Introduction

The study of vibrations is concerned with the oscillatory motion of bodies and the forces associated with them. All bodies possessing mass and elasticity are capable of vibrating. Thus most engineering machines and structures experiences vibration to some degree and their design generally requires consideration of their oscillatory behaviour. The oscillatory motion of the system may be objectionable or necessary for performing a task.

The objective of the designer is to control the vibration when it is objectionable and to enhance the vibration when it is useful. Objectionable or undesirable vibration in machine may cause the loosening of parts, its malfunctioning or its failure. The useful vibration helps in the design of shaker in foundries, vibrators in testing machines etc. Sometimes vibrations are bad and other times they are good.

1.1. Causes of vibration: - The main causes of vibration are:-

1) **Unbalanced forces in the machine**. These forces are produced from within the machine itself because of non-uniform material distribution in a rotating machine element.

2) **Dry friction between the two mating surfaces**: This is what known as self-exited vibration.

3) **External excitations**. These excitations may be periodic, random or of the nature of an impact produced external to the vibrating system.

4) **Elastic nature of the system**

5) **Earth quakes**. These are responsible for the failure of many buildings, dams etc.

6) **Winds.** These may cause the vibrations of transmission and telephone lines under certain conditions.

The effect of vibrations is excessive stresses, undesirable noise, looseness of parts and partial or complete failure of parts. Inspite of these harmful effects the vibration phenomenon does have, some uses also e.g. in musical instruments, vibrating screens, shakers, stress relieving.etc.

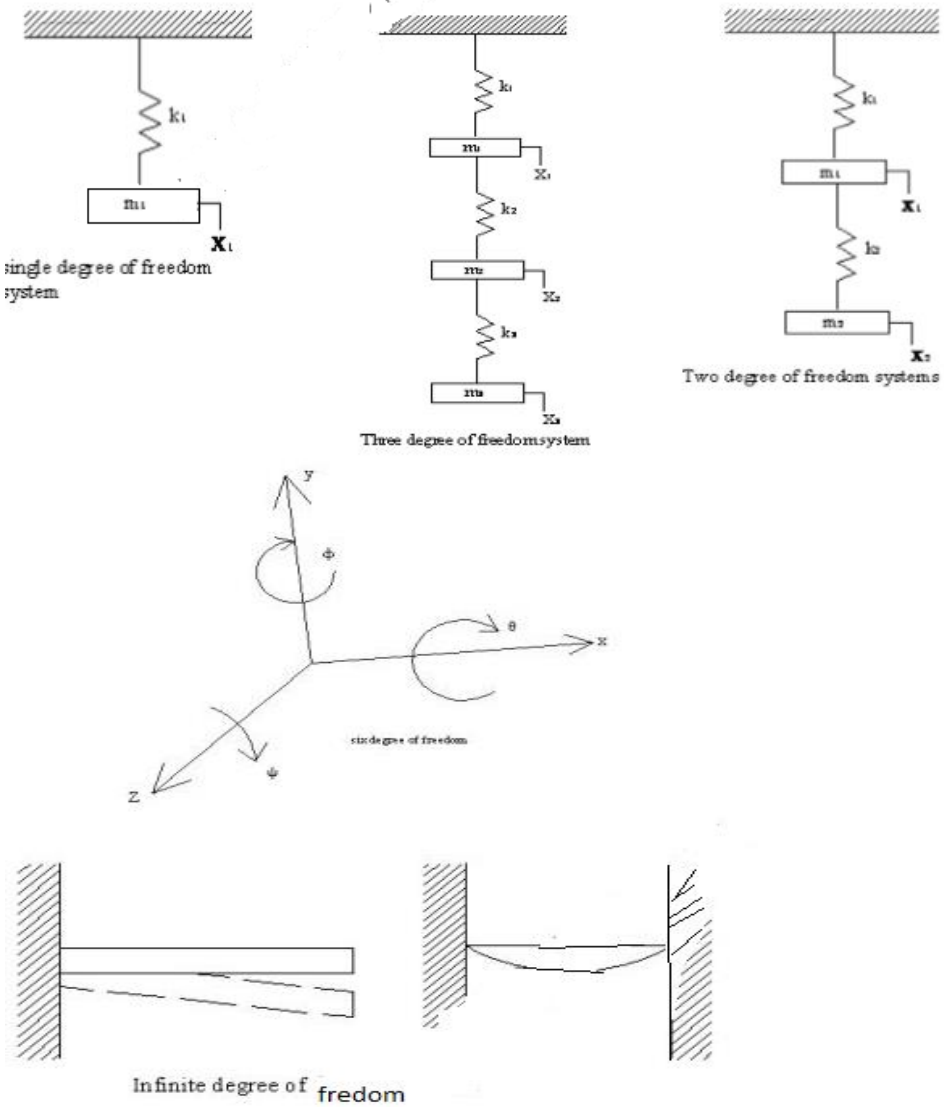
1.2. Methods to reduce vibrations

Elimination or reduction of the undesirable vibrations can be obtained by one or more of the following methods

1. Removing the cause of vibrations
2. Putting in screens if noise is the only objection
3. Resting the machinery in proper type of isolators
4. Shock absorbers.
5. Dynamic vibration absorbers

Vibration terminology:

1) **Periodic motion**: A motion which repeats itself after equal intervals of time is known as periodic motion. Any periodic motion can be represented by function x (t) in the period T. the function x(t) is called periodic function
2) **Time period**: - Time taken to complete one cycle is called time period.
3) **Frequency:** - The number of cycles per unit time is known as frequency.
4) **Natural frequency**: - When no external force acts on the system after giving it an initial displacement, the body vibrates. These vibrations are called free vibrations and their frequency as natural frequency. It is expressed in c/s or hertz
5) **Amplitude**: - The max displacement of a vibrating body from its equilibrium position is called amplitude.
6) **Fundamental mode of vibration**: - The fundamental mode of vibration of a system is the mode having the lowest natural frequency.
7) **Resonance:** - When the frequency of external exitation is equal to the natural frequency of a vibrating body, the amplitude of vibration becomes excessively large. This concept is known as resonance.
8) **Mechanical systems**: - The systems consisting of mass shiftness and damping are known as mechanical systems.
9) **Continuous and discrete systems**: - Most of mechanical systems include elastic members which have infinite number of degree of freedom. Such systems are called continuous systems. Continuous systems are also known as distributed systems. Ex. Cantilever, Simply supported beam etc. Systems with finite number of degrees of freedom are called discrete or lumped systems.
10) **Degree of freedom**: - The minimum no of independent co-ordinates required specifying the motion of a system at any instant is known as degree of freedom of the system. Thus a free particle undergoing general motion in space will have three degree of freedom, while a rigid body will have six degree of freedom i.e. three components of position and three angles defining its orientation. Furthermore a continuous body will require an infinite number of co-ordinates to describe its motion; hence its degree of freedom must be infinite.
11) **Simple harmonic motion (SHM)** A periodic motion of a particle whose acceleration is always directed towards the mean position and is proportional to its distance from the mean position is known as SHM. It may also be defined as the motion of a projection of a particle moving round a circle with uniform angular velocity, on a diameter.
12) **Phase difference** It is the angle between two rotating vectors representing simple harmonic motion of the same frequency



2.2.2 Classification of vibrations Mechanical vibrations may broadly be classified the following types

1) Free and forced vibration
2) Linear and nonlinear vibration
3) Damped and un damped vibration
4) Deterministic and random vibration
5) Longitudinal, transverse and torsional vibration
6) Transient vibration

1. Free and Forced vibration

Free vibration takes place when system oscillates under the action of forces inherent in the system itself and when external impressed forces are absent. The system under free vibration will vibrate at one or more of its natural frequencies. Vibration that takes place under the exitation of external forces is called forced vibration. When the exitation is oscillating the

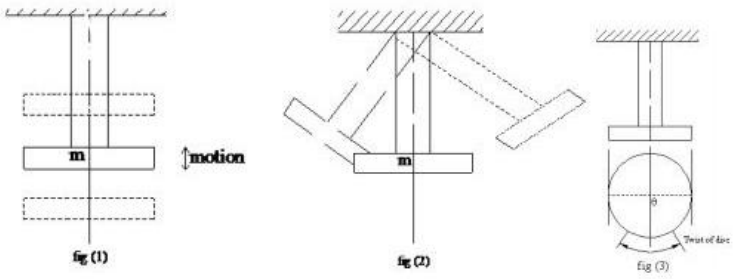
system is forced to vibrate at the exitation frequency. If the frequency of excitation coincides with one of the natural frequency of the system, a condition of resonance is encountered, and dangerously large oscillations may result.

2**) Linear and Non-linear vibration** If in a vibrating system mass, spring and damper behave in a linear manner, the vibrations caused are known as linear in nature. Linear vibrations are governed by linear differential equations. They follow law of superposition. On the other hand, if any of the basic components of a vibrating system behaves non-linearly, the vibration is called non-linear. Linear vibration becomes non-linear for very large amplitude of vibration. It does not follow the law of super- positions.

3) Damped and Undamped vibration If the vibrating system has a damper, the motion of the system will be opposed by it and the energy of the system will be dissipated in friction. This type of vibration is called damped vibration. The system having no damper is known as undamped vibration

4) Deterministic and Random vibration If in the vibrating system the amount of external excitation is known in magnitude, it causes deterministic vibration. Contrary to it the non-deterministic vibrations are known as random vibrations.

5) **Longitudinal, Transverse and Torsional vibration** Fig represents a body of mass 'm' carried on one end of a weightless spindle, the other end being fixed. If the mass moves up and down parallel to the spindle and it is said to execute longitudinal vibrations as shown in fig (1).



When the particles of the body or spindle move approximately perpendicular to the axis of the spindle as shown in fig (2) the vibrations so caused are known as transverse vibrations if the spindle gets alternately twisted and untwisted on account of vibrating motion of the suspended disc, it is said to be undergoing torsional vibrations as shown in fig(3).

6**) Transient Vibration** In ideal system the free vibrations continue indefinitely as there is no damping. The amplitude of vibration decays continuously because of damping (in a real system) and vanishes ultimately. Such vibration in a real system is called transient vibration

ILLUSTRATIONS

1. **What do you by vibration? Explain the causes of Vibration**.

Ans) Vibration is a mechanical phenomenon whereby oscillations occur about an equilibrium point. The oscillations may be periodic such as the motion of a pendulum or random such as the movement of a tire on a gravel road.

Causes of vibration: - The main causes of vibration are:-

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2.Define the following:

a) Periodic Motion b) Time Period c) Frequency d) Amplitude

ans) Periodic motion: A motion which repeats itself after equal intervals of time is known as periodic motion. Any periodic motion can be represented by function x (t) in the period T. the function x(t) is called periodic function.

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Amplitude: - The max displacement of a vibrating body from its equilibrium position is called amplitude

4. Explain any five types of vibrations, with examples.

Ans) 1. Free and Forced vibration

Free vibration takes place when system oscillates under the action of forces inherent in the system itself and when external impressed forces are absent. The system under free vibration will vibrate at one or more of its natural frequencies. Vibration that takes place under the

excitation of external forces is called forced vibration. When the excitation is oscillating the system is forced to vibrate at the exitation frequency. If the frequency of excitation coincides with one of the natural frequency of the system, a condition of resonance is encountered, and dangerously large oscillations may result.

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