Unit 12

WAVE MOTION

Q. What is wave? Write its importance in our daily life.

Ans. "Wave is a mechanism in which energy is transferred from one place to another place due to disturbance in the medium".

Importance:

There are some waves, which we can see while there are some, which we cannot see, but can be detect with some sensitive instruments.

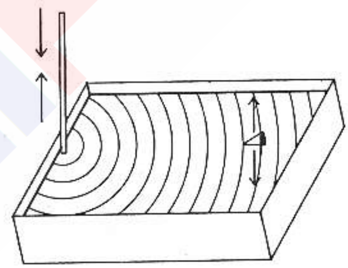
1- Sound reaches in our ears in the form of waves.
2- The sunlight and heat reaches us through waves.
3- The broad casting of radio and television is possible by waves.
4- The defects in human body e.g. broken bones, tumors, bullets can also be detected by waves.

Q. What is wave motion? Explain.

Ans. "Wave motion in a medium is due to generated disturbance which cause the constituent particles to repeat it's to and fro motion about its mean position in equal interval of time, and this disturbance is passed over from one end of the medium to the other."

Explanation:

Experiment-1:



Take a tub of water and dip one end of a pencil at the edge of a tub. Move the pencil rapidly up and down vertically. The ripples emerge outward on the surface of water. Place some pieces of paper or cork equally spaced in the direction of waves and observe the movement of paper, we will see that every piece of paper move up and down about its mean position. They are not displaced forward from their original position along with water waves. The pieces exhibit vibratory motion and have consecutive vertical vibratory motion. Hence this disturbance is transferred along with the wave and visible water waves are observed.

Experiment-2:

Take a string and mark it with different colours at equal intervals. Attach one end of string with a hook and keep the other end to oscillates. We will see that string will start oscillating vertically up and down briskly and wave will seen. When the colour markings are observed, the wave will travel down the string and they are vibrating about their mean position. At particular time it will observe that the markings are in different position along their vibratory path rather than vibrating together.

Conclusion:

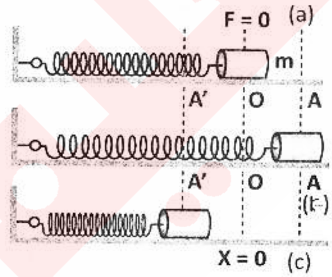
From this we can conclude that by moving the free end up and down disturbance is generated and transferred to the other end of the string and they start vibratory motion about their mean position. This disturbance travel along the string in the form of waves.

Q. What is Simple Harmonic Motion? (L. B'07, 08)

Prove that Mass Attached with a spring performs simple Harmonic Motion.

Ans. The kind of vibratory motion in which acceleration of the body is directly proportional to the displacement from the mean position and is always directed towards the mean position is known as Simple Harmonic Motion.

MASS ATTACHED WITH SPRING:



Consider the motion of mass attached with a spring. The body of mass 'm' is attached with a spring and is placed on a horizontal surface. Other end of spring is attached with a firm support. There is no extension in the spring in this state. This means that body is at equilibrium position.

If an external force is applied on the mass, the length of spring increases by an amount 'x' and mass move from 'O' to new position 'A'. This show that body is at extreme position.

Hook's Law:

The external force applied on the spring is directly proportional to the increase in length. i.e.

$F_{ext} \propto x$

$F_{ext} = Kx$ Where "K" is constant and is called spring constant.

Spring Constant:

The ratio of external force acting on a spring to the increase in length is called spring constant. Mathematically it can be written as:

$$K = \frac{F_{ext}}{x}$$

Unit:

Its unit is Nm^{-1}.

RESTORING FORCE:

When an external force is applied on the spring, its length will increase. After releasing the force, the spring will move towards mean position. The motion of spring toward mean position is due to a force which is called restoring force. If displacement is 'x' of mass 'm' then restoring force is:

$$F = -kx \qquad \text{..............(i)}$$

When mass 'm' is let free, it starts moving towards 'O'.

According to 2^{nd} law of motion.

$$F = ma \quad ....(ii)$$

comparing (i) and (ii)

$$ma = -kx$$

$$a = -\frac{k}{m}x$$

$$a = -\text{constant}\ (x)$$

$$a \propto -x$$

This shows that acceleration is directly proportional to displacement from the mean position and negative sign shows that it is directed towards mean position.

