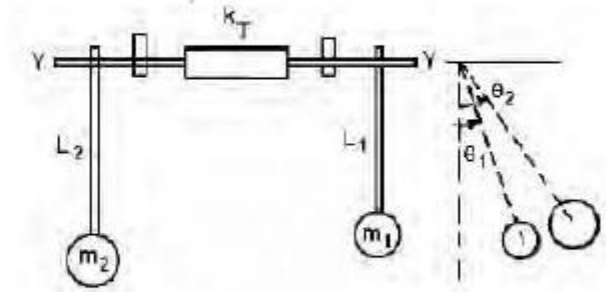
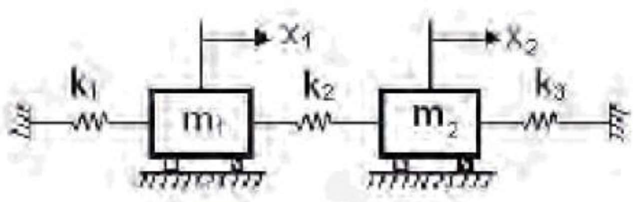
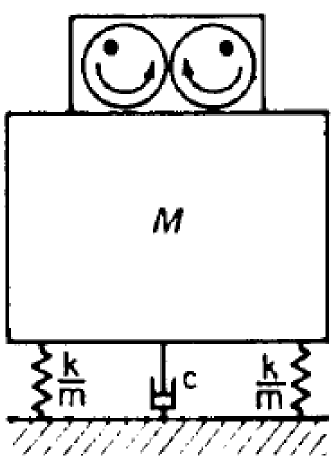
10	A wheel is mounted on a steel shaft (G = 83 * 10 ^{9} N/m2) of length 1.5m and 0.80 cm. The wheel is rotated 5o and released. The period of oscillation is observed as 2.3s. Determine the mass moment of inertia of the wheel. 	Remember	2
11	Derive the convolution integral for a single degree of freedom subjected to an impulse.	Understand	2
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	2
13	Explain the terms generalized impedance and admittance of a system.	Remember	2
14	Find the undamped response spectrum for the sinusoidal pulse force using initial conditions x(0)=0,dx/dt (0)=0	Remember	2
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	2
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	2
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	2
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	2
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	2
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	2
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	2

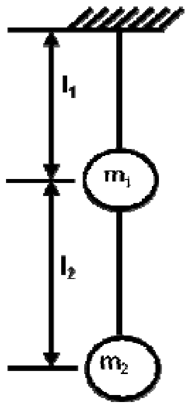
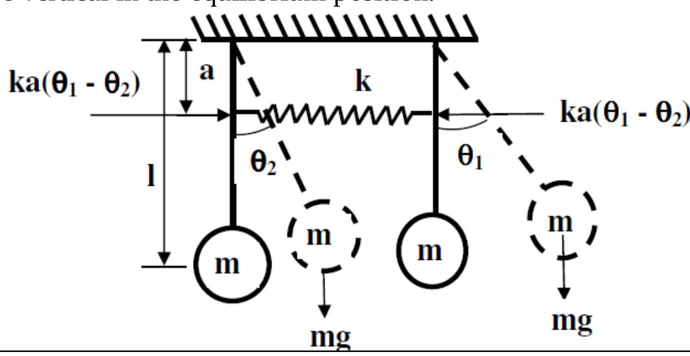
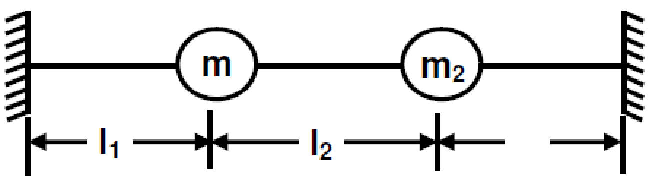
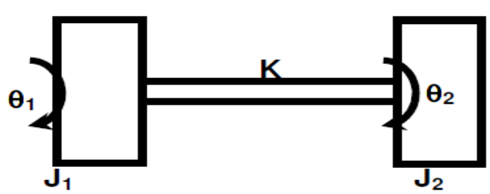
2	A mass of 20kg is supported on two isolators as shown in fig below. Determine the undamped and damped natural frequencies of the system, neglecting the mass of the Isolators.  Fig Q (2)	Understand	2
3	A gun barrel of mass 500kg has a recoil spring of stiffness 3,00,000 N/m. If the barrel recoils 1.2 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	2
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	2
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?  	Remember	2
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	2

