Different Terms of Vibration Terminology

Vibration Terminology:

Vibration terminology consists of 12 terms which are:

1. **Periodic Motion**
2. **Time Period**
3. **Cycle**
4. **Frequency**
5. **Amplitude**
6. **Natural Frequency**
7. **The fundamental mode of vibration**
8. **Degree of freedom**
9. **Simple harmonic motion**
10. **Damping**
11. **Resonance**
12. **Mechanical System**

1. Periodic Motion:

The motion which repeats itself after an equal interval of times is called Periodic motion.

2. Time Period:

This is defined as time to complete one cycle is called a Time period and it is normally expressed in seconds (s).

3. Cycle:

It is motion completed during one time period.

4. Frequency:

This is defined as the number of cycles describes in one second.

5. Amplitude:

The maximum displacement of the vibrating body from its equilibrium position.

6. Natural frequency:

When no external force acts on the system after giving its an initial displacement, the body vibrates.

The vibration is called as free vibration and the frequency is called Natural frequency. This is expressed in rad/sec or Hertz.

7. The fundamental mode of vibration:

The fundamental mode of vibration is the model having the lowest natural frequency

8. Degree of Freedom:

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

9. Simple Harmonic Motion:

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

10. Damping:

It is resistance to the motion of a vibrating body.

The vibration associated with the resistance is known as Damped Vibration.

11. Resonance:

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

12. Mechanical System:

The system consists of Mass, stiffness, and damping are known as a mechanical system.

Vibration-Definition, Types (Free or Natural, Forced, Damped), Terminology, PDF

What is Vibration Definition?

Vibration defined as when an elastic body such as spring, a beam, and a shaft are displaced from the equilibrium piston by the application of external forces and then released they executive as vibratory motion.

When body particles are displaced by the application of external force, the internal force in the form of elastic energy are present in the body, tries to bring the body to its original position.

At equilibrium position, the whole elastic energy is converted into kinetic energy and the body continues to move in the opposite direction of it.

The whole of kinetic energy is again converted into elastic or strain energy due to which the body again returns to its equilibrium position.

In this way, vibratory motion is repeated indefinitely and exchange of energy takes place.

Thus, any motion which repeats itself affect an interval time is called Vibration or Oscillation.

Vibration Types:

There are 3 types of Vibration:

1. **Free or Natural**
2. **Forced and**
3. **Damped Vibration**

1. Free or Natural Vibration:

This is defined as when no external force acts on the body, after giving it an initial displacement, then the body is said to be under free or natural vibration.

The frequency of free or natural vibration is called free or natural frequency.

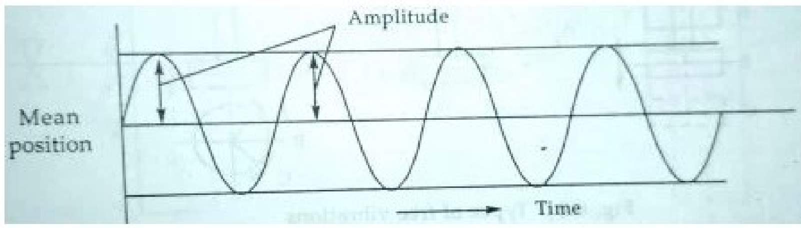
It is observed that the amplitude keeps decreasing with respect to the time shown in the above diagram.

2. Forced Vibrations:

When the body vibrates under the influence of external force, the body is said to under forced vibrations.

The external force is applied to the body is a periodic distributing force created by unbalance.

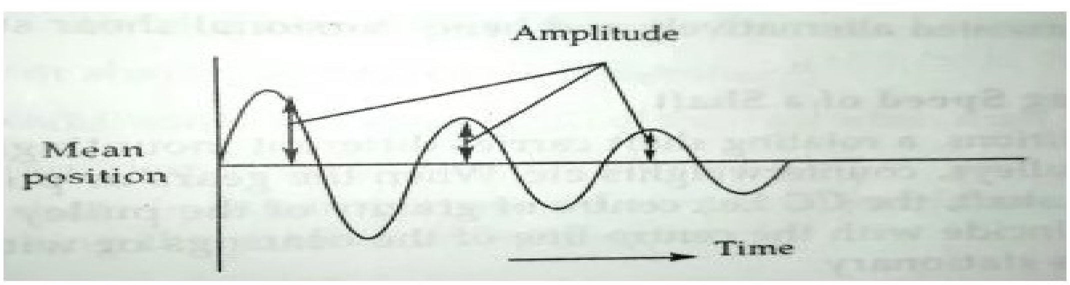
This has the same frequency as the applied force.



Here It is observed that the amplitude remains constant with respect to the time shown in the above diagram.

3. Damped Vibration:

When there is a reduction in amplitude over every cycle of vibration, the motion is said to be damped vibration.

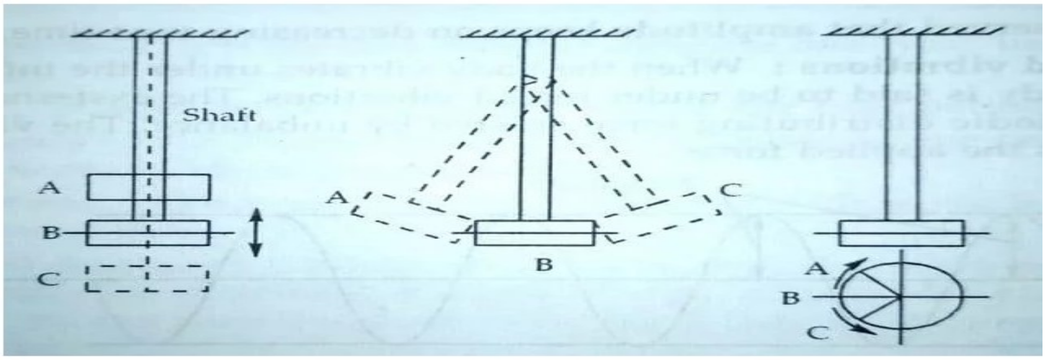


It is observed that the amplitude reduces abruptly with respect to the time shown in the above diagram.