ZERO ACCELERATION:

As the mass m moves towards 'O' its displacement goes on decreasing, hence the acceleration of the body 'a' also decreases. At 'O' 'x' is zero, so the acceleration is also zero. Here velocity is maximum.

COMPRESSION OF SPRING:

Due to inertia the mass 'm' will not stop at point 'O' but continues its motion towards left till it reaches at $A^{/}$. During this motion the spring is compressed. At this stage restoring force and the acceleration is opposite to the motion of mass which means that the acceleration is still directed toward mean position 'O. Hence velocity of the mass 'm' again starts decreasing as it passes the point 'O' and becomes zero at point A.

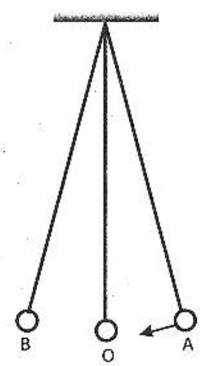
After coming to rest at the point A, the body returns to the point 'O' under the action of restoring force. This process continues and the mass 'm' keeps on vibrating between A and $A^{/}$.

TIME PERIOD:

The time period of simple harmonic motion of a mass attached to a spring can be found by:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

Q: What is simple pendulum? Prove that motion of simple pendulum is SHM.



Ans. A simple pendulum consists of a single isolated bob suspended from frictionless support by light inextensible string. A small bob of mass 'm' is suspended by light inextensible string of length 'ℓ'.

Velocity of Bob Between 'A' and 'B':

1- In equilibrium position, the pendulum is held stationary in a vertical position at point "O".

2- When the bob is disturbed from 'O' to 'A' it starts moving towards the mean position under the action of gravitational force.

3- At 'O' the velocity of bob is maximum and due to inertia, the bob will not stop at 'O' and move to the other end 'B' and the velocity of the bob begin to decrease, and becomes zero at 'B'.

4- The bob starts its motion from 'B' to 'O' and towards 'A' the bob will continue its motion between 'A' and 'B'.

Acceleration of Bob Between A and B:

1. As speed of bob increases while moving from point 'A' to 'O', the acceleration of the bob is towards 'O' the direction of acceleration remains same.
2. The direction of acceleration remain same towards 'O' during motion from point 'O' to 'B' because the speed of bob start decreasing.

This means that the direction of acceleration always towards mean position.

This show that acceleration is always directed towards the mean position and is directly proportional to the displacement. So we can say that motion of simple pendulum is simple harmonic motion.

Energy Changes Between A and B:

1. At point 'O', the bob is at lowest position so the potential energy of the bob is minimum.
2. At point 'A' at the highest level or at 'B' the potential energy is maximum and K.E of the bob is minimum i.e. zero.
3. In between extreme and mean position, the energy of the bob is partly potential and partly kinetic. But the total energy remains the same.

Note: In simple harmonic motion, a body repeats its to and fro motion, in equal interval of time about its mean position.

Time Period:

Time period of simple pendulum can be found by the formula.

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

Where 'ℓ' is length of pendulum, which is equal to the distance between the point of suspension and center of bob.

Factors upon which Time Period of Simple Pendulum Depends:

The time period of simple pendulum depends on length 'ℓ' and the value of gravitational acceleration 'g', but it is independent of mass of body.

Q: Write the characteristic of Simple Harmonic Motion.

Ans.

(1) In SHM, body executes to and fro motion.

(2) Acceleration is always directed towards the mean position.

(3) Acceleration is directly proportional to the displacement from the mean position $a = 0$ at the mean position, 'a' is maximum at extreme position.

(4) Velocity is maximum at mean position and minimum at extreme position.

Q: Explain the following terms: (L.B'07, 08)

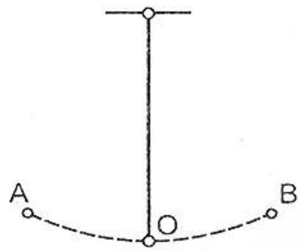
(a) Amplitude **(b) Vibration** **(c) Time period**

(d) Periodic Motion **(e) Displacement**

Ans.

Amplitude:

The maximum displacement between mean position and extreme position of the vibrating body on either side is called amplitude.



Vibration:

One complete round trip of the vibrating body about its mean position is called vibration.

Time Period:

The time required to complete one vibration is called time period.

Displacement:

The distance of vibrating body at any time from t mean position is called displacement.