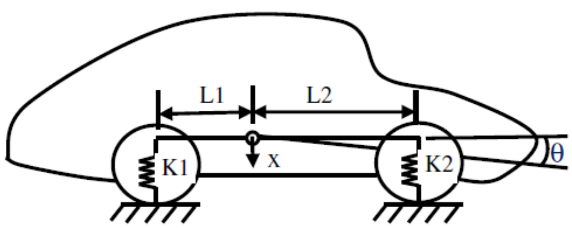
7	A mass of 1 kg is to be supported on a spring having a stiffness of 9800 N/m. The Damping coefficient is 5.9 N-sec/m. Determine the natural frequency of the system. Find also the logarithmic decrement and the amplitude after three cycles if the Initial displacement is 0.003m.	Remember	2
8	The damped 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	2
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	2
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?	Understand	2
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	2
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.	Remember	3
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	3
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	3
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	3
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 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.	Remember	3

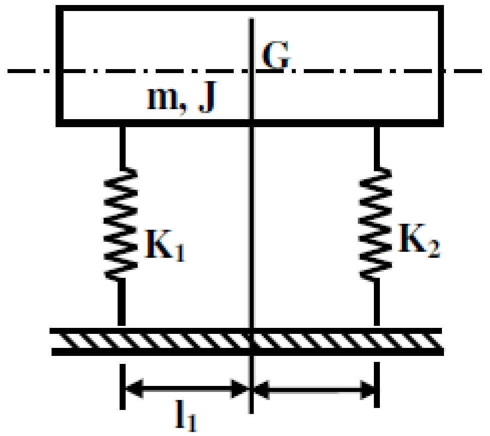
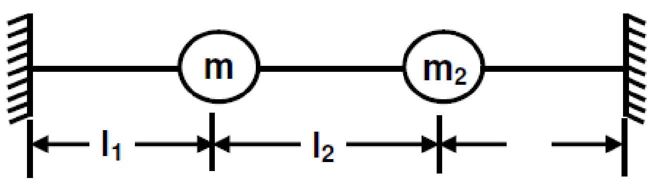
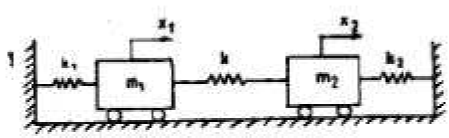
17	The time of free vibration of a mass hung from the end of a helical spring is 0.8 s. When the mass is stationary, the upper end is made to move upwards with displacement *y* mm given by *y* = 18 sin 2πt, where t is time in seconds measured from the beginning of the motion. Neglecting the mass of spring and damping effect, determine the vertical distance through which the mass is moved in the first 0.3 seconds.	Understand	2
	UNIT - II **TWO DEGREE FREEDOM SYSTEMS**		
	Part – A (Short Answer Questions)		
1	Write the frequency equation for the two DOF spring mass system	Remember	4
2	Write the frequency equation for the two DOF torsional system	Remember	4
3	What is the main disadvantage of a dynamic vibration absorber?	Understand	5
4	What is coordinate coupling?	Remember	5
5	What are static and dynamic couplings?	Remember	6
6	Define mass coupling	Remember	4
7	Define velocity coupling	Understand	4
8	Define elasticity coupling	Remember	4
9	What is semi definite system	Understand	4
10	Write a short note on principal mode of vibration	Remember	6
11	What are generalized coordinates?	Understand	6
12	What are principle coordinates?	Remember	4
13	Write a short note on Orthogonality principle as applied to two degree freedom system	Remember	4
14	What is the basic working principle of a dynamic vibration absorber?	Remember	5
15	How can we make system vibrate in one of its natural modes?	Remember	6
16	In a two D.O.F spring mass system, explain how Dynamic coupling exists.	Understand	4
17	What are principal co-ordinates when the system h subjected to linear as well as angular displacement?	Remember	6
18	Under what conditions a tuned absorber exists?	Understand	6
19	Explain conditions that are to be satisfied for a Ring tensional vibration absorber	Remember	4
20	What in the principle of working in a Houdille unturned damper?	Remember	4
	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	5
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	4
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	4

