Question Bank

Chapter : 1 Balancing of Rotating Masses

1.	Explain the method of balancing of several masses in different planes.
2.	Explain the balancing of several masses rotating in same plane by Graphical Method.
3.	Why is balancing of rotating parts necessary for high speed engines? Explain clearly the terms static balancing and dynamic balancing. State the necessary conditions to achieve them.
2.	What are the reasons for unbalance in rotating machine elements? Give two practical examples of rotating unbalances in systems.
3.	What is meant by field balancing? Explain the procedure in detail.
4.	A statically balanced system need not to be dynamically balanced always. Justify the statement.
5.	Explain the balancing of several masses rotating in same plane by Graphical Method.
6.	What is static and dynamic balancing?

Examples

1.	Four masses A, B, C & D are completely balanced. Masses C & D makes an angle of 90^0 and 195^0 respectively with that of mass B in the counterclockwise direction. The rotating masses have the following properties: masses at B, C & D are 25 Kg, 40 Kg and 35 Kg respectively with their radii of rotations are 200 mm, 100 mm & 180 mm respectively. The radius of rotation of mass A is 150 mm. Planes B & C are 250 mm apart. Determine the (i) mass A and its angular position with that of mass B, (ii) position of all the planes relative to plane of mass A.
2.	A rotating shaft carries four unbalanced masses A=20 kg, B=15kg, C=18kg and D=12kg. The mass centers are 50, 60, 70 and 60 mm respectively from the axis of the shaft. The second, third and fourth masses rotates in planes 100, 150 and 300 mm respectively measured from the plane of first mass and at angular locations of 60º, 120º, and 280º respectively, measured clockwise from the first mass. The shaft is dynamically balanced by two masses, both located at 50mm radii and revolving in planes midway between those of first and second masses and midway between those of third and fourth masses. Determine the balancing masses and their angular positions.
3.	The four masses m1, m2 m3 and m4 having their radii of rotation as 200 mm, 150 mm, 250 mm and 300 mm are 200 kg, 300 kg, 240 kg and 260 kg in magnitude respectively. The angles between the successive masses are 45˚, 75˚ and 135˚ respectively. Find the position and magnitude of the balance mass required, if its radius of rotation is 200 mm. Use analytical method.

4.	Four masses 150 kg, 200 kg, 100 kg and 250 kg are attached to a shaft revolving at radii 150mm, 200 mm, 100 mm and 250 mm ; in planes A, B, C and D respectively. The planes B, C and D are at distances 350 mm, 500 mm and 800 mm from plane A. The masses in planes B, C and D are at an angle 105^0, 200^0 and 300^0 measured anticlockwise from mass in plane A. It is required to balance the system by placing the balancing masses in the planes P and Q which are midway between the planes A and B, and between C and D respectively. If the balancing masses revolve at radius 180 mm, find the magnitude and angular positions of the balance masses.
5.	A, B, C and D are four masses carried by a rotating shaft at radii 0.1 m, 0.15 m, 0.15 m and 0.2 m respectively. The planes in which the masses rotate are spaced at 500 mm apart and the magnitude of the masses B, C and D are 9 kg, 5 kg and 4 kg respectively. Find the required mass A; and the relative angular settings of the four masses so that the shaft shall be in complete balance.
6.	The four masses A, B, C and D revolve at equal radii are equally spaces along the shaft. The mass B is 7 kg and radii of C and D makes an angle of 90° and 240° respectively (counterclockwise) with radius of B, which is horizontal. Find the magnitude of A, C and D and angular position of A so that the system may be completely balance. Solve problem by analytically.