Periodic Motion:

The type of motion which is repeated after regular interval of time is called Periodic Motion.

Q: What are Mechanical waves? Give its examples.

Ans. The types of waves which require a medium for their production and propagation are called mechanical waves.

Examples

1. Waves on the surface of water.
2. Wave produced in stretched string.

Q: What are Electromagnetic waves?

Ans. The waves which do not require a medium for their production and propagation are called electromagnetic waves.

(1) Radio waves (2) Heat and light waves (3) X-Rays

Q: Write the types of Mechanical Waves.

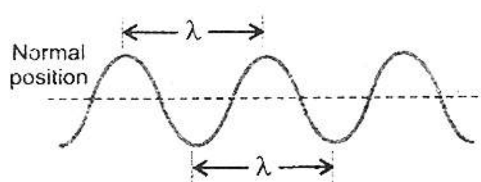
Ans. Mechanical waves are of two types.

(1) Transverse waves.

(2) Longitudinal or compressional waves.

(1) Transverse Waves: **(L. B'08, 10)**

The type of mechanical waves in which the particles of the medium vibrate perpendicular to the direction of propagation of the wave are called transverse waves.



Example:

(i) If one end of the pencil is dipped in water and then move up and down waves are produced on the surface of water due to which the particles of the medium vibrate up and down, which means that direction of vibratory motion of water particles is perpendicular to the motion of waves.

(ii) The waves produced by moving one end of stretched string up and down also produces transverse wave because different parts of the string vibrate perpendicular to the string.

(2) Longitudinal Waves:

The types of mechanical waves in which the direction of vibratory motion of the particles of medium is parallel to the direction of propagation of waves.

Examples:

(i) The sound waves.

(ii) The waves produced in the mass attached with a spring.

Q: Define the following:

(1) Crest (2) Trough (3) Wave Length (4) Frequency

Ans.

(1) CREST:

The part of transverse waves where particles of medium are above the normal position are called crest.

(2) TROUGH:

The part of transverse waves where the particles of medium are below the normal position are called Trough.

(3) WAVE LENGTH (λ):

The distance between two consecutive crests or troughs is called wave length. It is represented by (λ).

Note:

A crest and a trough is joined to make one complete wave.

(4) FREQUENCY (f):

The number of waves passing through a point in one second is called frequency.

Unit:

The unit of frequency is Hertz or cycle/sec or vib/sec.

Mathematically it can be written as:

$$f = \frac{1}{T}$$

Q. Write a note on waves as a carrier of energy. In how many ways energy can be transferred from one place to another?

Ans. Energy can be transferred from one place to another by two methods.

(1) Through Matter.

(2) Through Waves.

(1) Through Matter:

Most of the time energy is transferred by matter.

Example:

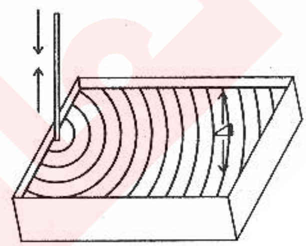
(i) When gun is fired, the bullet gets energy through explosion and moves towards the target. The energy of bullet is K.E. on striking the target, it transfers its energy to the target and damage or breaking take place.

(ii) The energy of running water in the tunnel of a dam is also kinetic in nature. On reaching the turbine, it transfer its energy to the blades of turbine due to which it starts rotating and electricity is produced.

(2) <u>Transfer of Energy Through Waves:</u>

Energy can also be transferred by waves, without transfer of matter.

Example:



Take a rectangular tray and fill it with water. Start moving a vertical rod in the water up and down which produces transverse waves on the surface of water.

Place a cork on the surface of water near the other end of the tray apposite to rod.

When waves pass through cork, the cork vibrates up and down perpendicular to the water surface.

Reason:

We have transferred our energy in moving the rod up and down. This energy reaches the cork through water wave due to which cork vibrates.

Conclusion:

(1) Water particles do not make any forward motion along the direction of wave.

(2) They keep on vibrating at their respective places and wave passes through it.

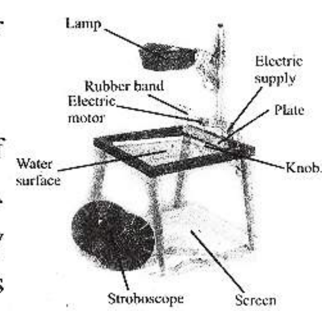
Q. Write the names of Characteristics of waves.

Ans. There are four properties of waves.