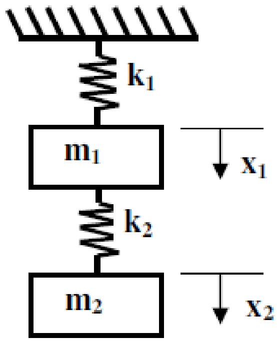
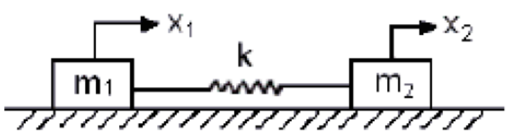
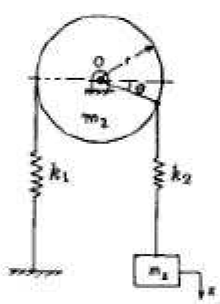
4	What is meant by static and dynamic coupling? How can coupling of the equations of motion be eliminated? Derive the governing equations through Lagrange energy approach.	Understand	4
5	Determine the natural frequency of torsional vibrations of a shaft with two circularises of uniform thickness at the 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 = $0.83 \times 10^{11} N/m^2$ 	Understand	6
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	4
7	Solve the problem shown in figure. m1=10kg, m2=15kg and k = 320 N/m. 	Remember	4

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	4
9	Determine the modes of vibrations for the system shown in figure 	Remember	6
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	6

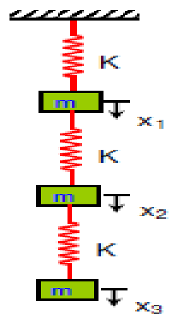
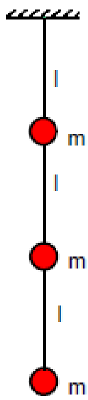
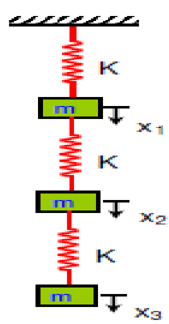
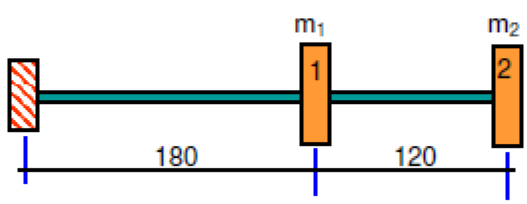
11	Derive the frequency equation for a double pendulum shown in figure. Determine the natural frequency and mode shapes of the double pendulum when $m_1=m_2=m$, $l_1=l_2=l$. 	Understand	5
12	Determine the natural frequencies of the coupled pendulum shown in the figure. Assume that the light spring of stiffness 'k' is un-stretched and the pendulums are vertical in the equilibrium position. 	Remember	4
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	4
14	Derive the equation of motion of a torsional system shown in figure  Figure Two Rotor System	Remember	4

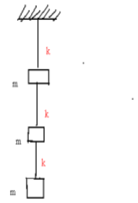
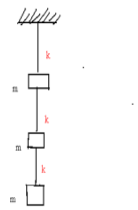
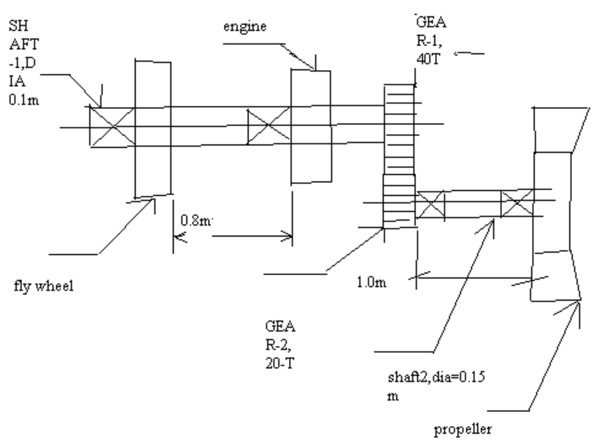
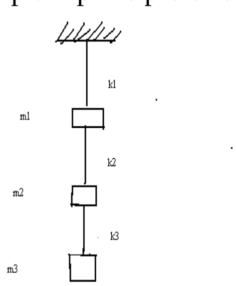
15	For the system shown in fig find the two natural frequencies when $m_1=m_2=9.8$ kg $K_1=K_3=8820$N/m, $K_2=3430$N\m. Find out the resultant motions of m_1 and m_2 for the following cases. The displacements mentioned below are from the equilibrium positions of the respective masses. Both masses are 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	4
16	Explain the working principle of Bifilar Suspension absorber with a neat diagram.	Remember	4
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	4
18	With a neat sketch, derive the governing equation of the Ring Tensional absorber	Remember	4
19	Explain the absorber principle in the case of centrifugal pendulum absorber from the first principles.	Remember	4
20	Draw and explain the amplitude and phase plots in a dynamic Vibration absorber .	Remember	4
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	4