Chapter : 2 Dynamics of Reciprocating Engines

1.	Explain why the reciprocating masses are partially balanced.
2.	Explain Primary and Secondary Unbalanced Force Due to Reciprocating Masses.
3.	Partial balancing of Primary Unbalanced Force in Reciprocating Engine
4.	How and why are reciprocating masses balanced in a piston-cylinder assembly? Why reciprocating masses are partially balanced?
5.	What is Hammer blow? Derive an expression for limiting speed required for hammer blow.
6.	Write down short note on 'Variation of Tractive Force'.
7.	Derive the expressions for variation of tractive force, for an uncoupled two cylinder locomotive engine
8.	What are inline engines? How these engines are balanced?
9.	What is a secondary balancing of inline multi cylinder engines?
10.	Derive the expressions for primary and secondary unbalanced forces in a V -Engine.
11.	Explain concept of Balancing of V engines.
12.	Explain the direct and reverse crank method for determining unbalanced forces in radial engines.
13.	Explain concept of Direct and Reverse Crank.

Examples

1.	The following data relate to a single cylinder reciprocating engine; mass of reciprocating parts = 40 kg, mass of revolving parts = 30 kg at crank radius, speed = 150 rpm and stroke = 350 mm. If 60 % of the reciprocating and all the revolving parts are to be balanced. Determine (a) the balance mass required at a radius of 320 mm & (b) the unbalanced force when the crank has turned 45^0 from top dead centre.
2.	A single cylinder reciprocating engine has speed 240 rpm, stroke 300 mm, mass of reciprocating parts 50 kg, mass of revolving parts at 150 mm radius 30 kg. If all the mass of revolving parts and two-third of the mass of reciprocating parts are to be balanced, find the balance mass required at radius of 400 mm and the residual unbalanced force when the crank has rotated 60° from IDC.

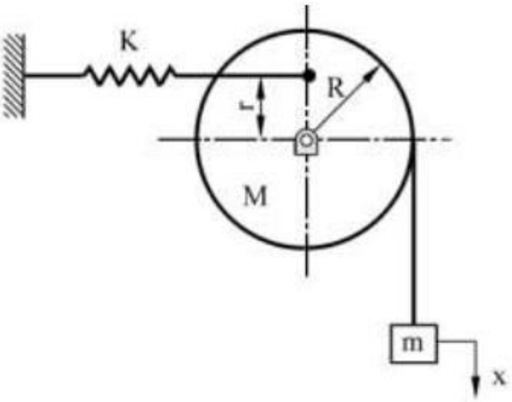
3.	The three cranks of three cylinder locomotive are all on the same axle and are set at 120 o .The pitch of the cylinders is 1 meter and the stroke of each piston is 0.6 m. The reciprocating masses are 300 kg for inside cylinder and 260 kg for each outside cylinder and the planes of rotation of the balance masses are 0.8 m from the inside crank. If 40% of the reciprocating parts are to be balanced, Find:- 1. The magnitude and the position of the balancing masses required at a radius of 0.6 m. 2. The hammer blow per wheel when the axle makes 6 r.p.s
4.	The following data refers to an inside cylinder locomotive: Mass of reciprocating parts/cylinder = 36 kg; Revolving masses/cylinder = 16 kg; Pitch of the cylinder = 700 mm; Angle between crank = 90^0; Length of each crank = 320 mm; Wheel tread diameter = 1900 mm; Distance between planes of wheel = 1800 mm; Limiting speed of locomotive = 100 km/h; If total revolving masses and 2/3 of the reciprocating parts are to be balanced; Determine: (i) Variation of tractive force (ii) Maximum swaying couple.
5.	The cranks and connecting rods of a four cylinder in-line engine running at 2000 rpm are 50mm and 200mm each respectively. The cylinders are spaced 0.2m apart. If the cylinders are numbered 1 to 4 in sequence from one end, the cranks appear at intervals of 90^o in an end view in the order 1-4-2-3.The reciprocating mass for each cylinder is 2kg. Determine (i) unbalanced primary and secondary forces, (ii) unbalanced primary and secondary couples with reference to central plane of the engine.
6.	The cranks and connecting rods of a 4-cylinder in-line engine running at 1800 r.p.m. are 60 mm and 240 mm each respectively and the cylinders are spaced 150 mm apart. The reciprocating mass corresponding to each cylinder is 10kg. If the cylinders are numbered 1 to 4 in sequence from one end, the cranks appear at intervals of 90° in an end view in the order 1-4-2-3. Determine: (I) Unbalanced primary and secondary forces, if any, and (ii) Unbalanced primary and secondary couples with reference to central plane of engine.
7.	The crank radius and connecting rod length of a four cylinder inline engine are 200 mm and 900 mm respectively. The outer cranks are set at 120^0 to each other and each has a reciprocating mass of 200 kg. The spacing between adjacent planes of cranks are 400 mm, 600 mm and 500 mm. If the engine is in complete primary balance, determine the reciprocating masses of the inner cranks and their angular positions. Also find the secondary unbalanced force if the engine speed is 300 rpm.
8.	A V-twin engine has the cylinder axes at right angles and connecting rod operate a common crank. The reciprocating mass per cylinder is 10 Kg and crank radius is 80mm.The length of connecting rod is 0.4m. Show that the engine may be balanced for primary forces by means of a revolving balance mass. If the engine speed is 600 rpm, what is the value of maximum resultant secondary force?