(1) Reflection	(2) Refraction
(3) Interference	(4) Diffraction

To study these properties we will use ripple tank.

Q. Write a note on Ripple Tank. How can we generate straight waves and circular waves with the help of Ripple Tank?



Ans. It is an apparatus which is used to produce waves and study their properties.

<u>CONSTRUCTION:</u>

It consists of rectangular tray with glass bottom. It is placed nearly half metre above the surface of table by means of four supporting legs. Waves are produced on the surface of water present in the tray by means of vibrator. The vibrator is an oscillating electric motor which is fixed on wooden bar. The plate is suspended by means of rubber band and its lower end touches the surface of water.

Straight Waves

On setting vibrator on, the plates start vibrating and straight waves are generated on water surface.

A lamp is hung over tray, to see image of water waves which is obtained on white paper or screen. The crest of wave appear as bright line on the paper because they function like convex lens and converge the light falling on them. The trough behaves like concave lens and diverge the light and appear as dark straight portions between bright lines.

GENERATION OF CIRCULAR WAVES:

To generate circular waves, the vibrating bar is raised up and a knob is attached, which is lowered in such a way that it touches the surface of water, when vibrator is set, circular waves are produced.

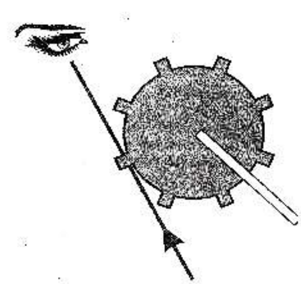
The picture of waves has been taken by the help of a high power camera. The waves were seen continuously moving on the paper.

Q. What do you mean by Stroboscope? (L. B'06)

Ans. STROBOSCOPE:

Freezing of waves is done with the help of a device called Stroboscope.

Construction:

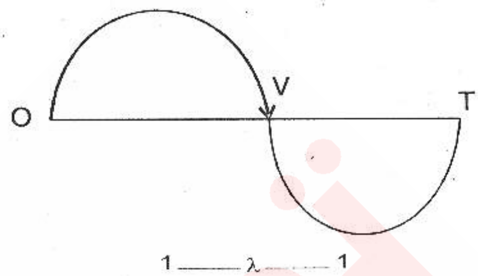


A stroboscope consists of a round disc with slits on its edge. The disc can rotate about its centre by putting it into motion by a finger. When we see through this disc, the wave can be seen only when a slit passes against our eye. We can adjust the speed of stroboscope in such a way that a slit in front of our eye is replaced by another during the time in which the wave move forward by one wave length. Therefore the wave appears to be stationary and we say that their motion is rather frozen.

Q. Using ripple tank, establish a relation between wave speed (v), frequency (f) and wavelength (λ). Or Prove that V = f λ

Ans. <u>Relation between Frequency Wave Length and Velocity:</u>

Place a piece of paper on the water surface and observe its motion. The piece of paper will not move forward but it vibrates up and down on its place.



The time of vibration of the paper is equal to the time taken by the successive crest to pass through certain position during the time of vibration of a piece of paper the waves cover distance equal to the wave length, therefore the time of vibration of a piece of paper, the wave covers a distance equal to one wave length. If the speed of the wave is 'V' and the time period is 'T' second, the distance covered by the wave will be VT. As it is equal to wavelength, so

$$\lambda = vT$$

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

or $v = \lambda \times \frac{1}{T}$

since $\frac{1}{T} = f$

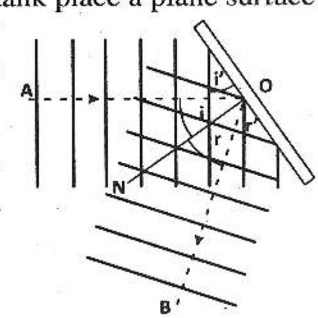
so $V = f\lambda$

This equation shows that wave speed is the product of frequency and wavelength. Frequency of waves, that is number of waves passing through a certain point in one second, can be changed by changing frequency of the vibrator. Other two quantities (i.e. v and λ) depend upon the properties of the medium.

Q. Write a note on reflection on waves using ripple tank.

Ans. (i) Reflection of Waves:

The water waves are reflected according to the laws of reflection of light waves. To observe the reflection of water waves straight waves are generated in the ripple tank place a plane surface obstacle in the path of waves making certain angle with the direction of propagation of waves. After striking the obstacle, the waves will be reflected in a particular direction.