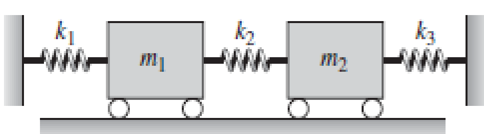
2	Determine the natural frequencies and mode shape of un-damped coordinate coupling system with two degrees of freedom 	Understand	4
3	Determine the natural frequencies of undamped dynamic vibration absorber	Remember	4
4	Determine the frequencies and the location of oscillation centres of an automobile 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	4
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	4
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	5

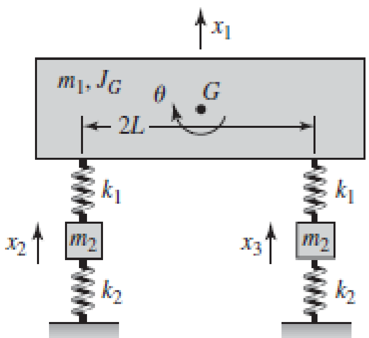
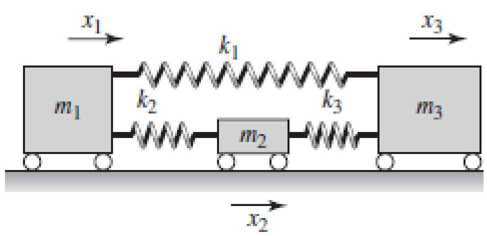
7	Figure shows a vibrating system having two DOF. Determine the two natural frequencies of vibrations and the ratio of amplitudes of the motion of m1 and m2for the two modes of vibrations  	Understand	6
8	Solve the problem shown in figure. m_1= 20kg, m_2= 35kg and k= 360 N/m  	Remember	6
9	Find the natural 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	6
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	6
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	7
2	Name a few methods for finding the fundamental natural frequency of a multi degree of freedom system	Understand	7

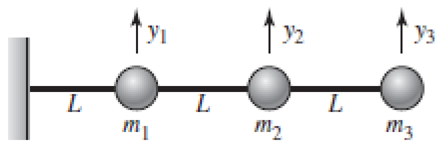
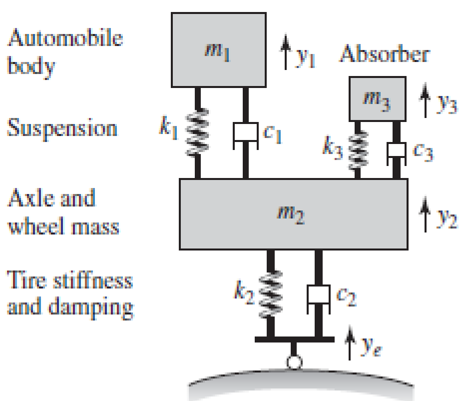
3	What is the matrix iteration method?	Understand	8
4	Can we use any trial vector in the matrix iteration method to find the largest natural frequency?	Understand	7
5	What is the difference between the matrix iteration method and Jacobi's method?	Understand	8
6	Using the matrix iteration method, how do you find the intermediate natural frequencies?	Understand	8
7	What are the different methods by which a vibrating system having several degrees of freedom can be analysed?	Remember	9
8	State Maxwell reciprocal theorem.	Remember	8
9	Distinguish between flexibility influence coefficient and stiffness coefficient.	Understand	9
10	Define stiffness influence coefficient as applicable to multi degree freedom vibrations.	Remember	9
	MID-II		
11	Write a short notes on matrix iteration method as applied to multi degree freedom	Understand	9
12	Write a short notes on orthogonality principle	Understand	9
13	What is mode shape?	Remember	7
14	State orthogonality principle in case of multi degree freedom system.	Understand	7
15	Write short notes on modal analysis.	Remember	8
16	What is the difference between vibiometer and Velometer?	Understand	4
17	What is the need for vibration measuring instruments?	Understand	4
18	Draw the sketch of a seismic instrument and label the parts	Understand	4
19	Write the governing equation for the instrument we the low natural frequency and Name the instrument	Understand	4
20	An instrument having high fundamental frequency. What is the governing equation and name of the instrument?	Understand	4
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	7
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	7
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	7

