Unit ①

Introduction:-

Vibration:-

Any motion which repeats itself an interval of time is called vibration or oscillation.

for example,- the swinging of simple pendulum is an example of vibration or oscillation as the motion of ball is to and fro from its mean position repeatedly.

The main reasons of vibration are

1. Unbalanced centrifugal force in the system. This is caused because of non-uniform material distribution in a rotating machine element.
2. Elastic nature of the system.
3. External excitation applied on the system.
4. winds may cause vibrations of certain systems such as electricity lines, telephone lines. etc...

Importance of Vibration study in Engineering.

Is vibration good or bad ???

→ Both,

* high speed engines and turbines are subjected to vibration, due to faulty design and poor manufacture there is an unbalance in the engines which causes excessive and unpleasant stresses in the rotating system.
* Vibration cause rapid wear of machine part such as bearings and gears.
* Unwanted vibration may cause loosening of parts from the machine.
* Many buildings, structures and bridges fail because of vibration Ex: Tacoma Narrow bridge:-
* Sometimes because of heavy vibrations proper reading of instrument cannot be taken.
* Excessive vibration is dangerous for human beings.

* Vibration can be used for useful purposes such as Vibration testing equipments, vibratory conveyors, hoppers,

* Vibration is found very fruitful in mechanical workshops such as in improving the efficiency of machining, casting, forging and welding Techniques, musical instruments and earthquakes for geological research.

* It is useful for the propagation of sound.

∴ Thus undesirable vibrations should be eliminated or reduced upto certain extent by the following methods,

1. Removing external excitation, if possible.
2. Using shock absorbers
3. Dynamic absorbers
4. Resting the system on proper vibration isolators.

DEFINITIONS: Ref book : V.P Sing.

1. Periodic motion:-

* A motion which repeats itself after equal intervals of time

2. Time period

* Time Taken to complete one cycle. $t = \frac{2\pi}{\omega}$

3. Frequency.

* Number of cycles per unit time $f = \frac{1}{t}$, $f = \frac{\omega}{2\pi}$

4. Amplitude.

* The maximum displacement of a vibrating body from its equilibrium position

5. Natural frequency:-

* When no external force acts on the system after giving it an initial displacement the body vibrates. These vibrations are called free vibration and their frequency as natural frequency. It is expressed in rad/sec (or) Hertz

ω = angular f (linear (or) non-linear)

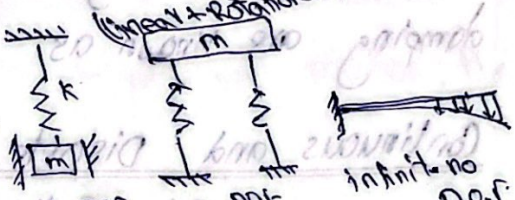
Fundamental mode of vibration:

The fundamental mode of vibration of a system is the mode having the lowest natural frequency.

Degree of freedom:-

The minimum number of independent coordinates required to specify the motion of a system at any instant is known as degrees of freedom of the system.

1. Finite degree of freedom
2. Infinite degree of freedom.

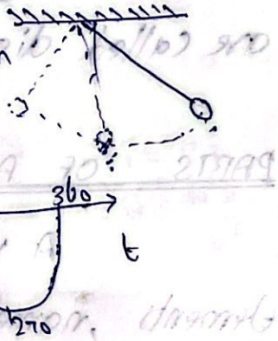


Simple harmonic motion:

The motion of a body to and fro about a fixed point is called simple harmonic motion.

"The motion is periodic and its acceleration is always directed towards the mean position and is proportional to its distance from mean position".

The motion of the simple pendulum



$$\therefore \quad x = A \sin \omega t$$

$$\dot{x} = A\omega \cos \omega t$$

$$\ddot{x} = -A\omega^2 \sin \omega t$$

$$\ddot{x} = -\omega^2 x \quad \therefore \ddot{x} \propto x$$

where, x, $\dot{x}$, $\ddot{x}$ are displacement, velocity and acceleration of the body (pendulum).

Damping:

It is the resistance to the motion of a vibrating body. The vibrations associated with this resistance are known as damped vibrations.

phase difference:

Suppose there are two vectors x_1 and x_2 having frequencies ω rad/sec each. The vibrating motions can be expressed as:

$$x_1 = A_1 \sin \omega t$$

$$x_2 = A_2 \sin (\omega t + \phi)$$

ϕ = phase difference.

Resonance:

When the frequency of external excitation is equal to the natural frequency of a vibrating body, the amplitude of vibration becomes excessively large. This concept is known as resonance.

Mechanical systems:

The systems consisting of mass, stiffness and damping are known as mechanical system.

Continuous and Discrete System:

Most of the mechanical systems include elastic members which have infinite number of degree of freedom. such system are called continuous systems. Continuous systems are also known as distributed systems. Cantilever, simply supported beam..etc.

systems with finite number of degrees of freedom are called discrete or lumped systems.

PARTS OF A VIBRATING SYSTEM:-

A vibratory system basically consist of three elements, namely the mass (m) the spring (k) and Damper(c) In a vibrating body there is exchange of energy from one form to another. Energy is stored by mass in the form of kinetic energy ($\frac{1}{2}m\dot{x}^2$) in the spring in the form of potential energy ($\frac{1}{2}kx^2$) and dissipated in the damper in the form of heat energy which opposes the motion of the system.

Energy enters the system with the application of external force known as excitation.

The excitation disturbs the mass from its mean position and mass goes up and down from the mean position.