<u>Angle of Incidence:</u>

By using stroboscope and protector, the angle between incident ray and normal ∠i can be measured.

<u>Angle of Reflection:</u>

The angle between reflected ray and normal can be measured '∠r '.

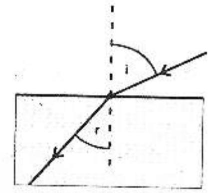
<u>Angle of incidence and angle of Reflection:</u>

The angle between the line AO and normal NO is called angle of incidence and the angle between OB and ON is the angle of reflection.

It is evident that angle of incident is equal to angle of reflection i.e. $\angle_i = \angle_r$.

Q. Write a note on refraction of waves using ripple tank.

Ans. Definition:



When a ray of light enters from one medium to another transparent medium, it bends away from path. The bending of waves from their incident path is called Refraction.

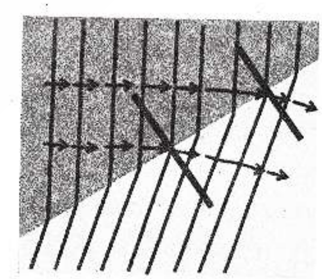
The speed of light is more in air or vacuum than in glass or water. The speed of water waves depends upon the depth of water. Its speed is reduced when it enters in shallow water. To observe the relations between wave speed with water depth cover the half of the bottom of the ripple tank with a thick glass plate. By doing so we get two portions of water with different depths. The edge of the plate separating the two portions should be parallel to the bar of the vibrator.

When the electric motor is switched on, straight waves are produced on the surface of water we find that the wavelength of the waves decreases when they reach the shallow part. The frequency of the waves does not change in both parts of the water because it is equal to the frequency of vibrator.

In the shallow part, the decrease in wavelength is due to decrease in speed of wave according to the equation.

$V = f\lambda$

Refraction of water waves in ripple tank:



To observe refraction of water wave, repeat the experiment in such a way that in ripple tank the line separating two different parts of the depth makes an angle with them. We will see that wavelength of wave while entering from the part of shallow depth to the greater depth changes its direction in addition to the decrease in wavelength. It is clear that when water enter the shallow part they bend towards normal on the line separating the two parts. This changing of path in water waves is called refraction of waves.

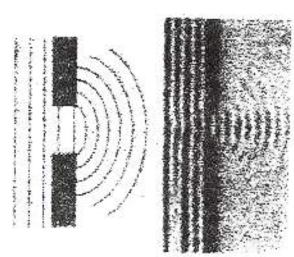
Q. Explain diffraction with the help of Ripple tank.

Ans. Diffraction:

The bending of waves around the corner or obstacles is called diffraction.

Explanation:

To generate straight waves in a ripple tank place two obstacles in a line in such a way that the separation between them is equal to the wavelength of water wave. After passing through the slit between two obstacles the waves can be seen spreading in every direction and changing to circular from.



Condition:

Diffraction of wave can be observed clearly only when size of slit or obstacle is nearly equal to the wavelength of the wave.

But if the size of the slit is larger than the wavelength of the wave, then diffraction is not significant and waves keep their initial motion even after passing through the slit, and their shape remains straight. A little diffraction effect appeared near the corner of the obstacle.

Q. What is interference? Explain.

Ans. When particles of medium are subjected to two waves simultaneously, then the effect being produced is called interference.

Water wave interference:

If two identical waves propagate through a medium in such a way that crest of one wave falls on the crest of other wave or trough of one wave falls on the trough of other wave. Then the resultant displacement of particles coming under their simultaneous action doubled the displacement of the individual wave.

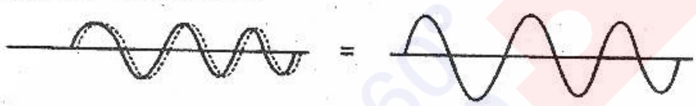
Interference is of two types:

(1) Constructive Interference.

(2) Destructive Interference.

Q. What is Constructive Interference?

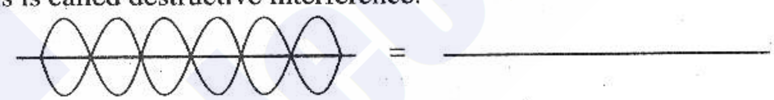
Ans: If two waves meet with each in such a way that crest of one wave fall on the crest of other and trough of one wave fall on the trough of other wave than as a result amplitude of waves gets doubled called construction interference.