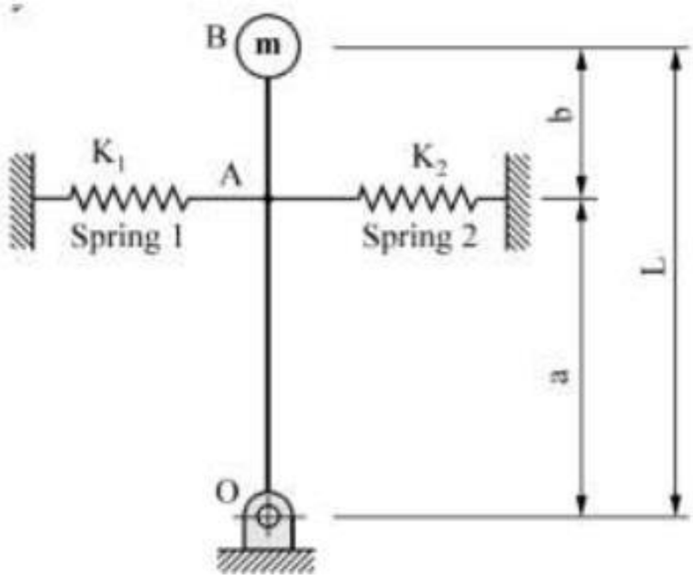
9.	The reciprocating mass per cylinder in a 60˚ V- twin engine is 1.5 kg. The stroke is 10 cm for each cylinder. If the engine runs at 1800 rpm, determine the maximum and minimum value of the primary forces and out the corresponding crank position.
10.	For a twin V-engine the cylinder centerlines are set at 90^0. The mass of reciprocating parts per cylinder is 2.5 kg. Length of crank is 100 mm and length of connecting rod is 400 mm. determine the primary and secondary unbalanced forces when the crank bisects the lines of cylinder centerlines. The engine runs at 1000 rpm.

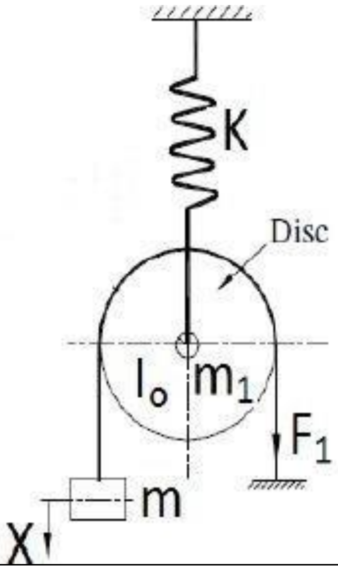
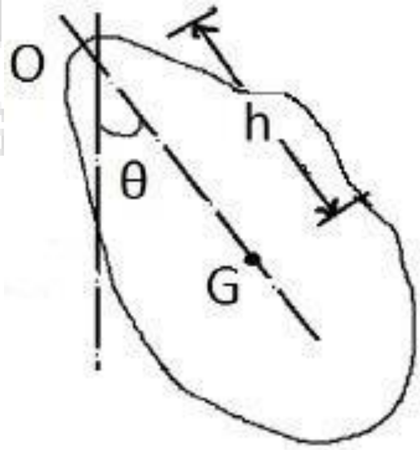
Chapter : 3 Introduction to Mechanical Vibrations