4	Obtain the approximate fundamental natural frequency of the linear spring system shown in Fig. using matrix method 	Understand	8
5	Obtain of the Flexibility influence coefficients of the pendulum system shown in the Fig 	Understand	8
6	Obtain the stiffness coefficients of the system shown in Fig 	Understand	9
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	9

8	Obtain natural frequency equation in matrix form for system shown in Fig. using Eigen value method 2. 	Understand	9
9	Find modal vectors and mode shapes of the system shown using Eigen value method 3 	Remember	9
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	9
	MID-II		
11	Explain principle of orthogonality of modal vectors 	Understand	9

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	8
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	8
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	8
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	7
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	7
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 $\omega^2 Z = 0.5 m/s^2$ when the system performs a harmonic motion at (i) 400 cpm (ii) 800cpm.	Understand	7
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	7
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	8
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	9
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	7
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	7
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	7

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 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. 	Understand	8
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	7
	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	8
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	9
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	9

9	Consider the system shown in Figure E8.10 in which the three masses *m*1, *m*2, and *m*3 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 $$[K]^{-1} = \frac{L^3}{3EI}\begin{bmatrix} 27 & 14 & 4 \\ 14 & 8 & 2.5 \\ 4 & 2.5 & 1 \end{bmatrix}$$ 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. 	Understand	9
10	Derive the equations of motion of the vehicle model shown in Figure 	Understand	9

UNIT-IV

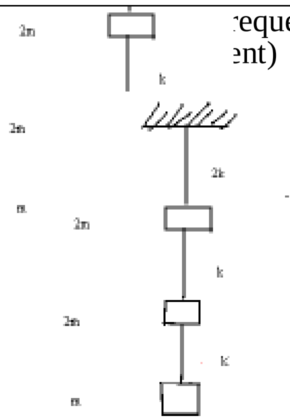
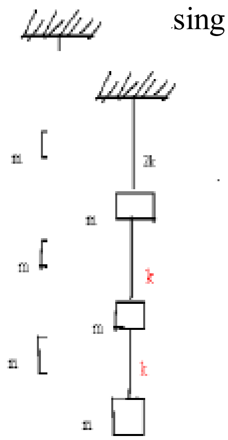
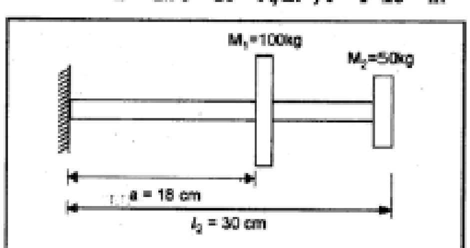
FREQUENCY DOMAIN VIBRATION ANALYSIS