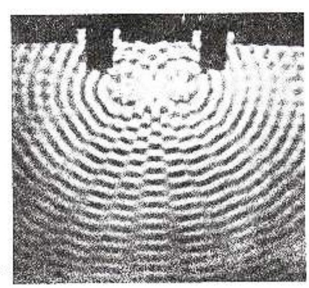
The generation of single wave due to this interference is double in amplitude.

Q. What is destructive interference?

Ans. When two waves meet with each other in such a way that the crest of one wave falls on the trough of other, they will cancel each other's affect and as a result surface of the medium remain undisturbed. This is called destructive interference.



Q. Explain interference of water waves using ripple tank.



Ans. To observe interference of water waves the two knobs attached to the vibrating bar and lowered in such a way that two knob touch the water surface.

When motor is switched on two set of circular wave is produced and are seen to be moving on the water surface.

The frequency and amplitude of two waves is same and they are generated at the same time on the surface of water where these set of waves pass simultaneously interference occurs and can be seen.

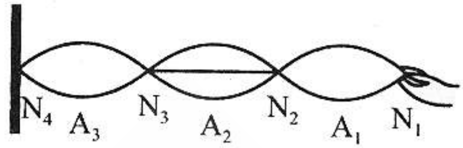
Q. Describes briefly how stationary waves are generated? **(L. B' 08)**

Ans. Stationary Waves: **(L. B' 10)**

When two identical waves pass through a medium along the same line in opposite direction then stationary waves are produced at certain frequency.

Generation:

Fasten one end of the string to a firm support and hold its other free end. The up and down motion of the hand will produce waves in string. If wave continue to increase the rate of up and down motion of hand, then at particular frequency, the string will start vibrating with maximum amplitude. The waves produce will called stationary waves.



Condition for generation of stationary waves:

(1) The two waves must be identical in all respects.

(2) They must travel in opposite direction, along the same line.

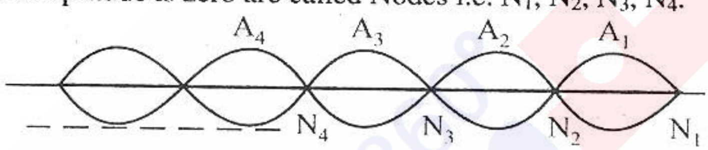
Q. What are nodes and antinodes? (L. B' 07, 08)

Ans. Stationary waves are produced due to the up and down movement of string. Due to such waves the amplitude of string is different at different section.

At some position of string, the amplitude is maximum while at the other end is zero.

Nodes:

The points where amplitude is zero are called Nodes i.e. N_1, N_2, N_3, N_4.



Antinodes:

The points where amplitude is maximum are called antinodes.

i.e. A_1, A_2, A_3, A_4.

The wavelength of the stationary wave is twice the distance between two successive nodes or anti nodes.

Q. What is meant by fundamental frequency of stationary waves? How higher frequencies relate with fundamental frequency?

Ans. Fundamental Frequency:

The string makes a single loop at the lowest frequency. This lowest frequency called fundamental frequency or first harmonic.

Relationship between Fundamental Frequency and higher frequency:

The number of loops on the string depends upon the frequency of up and down motion of the hand. And if string makes two loops, the frequency at which it does so is called 2^{nd} harmonic or first overtone, and this frequency is found to be two times the fundamental frequency

i.e. $f_2 = 2f_1$

Even at higher frequency, the string can be seen making three, four loops representing third, fourth harmonic and formula can be generalized as:

$$f_n = nf_1$$

Note:

The above experiment stationary waves are produced due to interference of waves being generated by the up and down motion of hand and the one exactly reflected by the support and traveling in the opposite direction.

EXAMPLES

Example 12.1

Find the time periods of a simple pendulum of 1-meter length. Placed on Earth and on moon. The value of g on the moon is 1/6th of its value on Earth. Where g is $10ms^{-2}$. (L. B' 10)

Solution:

The given data is

Length of simple pendulum = ℓ = 1m

Acceleration due to gravity = g = $10ms^{-2}$

on the surface of earth

Acceleration due to gravity = $g_m = \frac{1}{6}(g) = \frac{10}{6} ms^{-2} \Rightarrow 1.66ms^{-2}$

on the surface of moon

Time period on earth = T_E = ?