Types of Free Vibration:

1. **Longitudinal**
2. **Transverse and**

3. **Torsional Vibration.**



1. Longitudinal Vibrations:

In this, the particles of the shaft or disc move parallel to the axis of the shaft as shown in the above diagram.

In this case, the shaft is elongated and shortened alternately thus executing the tensile and compressive stresses alternately on the shaft.

2. Transverse vibrations:

In this, the particles of the shaft or disc move perpendicular to the axis of the shaft as shown in the above diagram.

Here the shaft is straight and bent alternatively and hence bending stresses are induced in the shaft.

3. Torsional Vibrations:

In this, the particles of the shaft or disc move in a circle about axis of the shaft as shown in the above diagram.

Here the shaft is twisted and untwisted alternatively and hence torsional shear stress is induced in the shaft.

Free Longitudinal vibrations:

Equilibrium Method:

It is based on the principle that whenever a vibratory system is in equilibrium, the algebraic sum of forces and moments acting on it is zero recordings to D'Alembert's Principle that the sum of inertia forces and external forces on a body in equilibrium must be zero.

Let, Δ = static deflection

k = Stiffness of the spring

Inertial force = ma (upwards, a = acceleration)

Spring force = kx (upwards)

So the equation becomes

ma + kx = 0

$\Rightarrow \omega_n = \sqrt{(k/m)}$

Linear frequency **$f_n = (1/2\pi)\sqrt{(k/m)}$**

Time period **$T = 1/f_n = 2\pi\sqrt{(m/k)}$**

Energy method:

In a conservative system (system with no damping) the total mechanical energy i.e. the sum of the kinetic and the potential energies remains constant

d/dt (K.E+ P.E.) = 0

Rayleigh's Method:

In this method, the maximum kinetic energy at the mean position is made equal to the maximum potential energy(or strain energy) of the extreme position.

The displacement of the mass 'm' from the mean position at any instant is given by

$a+\omega_n^2 x = 0$

$x = A \sin\omega_n t + B \cos\omega_n t$

Let $A = X \cos \varphi$; $B = X \sin \varphi$

$x = X \sin(\omega_n t +\varphi)$

Velocity, $V = X\omega_n \sin [\pi/2 + (\omega_n t +\varphi)]$

Acceleration, $f = X\omega_n^2 \sin[\pi + (\omega_n t +\varphi)]$

These relationships indicate that

- the velocity vector leads the displacement vector by $\pi/2$.
- acceleration vector leads the displacement vector by π.

Consider, 'm' = man of the spring wire per unit length

l = total length of the spring wire $m_1 = m'l$

KE of the spring = 1/3 * KE of a mass equal to that of the spring moving with the same velocity as the free end.

$f_n = (1/2\pi) \sqrt{(s/(m+(m_1/m)))}$

$\mathbf{f_n = (1/2\pi) \sqrt{g/\Delta}}$

Damped Vibrations:

When an elastic body is set in vibratory motion, the vibrations die out after some time due to the internal molecular friction of the mass of the body and the friction of the medium in which it vibrates. The diminishing of the vibrations with time is called damping.

Shock absorbers, fitted in the suspension system of a motor vehicle, reduce the movement of the springs. when there is a sudden shock.

It is usual to assume that the damping force is proportional to the velocity of vibration at lower values of speed and proportional to the square of velocity at high speeds.

$F \propto V$ at a lower speed

$F \propto V^2$ at a higher speed

C = damping coefficient (damping force per unit velocity)

ω_n = frequency of natural undamped vibrations

$a + (c/m)v + (k/m)x = 0$

$\alpha_{1,2} = -(c/2m) \pm \sqrt{[(c/2m)^2-(k/m)]}$

Degree of dampness:

$=(c/2m)^2/(k/m)$

Damping factor:

$\xi = c/(2\sqrt{km})$

Damping coefficient:

$c = 2\xi\sqrt{km} = 2\xi m\omega_n = 2\xi k/\omega_n$

When $\xi = 1$, damping is critical, thus under critical damping conditions

$\xi = 2\sqrt{km} = 2m\omega_n = 2k/\omega_n$

$\xi = c/c_c$ = Actual damping coefficient / Critical damoing coefficient

- $\xi > 1$; the system is over damped
- $\xi < 1$; the system is under damped
- $\omega_d = \omega_n\sqrt{(1-\xi^2)}$

In a critically damped system, the displaced mass return to the position of rest in the shortest possible time without oscillation. Due to this reason large guns are critically damped so that they return to their original positions in minimum possible time.

An undamped system ($\xi = 0$) vibrates at its natural frequency which depends upon the static deflection under the weight of its mass.

At critical damping ($\xi = 1$); $\omega_d = 0$ and $T_d = \infty$. The system does not vibrate and the mass 'm' moves back slowly to the equilibrium position.

For overdamped system ($\xi > 1$) the system behaves in the same manner as for critical damping