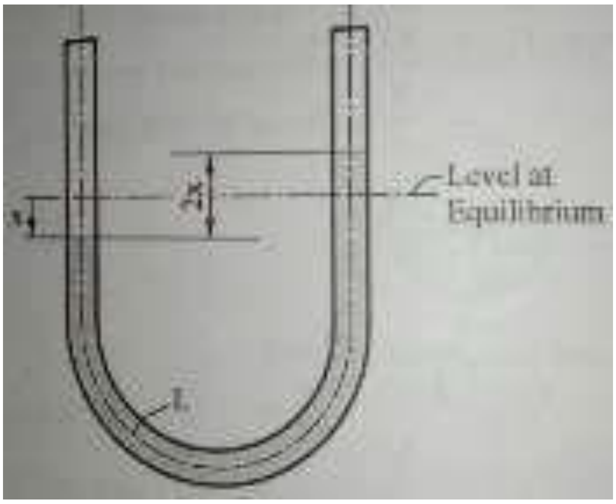
1.	**Define**: "Degrees of Freedom" (D.O.F).
2.	Write down detail **Classification of vibrations**.
3.	**Define:** (1) Time Period (2) Stiffness of Spring (3) Damped Vibration (4) Equivalent Damper in series.
4.	If two springs of stiffness K_1 and K_2 are connected in series and mass m is attached to it. Find its **natural frequency of the longitudinal vibration**.
5.	**Define**: resonance
6.	**Define**: steady state and transient vibrations.
7.	What is meant by **lumped parameter modelling**?
8.	Derive an expression for natural frequency of **cantilever beam subjected to point load at the end**.
9.	**Define**: (i) Degree of Freedom (ii) Damping (iii) Resonance

Single Degree of Freedom System (Linear and Torsional)

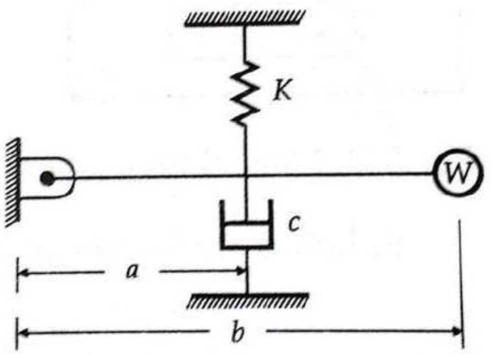
1.	**Define**: “Resonance & Damping”, “Undammed Free Vibration”, “Critical Damping Coefficient” (C_C), “Forced Vibrations”, ‘Force Transmissibility’ (T_r)
2.	Explain **Equilibrium method** to find the frequency of vibratory system.
3.	Write short note on **types of damping method**. (or What is **damping**? What are its **types**? Discuss any one of them.)
4.	Explain **Vibration isolation**.
5.	The equation of motion for a spring mass system is given by $m\ddot{x} + c\dot{x} + kx = F \sin \omega t$. Find **steady state response** of the system.
6.	Derive an expression for **logarithmic decrement**.
7.	Write short notes on: a) **Frequency Response Curve**, b) **Vibration Isolation**
8.	The mass 'm' is hanging from a chord attached to the circular homogeneous disc of mass 'M' and radius 'R' as shown in Figure. The disc is restrained from rotating by a spring attached at radius 'r' from the centre. If the mass is displaced downwards from rest position, determine the frequency of oscillations. 

