APPLIED PHYSICS -II

Kerala Govt. Polytechnic College, Kozhikode

UNIT-I WAVE MOTION AND ITS APPLICATIONS

1) Define periodic motion, Give two examples

A motion that repeats itself at regular intervals of time is called periodic motion

Examples :- a) Oscillations of a simple pendulum, b) The motion of the earth and other planets around the sun

2) Define simple harmonic motion (SHM), Give two examples

A particle is said to execute simple harmonic motion if its acceleration at any instant is directed to a fixed point and is directly proportional to the displacement from the fixed point. The fixed point is called the equilibrium position of the particle.

Differential equation for simple harmonic motion is given by

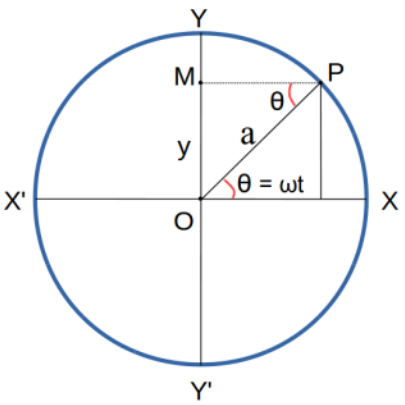
$$\frac{d^2y}{dt^2} = -\omega^2 y$$

Examples:- a) The oscillations of a simple pendulum, b) The oscillations of a spring

3)Derive expressions for displacement, velocity, and acceleration of a particle executing SHM

A linear simple harmonic motion can defined as the projection of a uniform circular motion along a diameter of the circle. Consider a particle is executing uniform motion along the cricular path of radius a with uniform angular velocity ω.

Let the body was initially at point X (at $t = 0$). After a time t, the particle comes to the position P describing an angle $\theta = \omega t$. Draw a perpendicular PM to the diameter YY'. When P moves once round the circle, the foot of the perpendicular M moves up and down along the diameter YY' with the point O as the equillibrium position.



Expression for displacement:-

From the figure, the displacement y of the point M during the time t is OM. From the triangle OMP,

$$OM = OPsin\theta$$

But $OP = a, OM = y$ and $\theta = \omega t$. Therefore

$$\boldsymbol{y = a\, sin\, \omega t}$$

This is the equation for the displacement.

Expression for velocity:-

$$\text{displacement, } y = a\, sin\, \omega t$$

differentiating with respect to time t we get the expression for velocity

$$\boldsymbol{\frac{dy}{dt} = a\, \omega\, cos\, \omega t}$$

Expression for acceleration:-

Differentiating the expression for velocity again with respect to time t we get the expression for acceleration, ie

$$\frac{dy^2}{dt^2} = -a\, \omega^2\, sin\, \omega t$$

Since $a\, sin\, \omega t = y$, we get

$$\boldsymbol{\frac{dy^2}{dt^2} = -\omega^2 y}$$

This is same as the differential equation for simple harmonic motion. Hence the projection of uniform circular motion is executing a simple harmonic motion

4) Explain the terms period, frequency, amplitude and phase of a simple harmonic motion.

Period (T) **:-** Period T is the time taken for one complete vibration

Frequency (f) **:-** Frequency f is the number of vibrations per second. If T is the period then, $f = 1/T$. Since angular velocity $\omega = 2\pi/T$. We can also write $f = \omega/2\pi$. SI unit of frequency is Hertz (Hz)

Amplitude (a) **:-** Amplitude is the maximum displacement of the particle executing simple harmonic motion. It is equal to the displacement from the equilibrium position to the point of maximum displacement.

Phase :- The phase of a particle executing simple harmonic motion at any instant is defined as the stage of vibration through which the particle is passing at that time.

5) Give the differential equation for simple harmonic motion

The differential equation for simple harmonic motion is

$$\frac{dy^2}{dt^2} = -\omega^2 y$$

Where y is the displacement from the equilibrium position and ω is the angular frequency of simple harmonic motion. The negative sign indicates that the acceleration ($\frac{dy^2}{dt^2}$) is directed opposite to the increasing displacement y.

6) Define wave motion

The propagation of disturbance from one point to another without the translatory motion of the particles of the medium is called wave motion. Wave motion is a periodic motion in which the particles of the medium execute the simple harmonic motion.

7) Give the characteristics of wave motion

The characteristics of wave motion are wavelength (λ), frequency (f), Wave velocity (v) and amplitude (a) .

Wavelength (λ) :- Wavelength is the linear distance between two consecutive crusts or troughs.

Frequency (f) :- The number of waves produced in one second.

Wave velocity (v) :- wave velocity (v) is the distance travelled by a wave in unit time.