Time period on moon = T_m = ?

Formula:

$$T_E = 2\pi\sqrt{\frac{\ell}{g}}$$

Putting values, we get

$$T_E = 2 \times 3.14\sqrt{\frac{1}{10}}$$

$$2 \times 3.14\sqrt{0.1}$$

$$= 2 \times 3.14 \times 0.3162$$

$$= 1.98 \text{ Sec}$$

or

T_E = 2 seconds

Similarly, the time period on moon is

$$T_m = 2\pi\sqrt{\frac{1}{g/6}}$$

$$T_m = 2\pi\sqrt{\frac{6x1}{g}}$$

$$T_m = \left(2\pi\sqrt{\frac{6x1}{g}}\right) = 2\times3.14\sqrt{\frac{6}{10}}$$

$$T_m = 2 \times 3.14 \times \sqrt{0.60} = 2 \times 3.14 \times 0.7745$$

$= 4.86$ Sec

or 4.9 Sec

$\boxed{4.9 \text{ Sec}}$

Example 12.2

A body of mass 0.5 Kg is attached to a spring placed on a horizontal frictionless surface. If the spring constant of this spring is 8 Nm^{-1}, find the time period of the body.

Solution:

The given data is

Mass = m = 0.5 kg

Spring constant = k = 8 Nm^{-1}

Time period = T = ?

Formula:

$$T = 2\pi\sqrt{\frac{m}{k}}$$

Putting values we get

$$T = 2 \times 3.14\sqrt{\frac{0.5}{8}}$$

$$= 2 \text{ x } 3.14 \sqrt{0.0625} = 2 \text{ x } 3.1 \text{ x } 0.25$$

$$T = 1.578 \text{ seconds}$$

$\boxed{T = 1.57 \text{ Seconds}}$

Example 12.3

The wavelength of a wave passing through a medium is 0.1 metre. If wave speed is 2ms^{-1}, then calculate the wave frequency.

Solution:

The given data is

Wave length = λ = 0.1 m

Speed of wave = v = 2ms^{-1}

Frequency = f = ?

Formula:

$$V = f\lambda$$

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

$$f = \frac{2}{0.1}$$

$$f = 20 \text{ Hz} \quad \text{Ans.}$$

Example 12.4:

A stationary wave of fundamental frequency 250 Hz has been generated in a medium. Calculate three higher frequencies by using formula $f_n = nf_1$ at which stationary waves could be produced.

Solution:

The given data is

Fundamental frequency = f_1 = 250 Hz

Next higher frequencies = ?

Formula:

$f_n = nf_1$

Using this formula we get

$f_2 = 2f_1 = 2 \times 250$ Hz

$= 500$ Hz **Ans.**

$f_3 = 3f_1 = 3 \times 250$ Hz

$= 750$ Hz **Ans.**

$f_4 = 4f_1$

$f_4 = 4 \times 250$ Hz

$f_4 = 1000$ Hz **Ans.**

NUMERICAL PROBLEMS

12.1: The time period of a simple pendulum is 2s. What will be its length on Earth? What will be its length on moon if $g_m = \frac{g}{6}$?

Solution:

The given data is

Time period = $T = 2$ s

Length on earth = $l_E = ?$

Length on moon = $l_m = ?$

$g_e = 10 ms^{-2}$

$g_m = \frac{g_e}{6} = \frac{10}{6} = 1.67 \ ms^{-2}$

Formula:

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

$$T^2 = 4\pi^2\frac{\ell}{g}$$

$$\frac{T^2 g}{4\pi^2} = \ell$$

Putting values, we get

$$\frac{(2)^2 \times 10}{4 \times (3.14)^2} = \ell_e$$

$$\frac{\not{4} \times 10}{\not{4} \times (3.14)^2} = \ell_e$$

$$\frac{10}{(3.14)^2} = \ell_e$$

$$1.02m = \ell_e$$

Similarly, for moon, we use formula.

$$\ell_m = \frac{T^2 g_m}{4\pi^2} = \frac{(2)^2 \times 1.67}{4 \times (3.14)^2}$$

$$= \frac{\cancel{4} \times 1.67}{\cancel{4} \times (3.14)^2} = \boxed{0.17 \text{ m}}$$

12.2: Length of a spring is 8 cm. When a mass of 4kg is hung to it, its length becomes 16 cm. What is its spring constant? (500 Nm^{-1})

Solution:

The given data is

Original length $x_1 = 8cm$

Extended length $x_2 = 16$ cm

Increase in Length $= x = x_2 - x_1 = 16 - 8$

$x_2 - x_1 = 8$ cm

$= \frac{8}{100}$ m

$= \boxed{0.08 \text{ m}}$

Spring constant = k = ?