9.	Find the natural frequency of system shown in Figure. If m, K_1, K_2, L are fixed, find the value of 'b' for which the system will not vibrate. 
10.	**Define**: period and cycle of vibration, damping ratio, magnification factor
11.	What is **equivalent spring stiffness**?
12.	Define **node in torsional vibration**.
13.	When do you say a vibrating system is **under damped**?
14.	Derive the differential equation of motion for a **free damped vibration**.
15.	Derive the **expression for equivalent damping coefficient**, when two dampers with damping coefficients C_1 and C_2 are connected in series and in parallel.
16.	Derive the **equation of motion for a disc** having mass moment of inertia 'I' suspended on wire of length 'L' with diameter 'd' ,when the disc was given an angular twist of 'Ɵ'.
17.	What is meant by **vibration isolation and transmissibility**?
18.	Discuss the vibration response of a single degree of freedom system if the damping provided is **under damped system.**
19.	**Define**: Resonance, logarithmic decrement and magnification factor.

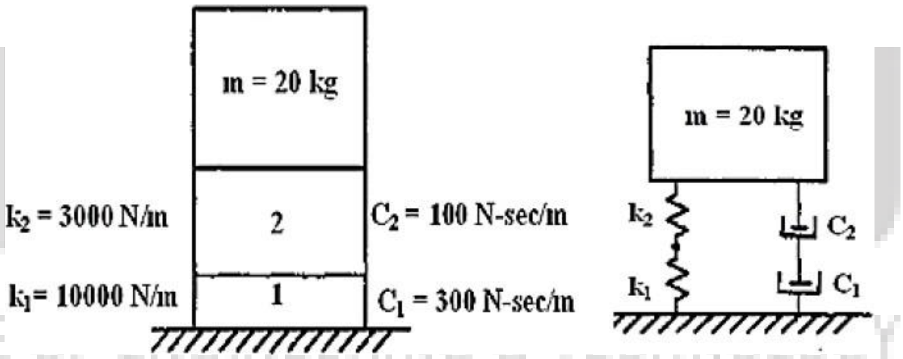
20.	Determine the **equation for the natural frequency** of the spring mass vibrating system shown in figure. 
21.	Find the **equation for natural frequency** of a spring mass vibrating system by using **Equilibrium method and Rayleigh's method.**
22.	Determine equation for the **natural frequency of vibration of the compound pendulum** shown in figure. 
23.	What is **vibration isolation**? What are its objectives & its materials?
24.	What is **transmissibility**? Plot the transmissibility and frequency curve for different damping conditions.
25.	What is the importance of forced **transmissibility** in mechanical vibrations?

26.	A U tube, open to atmosphere at both ends contains a column length L of a certain liquid as shown in figure. Find the **natural period of oscillation of the liquid column**. 
27.	Plot the **frequency response curve for the various damping factors** in the rage 0 to 2. State the observations made from the plot.
28.	What is **damping coefficient**? Explain with neat sketch **experimental method** of determination of damping coefficient of particular oil.
29.	Explain briefly **energy method** to find out characteristic equation for free vibration of single degree of freedom system.
30.	Discuss different cases showing the characteristics of the system performance for a **damped free vibration.**
31.	Write a short notes on "**Frequency Response Curve**"
32.	Define **force transmissibility**. Explain with neat sketch **transmissibility curves**.
33.	What are the various **sources of external excitations**?
34.	**Define**: Zero frequency and Node point.

Examples

1.	A coil of spring stiffness 4 N/mm supports vertically a mass of 20 kg at the free end. The motion is resisted by the oil dashpot. It is found that the amplitude at the beginning of the fourth cycle is 0.8 times the amplitude of the previous vibration. Determine the damping force per unit velocity. Also find the ratio of the frequency of damped and undamped vibrations.
2.	A single cylinder engine has a mass of 100 kg and is acted upon by a vertical unbalanced force of 400 sin (13πt) N. The engine block is supported on a spring having a stiffness 60 kN/m and a damper which gives a damping force of 700 N per unit velocity. Find the damping ratio and force transmitted to the foundation.
3.	A refrigerator unit having mass of 35 kg is to be supported on three springs, each having a spring stiffness s. The unit operates at 480 rpm. Find the value of stiffness s if only 10% of the shaking force is allowed to be transmitted to the supported.
4.	A vertical spring mass system has a mass of 0.5 kg and an initial deflection of 0.2 cm. find the spring stiffness and the natural frequency of the system.
5.	A vibrating system is defined by the following parameters: m=3 kg, k=100 N/m, C=3 N-sec/m. Determine (a) the damping factor (b) the natural frequency of damped vibration (c) logarithmic decrement (d) the ratio of two consecutive amplitudes (e) the number of cycles after which the original amplitude is reduced to 20 percent.
6.	Derive equation of motion for the system shown in Figure. If m = 1.5 kg, k = 4900 N/m, a = 6 cm and b = 14 cm, determine the value of damping coefficient (C) for which the system is critically damped. 