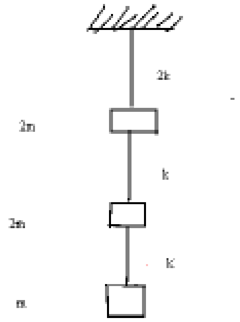
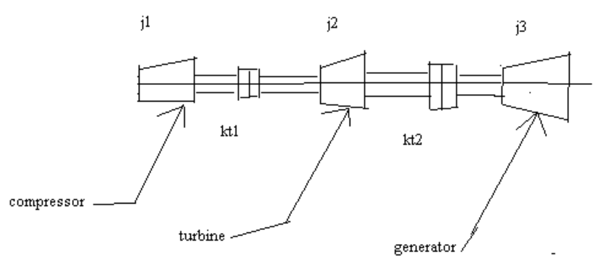
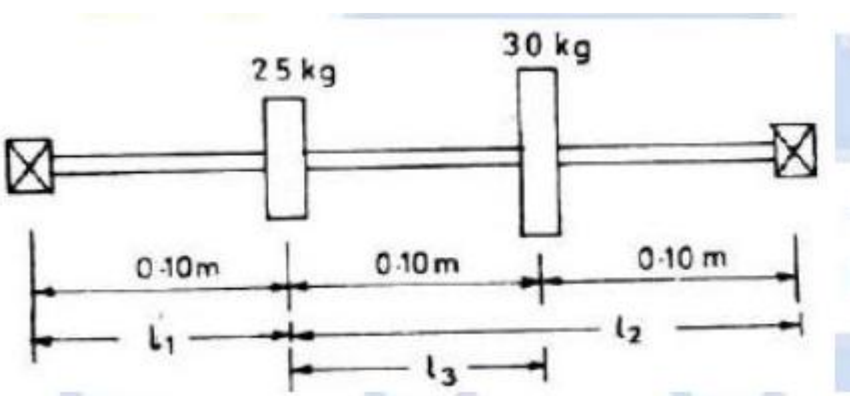
Part – A (Short Answer Questions)

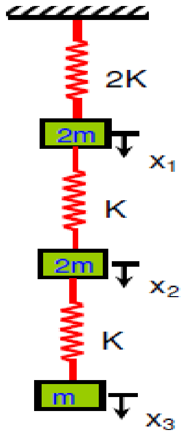
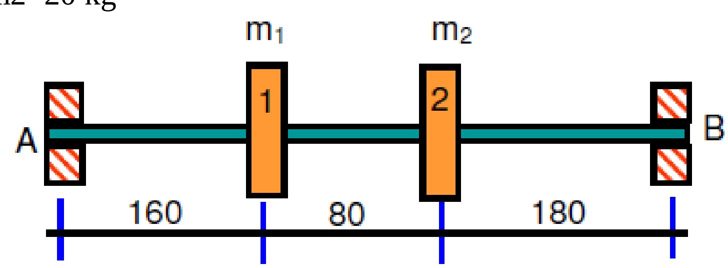
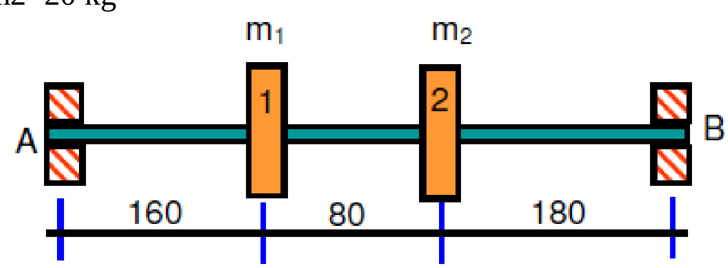
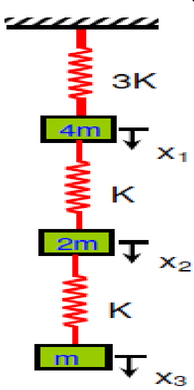
1	Why vibration analysis is important to monitor the condition of machine?	Understand	10
2	Write a short note on fast Fourier transform Theory?	Remember	10
3	What is complex fast Fourier transform theory?	Remember	10
4	Name some signal measurement and display units?	Remember	11
5	Name few vibration and acoustic measurement sensors	Remember	11
6	Name sources of vibrations in mechanical systems.	Remember	12
7	Explain the vibration phenomenon due to mechanical motion and force	Understand	11
8	Reciprocating linear motion machinery causes vibration why?	Understand	11
9	Write a short note on root cause analysis	Remember	10
10	Explain flow induced vibrations in mechanical systems.	Remember	11
11	Write a short note on machine train monitoring parameters	Understand	12
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	12