Amplitude (a) :- Amplitude (a) of a wave is the maximum displacement undergone by a particle of the medium during a wave cycle.

8)Distinguish between transverse waves and longitudinal waves

Transverse Wave :-

If the particles of a medium vibrate about their mean positions, in a direction perpendicular to the direction of propagation of the disturbance, the wave motion is called transverse wave motion.

Example : Water waves and light waves

Longitudinal wave :-

If the particles of a medium vibrate about their mean positions in a direction parallel to the direction of propagation of the disturbance, the wave motion is called longitudinal.

Example: sound waves

9)Derive a relation between velocity, frequency, and wavelength.

The velocity of the wave is the distance travelled by the wave in one second.

$$\text{i.e., wave velocity } = \frac{distance}{time}$$

Wavelength is the distance travelled in T seconds, then wave velocity is given by

$$v = \frac{\lambda}{T}$$

$$\text{Since frequency, } f = \frac{1}{T}$$

$$\text{We get } \boldsymbol{v = f\lambda}$$

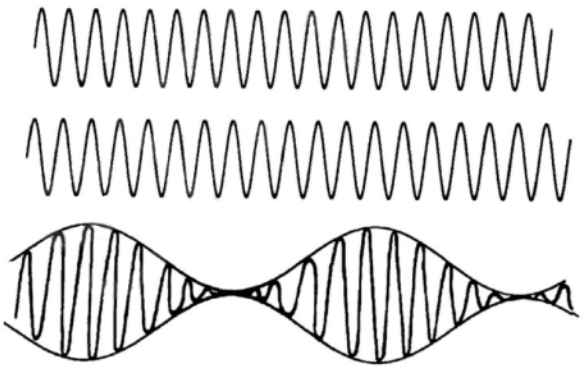
That is wave velocity is the product of frequency and wavelength.

10) State the Principle of superposition of waves

The principle of superposition of waves states that if two or more waves travel in a medium, each wave produces its own displacement and the resultant displacement of a particle at any point is the vector sum of the displacements due to each wave.

11)Explain the phenomenon of beats

When two sound waves of equal amplitudes and slightly different frequencies travelling in the same direction arrive simultaneously at a point, the intensity of sound caused by the superposition of two waves fluctuates. This periodic variations in the intensity of sound due to the superposition of two sound waves of slightly different frequencies are called beats.



12) A vibrating tuning fork is carried at a high speed towards a wall. An observer hears beats.Why?

Beats are formed when two sound waves of slightly different frequencies undergoes superposition. When we move a vibrating tuning fork at high speed towards a wall, becaues of the

dopler effect there will be a slight increase in the frequecy of sound waves falling on the wall compard to the sound waves travelling in the opposit direction (away from the wall). Hence when the sound waves reflected from the wall and the sound waves from the tuning fork meet at a point we can hear beats.

13) What are ultrasonics? Give few applications of ultrasonic waves

Sound waves having a frequency above 20 kHz are called ultrasonic waves.

Some of the important applications of ultrasonic waves are;

1) Sonar (echo sounding) :- Sonar is used for finding the depth of sea and to detect submarines, rocks etc. A sonar consists of an ultrasonic transmitter and receiver. The system sends ultrasonic pulses and receives its echo, From the time difference distance is calculated.

2) Ultrasonic signalling :- Due to the high directional property of ultrasonic waves, they are used for signalling purpose.

3) Underwater communication :- Ultrasonic waves are used for underwater communication

4) Metal testing :- Ultrasonic waves are used for detecting air pockets and other flaws in metal casting.

5) Ultrasonic cleaners :- Ultrasonic waves are used for cleaning purpose, in dish washer etc.

6) Medical scanning :- In ultrasound scanners for imaging the internal organs.

14) Explain the terms reverberation, reverberation time

Reverberation :- The prolongation of audible sound in a room or hall after the sound source has ceased to emit sound is called reverberation.

Reverberation time :- It is the time for which the sound persists in a room or hall after the original sound is cut off. This time is measured from the instant the source stops the emitting sound. To produce the best sound effects, the reverberation time should be as small as possible.

15) Distinguish between echo and reverberation

Reverberation :- The prolongation of audible sound in a room or hall after the sound source has ceased to emit sound is called reverberation.

Echo :- If the time interval between the the original sound and the reflected sound from the reflecting surface is greater than $\frac{1}{10}$th of a second, the original sound and the reflected sound can be separately heard. Such a reflection of sound is called echo

16) What is meant by saying that an auditorium has good acoustical properties

Good acoustical properties means, The intensity of sound heard by the audience in the auditorium must be sufficiently loud and uniform throughout. For that the reverberation and echo shoud be minimum. Also the auditorium should have good soundproofing to minimise the external noise.