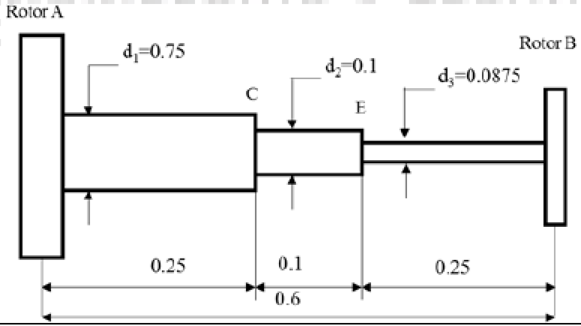
7.	A pump is supported on a spring and a damper. The spring stiffness is 6000N/m and the damper offers resistance of 480 N at 3.5 m/s. The unbalanced mass of 0.6 kg rotates at 40 mm radius and total mass of the system is 80 Kg. The pump is running at 500 rpm. Determine: i) damping factor, ii) amplitude of vibration iii) resonant speed and amplitude at resonance.
8.	Governing equation of motion of an underdamped single degree of freedom system with a mass of 31 kg is given as $d^2x/dt^2 + (3c/7m)\,dx/dt + (27k/7m)\,x = 0$. The amplitude of damped vibration reduces from 3 mm to 2 mm in successive vibrations in a duration of 0.1 seconds. Evaluate: i) frequency of damped vibration, ii) logarithmic decrement, iii) damping factor, iv) natural frequency, v) stiffness and vi) damping coefficient.
9.	A machine having mass of 100 kg is supported on a spring which deflects 20 mm under the dead load of machine. A dashpot is fitted to reduce the amplitude of free vibration to 10% of its initial value in two complete oscillations. Determine the stiffness of the spring, critical damping coefficient, logarithmic decrement, damping factor and frequency of damped-free vibration.
10.	The electric motor is supported on a spring and a dashpot. The spring has the stiffness 6400 N/m and the dashpot offers resistance of 500 N at 4 m/sec. The unbalanced mass 0.5 kg rotates at 50 mm radius and the total mass of vibratory system is 20 kg. The motor runs at 400 RPM. Determine (a) Damping factor (b) Amplitude of vibration and phase angle (c) Resonant speed and amplitude.
11.	A shock absorber is to be designed so that its overshoot is 10% of the initial displacement when released. Determine the damping factor.
12.	A gun barrel of mass 600 Kg has a recoil spring of stiffness 294 KN/m. If the barrel recoils 1.3 meter on firing, determine, (i) the initial recoil velocity of the barrel & (ii) the critical damping coefficient of the dashpot which is engaged at the end of the recoil stroke.
13.	In a single degree viscously damped vibrating system, the suspended mass of 16 Kg makes 45 oscillations in 27 seconds. The amplitude of natural vibrations decreases to one fourth of the initial value after 5 oscillations. Determine: (i) The logarithmic decrement, (ii) The damping factor and damping coefficient, (iii) The stiffness of the spring.
14.	A mass of 1 Kg is attached to a spring having a stiffness of 3920 N/m. The mass slides on a horizontal surface having coefficient of friction of 0.1. Determine the frequency of vibration of the system and the amplitude after one cycle if the initial amplitude is 2.5 mm.