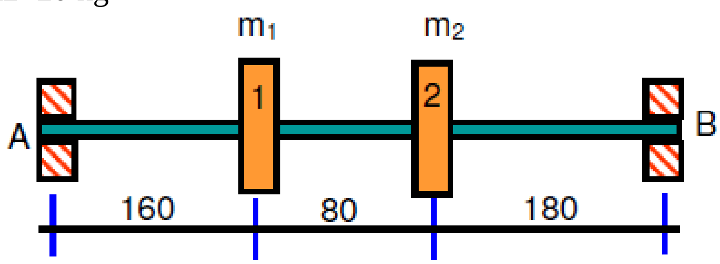
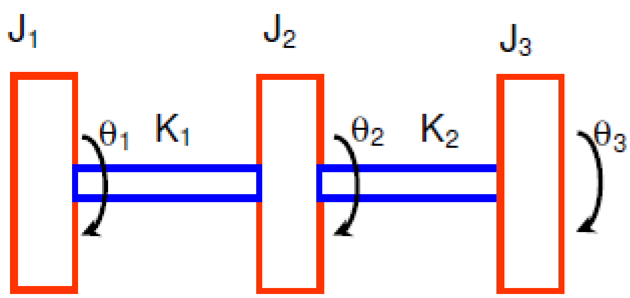
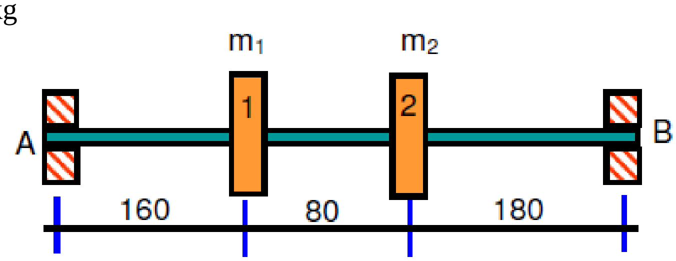
13	What types of instrumentation systems are used for condition monitoring of machines?	Remember	11
14	Change in vibration amplitude in an indication of a compounding change in operating system. Name the type of analysis technique to be used and explain.	Remember	12
15	Name different types of data types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

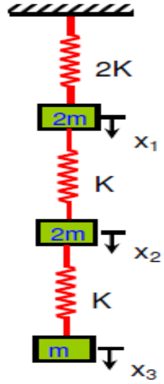
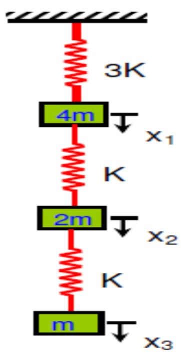
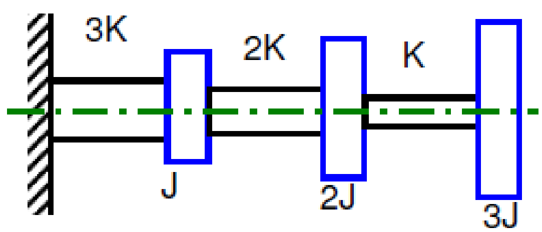
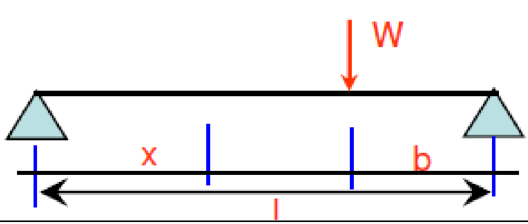
4	Explain faults in gears.	Understand	11
5	Explain rubs in rotor bearing system	Remember	12
6	Explain different types of data acquisition systems with compression to merits and demerits of each other.	Remember	12
7	Machine condition monitoring is very important. Explain thro trending analysis and its interpretation.	Understand	12
8	What conclusion can be drawn during condition monitoring of mechanical systems using failure mode analysis?	Remember	11
9	Explain signature analysis of a mechanical system subjected to forced vibration.	Understand	11
10	Root cause analysis is very essential for introducing to implement using fishbone chart. Explain	Remember	12
	UNIT-V **NUMERICAL METHODS**		
	Part - A (Short Answer Questions)		
1	Write a short notes on Stodola's method	Understand	13
2	Write a short notes on Rayleigh-ritz method	Remember	13
3	Write a short notes on Holzer's method	Remember	13
4	Write a short notes on matrix iteration method	Remember	14
5	Which numerical method is particularly used for torsional vibrations of shafts?	Remember	14
6	Which numerical method is usually applicable for solving for beam problems?	Understand	14
7	Which method is used to determine fundamental natural frequency of free undamped vibrating systems?	Remember	13
8	What are the disadvantages of stodola's method?	Remember	13
9	Write a short note on sweeping technique.	Understand	14
10	Write equation of motion of a vibrating system of n DOF in matrix form	Remember	15
11	Write down the fundamental natural frequency equation for Rayleigh Energy method applied for "n" masses	Remember	14
12	Dum Kerly's method used for determining natural frequency of 3 Rotor systems E X plain the procedure.	Understand	14
13	Distinguish between 3 to dole and Holzer methods.	Remember	13
14	Write any three numerical methods for obtaining fundamental frequency.	Remember	13
15	What are node points and mode shapes in case of matrix iferation method?	Remember	14
16	Which numerical method is used to finding torsional vibrations of shaft?	Understand	15
17	Write down the form in which frequencies are obtained using Rayleigh's Energy method.	Remember	14
18	Which method is most commonly used for determining fundamental frequency when the system me end in free and other end in fixed.	Understand	14
19	For solving beam problems, which numerical method is applied?	Remember	13
20	Explain node points and mode shapes. What is its physical significance?	Remember	13
	Part - B (Long Answer Questions)		