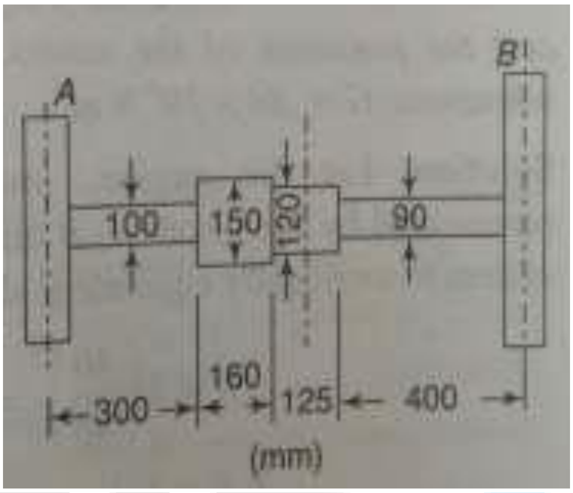
15.	A body of mass 70 Kg is suspended from a spring which deflects 20 mm under the load. If the damping factor of 0.23 is provided, then find the natural frequency of damped vibrations and ratio of successive amplitudes for damped vibrations. If the body is subjected to a periodic disturbance of 700 N at a frequency of 17.277 rad/sec, find the amplitude of forced vibration and the phase angle with respect to the disturbing force.
16.	A heavy machine weighing 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 75 mm. It is observed that the machine vibrates with an amplitude of 10 mm when the base of the foundation is subjected to harmonic oscillation at the undamped natural frequency of the system with an amplitude of 2.5 mm. find the (i) the damping constant of the foundation, (ii) the dynamic force amplitude on the base, (iii) the amplitude of the displacement of the machine relative to the base.
17.	A mass of 20 kg is supported on two isolators as shown in fig. Determine the undamped and damped natural frequencies of the system, neglecting the mass of the isolators. 
18.	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
19.	The damped vibration record of a spring-mass-dashpot system shows the following data. Amplitude on second cycle = 0.012 m; Amplitude on third cycle = 0.0105 m; Spring constant k = 7840 N/m; Mass m = 2 kg. Determine the damping constant, assuming it to be viscous.

Two Degrees of Freedom System

1.	**Give one Example** of two degree of freedom system.
2.	**Explain Torsionally Equivalent Shaft**.
3.	**Define:** torsional equivalent shaft.
4.	**Derive an expression** for length of torsionally equivalent shaft system.

Examples

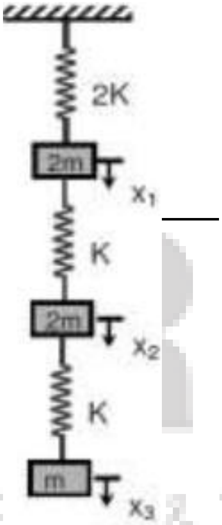
1.	Two rotors A and B are attached to the end of a shaft 50 cm long. Weight of the rotor A is 300 N and its radius if gyration is 30 cm and the corresponding values of B are 500 N and 45 cm respectively. The shaft is 7 cm in diameter for the first 25 cm, 12 cm for the next 10 cm and 10 cm diameter for the remaining of its length. Modulus of rigidity for the shaft material is 8×10^{11} N/m^2. Find: (i) the position of the node (ii) the frequency of torsional vibration.
2.	Two identical rotors are attached to the two ends of a stepped shaft as shown in Figure. Each rotor weighs 450 Kg and has radius of gyration of 0.38 m. The diameters of the shaft are 0.75 m for first 0.25 m length, 0.1 m for next 0.1 m length and for the remaining length 0.0875 m is the diameter. The total length of the shaft is 0.6 m. Find the frequency of free torsional vibrations of the system and position of the node from either masses. Assume modulus of rigidity as 80 x 10^9 N/m^2. 
3.	Two rotors, A and B are attached to the ends of the shaft 600 mm long. The mass and radius of gyration of rotor A is 40 kg and 400 mm respectively and that of rotor B are 50 kg and 500 mm respectively. The shaft is 80 mm diameter for first 250 mm, 120 mm for next 150 mm and 100 mm for the remaining length from the rotor A. Assume the modulus of rigidity of the shaft material 0.8×10^5 N/mm^2. Find: (i) Position of node on equivalent shaft of diameter 80 mm and on the actual shaft. (ii) Natural frequency of the torsional vibrations.