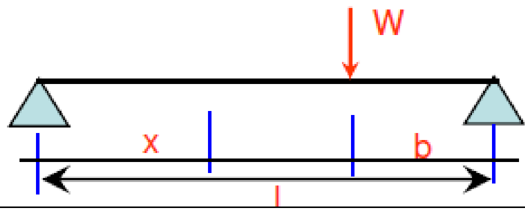
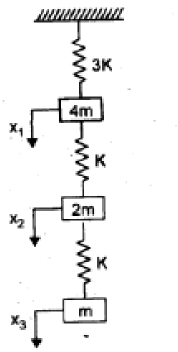
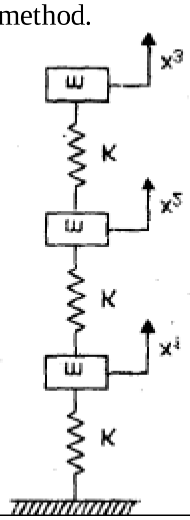
1	 equency using matrix Iteration method (use flexibility ent)	Understand	15
2	Estimate the approximate fundamental natural frequency of the system sing Rayleigh's method. Take: m=1kg and K=1000 N/m. 	Understand	15
3	Explain the Rayleigh ritz method for vibration analysis?	Remember	14
4	Find the lowest natural frequency of vibration for the system shown in Fig. by Rayleigh's method $E = 1.96 \times 10^{11}$ N/m^2 ; $I = 4 \times 10^{-7}$ m^4  Fig. 6.6	Remember	15

5	For system shown in below fig, determine the lowest natural frequency by “stodolas” method.(carry out two iterations)  	Remember	14
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	13
7	Determine the frequency of vibrations for the system shown in figure using stodola method.  	Understand	15

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	15
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	15
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	14
11	For the system shown in Fig. find the lowest natural frequency by holzer's method(carryout two iterations) 	Understand	15

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

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	13
3	For the system shown in Fig. find the lowest natural frequency by Stodola's method(carryout two iterations)  	Remember	14
4	For the system shown in the figure estimate natural frequencies using Holzar's Method.  	Remember	14
5	Find first natural frequency and modal vector of the system shown in the Fig. using Matrix iteration method. Use flexibility influence coefficient.  	Remember	14

6	Find the fundamental natural frequency and modal vector of a vibratory system shown in Fig. using Stodola's method. 	Understand	13
7	Determine the fundamental frequency and first mode of the system shown in Fig. using matrix Iteration method 	Remember	14
8	Determine the natural frequencies of the system shown in Fig using hozler's method. 	Understand	14
9	When one end is fixed and other end in free derive from the first principles for obtaining natural frequency using Holzer method..	Remember	14
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	15

Prepared By:
Prof. V.V.S.H Prasad, Professor

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