4.	The shaft shown in figure carries two masses. The mass A is 300 kg with a radius of gyration of 0.75 m and the mass B is 500 Kg with a radius of gyration of 0.9 m. Determine the frequency of the torsional vibrations. It is desired to have the node at the mid-section of the shaft of 120 mm diameter by changing the diameter of the section having a 90 mm diameter. What will be the new diameter? 

Multi Degrees of Freedom Systems and Analysis

1.	**Name any two methods** for analysis of multi degree of freedom systems
2.	Explain the **Stodola's method** to find out fundamental natural frequency of system having three degree of freedom.
3.	Discuss the **Rayleigh's method to obtain the natural frequency of the beam**.

Examples

2.	Estimate the approximate fundamental natural frequency of the system shown in Fig. using Rayleigh's method. Take: m=1 kg and K=1000 N/m. 

Rotating Unbalance

1.	What is **whirling speed of the shaft**?
2.	**Explain** Critical speed of shaft carrying single Rotor (without Damping).
3.	**Derive an expression** for critical speed of a shaft carrying rotor and without damping.
4.	What is meant by critical speed of a shaft? Which are the **factors affecting** it?
5.	What do you mean by whirling of shaft? **Why and where it is necessary to check the whirling speeds** of the shaft?

Examples

1.	A horizontal shaft of 10 mm diameter is simply supported at both ends by bearings. A rotor of mass 5 Kg is attached at middle of the horizontal shaft. The span between two bearings is 500 mm. The center gravity of the rotor is 2.5 mm offset from the geometric center of the rotor. The equivalent viscous damping at the center of the rotor-shaft may be taken as 52 Ns/m. Find the deflection of the shaft and critical speed of the shaft.
2.	A shaft of negligible weight 6 cm diameter and 5 metres long is simply supported at ends and carries four weights 50 kg each at equal distance over the length of the shaft. Find the frequency of vibration by Dunkerley's method. Take $E = 2 \times 10^6$ kg/cm^2.
3.	A rotor has a mass of 10 kg and is mounted on the middle of 22 mm diameter horizontal shaft supported at two bearings. The length of the shaft is 1 m. The shaft rotates at 2800 rpm. If the center of mass of the rotor is 0.11 mm eccentric to the geometric center of the rotor. Find the amplitude of steady state vibration and dynamic force transmitted to bearings. E=200 GN/m^2.
4.	A shaft of 50 mm diameter and 3 m length has a mass of 10 kg per meter length. It is simply supported at the ends and carries three masses of 70 kg, 90 kg and 50 kg at 1 m, 2 m and 2.5 m respectively from the left support. Find the natural frequency of transverse vibrations by using Dunkerley's method. Consider value of E = 200 GPa.

5.	The following data refers to a shaft held in long bearings. Length and diameter of shaft is 1200 mm and 14 mm respectively. Mass of the rotor at midpoint is 16 Kg, eccentricity of center of mass of rotor from center of rotor is 0.4 mm. Modulus of rigidity of shaft material 200 GN/m^2. Permissible stress in the shaft material is 70 x 10^6 N/m^2. Determine the critical speed of the shaft and the range of speed over which it is unsafe to run the shaft. Assume the shaft to be massless.

Chapter 4: Vibration Measurement

1.	What is the function of the **accelerometer**?
2.	Classification of **Vibration Measuring Instruments**. (or What are the classifications of vibration measuring instruments?)
3.	What are various **frequency measuring instruments**? Explain any one in detail.
4.	Explain, how the following systems can be used for vibration pickups: i) **LVDT**, ii) **Piezoelectric accelerometer**.
5.	Write a short note in **seismic instruments**.
6.	Why the measurement of vibration is necessary? What do you mean by vibration monitoring of machine? Enlist different vibration measuring instruments.