Mass = 4Kg

Formula:

By Hook's law

$$\boxed{\begin{array}{l} F = w \\ F = mg \end{array}}$$

$F = kx$

$K = \frac{F}{x}$

$K = \frac{mg}{x}$

Putting the values, we get

$K = \frac{(4) \times (10)}{(0.08)}$

$\boxed{K = 500 \text{ N m}^{-1}}$

12.3: If five waves pass through a point of a medium in 10 seconds. What is its frequency and time period? If its wavelength is 5 cm, calculate the wave speed.

Solution:

The given data is

Number of waves passed = n = 5

Time taken t = 10 sec.

Frequency = f = ?

Time period = T = ?

Wave length = λ = 5 cm = 0.05 m

Speed of Wave = v = ?

Solution:

$$\text{Frequency } f = \frac{\text{no of waves}}{\text{time}}$$

$$f = \frac{5}{10}$$

$$\boxed{f = 0.5\text{Hz}}$$

Formula:

$$\text{Time period} = \frac{1}{\text{frequency}}$$

$$T = \frac{1}{f}$$

Putting values, we get

$$T = \frac{1}{0.5}$$

$$\boxed{T = 2\text{ s}}$$

Formula:

$$f\lambda = v$$

$$(0.5) \times (0.05) = v$$

$$0.025\text{ ms}^{-1} = v$$

$$0.025 \times 100\text{ mms}^{-1} = v$$

$$\boxed{25\text{mms}^{-1} = v}$$

$$v = 25\text{ mms}^{-1}$$

12.4: The time period of a wave is 5s. If velocity of the wave is 10ms^{-1}, then what will be its wavelength?

Solution:

The given data is

$$T = 5\text{ s}$$

$$V = 10\text{ms}^{-1}$$

$$\lambda = ?$$

We know that

$$\lambda = V \times T$$

Putting the values, we get

$$\lambda = 10 \times 5$$

$$\lambda = 10 \times 5$$

$$\boxed{\lambda = 50\text{m}}$$

12.5: A stationary wave is making five loops. The distance between two stationary points is 10 cm and its velocity is 20ms^{-1}. What will be the fundamental harmonic frequency?

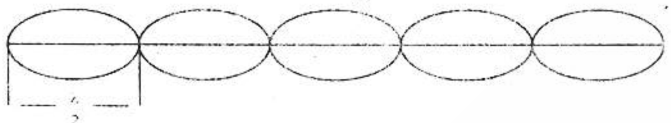
Solution:

The given data is

Number of loops = 5

Velocity = 20 ms^{-1}

Distance between two stationary points $= \frac{\lambda}{2} = 10cm$



$\lambda = 20$ cm
$\lambda = 0.2$ m
To find
Frequency of wave $= f_5 = ?$
Fundamental frequency $= f_1 = ?$
Solution
$V = f_5 \lambda$
$f_5 = \frac{V}{\lambda} = \frac{20}{0.2} = 100Hz$
$\boxed{f_5 = 100Hz}$ **Ans.**
$f_n = nf_1$
$f_5 = 5f_1$
$100 = 5f_1$
$\frac{100}{5} = f_1$
$\boxed{20Hz = f_1}$ **Ans**

MULTIPLE CHOICE QUESTIONS

Q. TICK THE CORRECT ANSWER:

1. **The disturbance traveling in a medium is called.**
   a) Wave motion
   b) Harmonic Motion
   c) Motion
   d) both a, b
2. **The waves, which are used to detect the broken bones, are called:**
   a) Light waves b) x-rays
   c) Sound waves d) both b, c
3. **The force applied on the mass attached with a spring is represented by:**
   a) F_a b) F_c
   c) F_{ext} d) F_s
4. **If there is no extension in the spring then this position is called.**
   a) Equilibrium
   b) Un equilibrium
   c) Neutral equilibrium
   d) stable equilibrium
5. **The unit of spring constant is**
   a) m b) kg
   c) Nm^2 d) Nm^{-1}
6. **If the displacement in spring is 'x' of mass "m" attached with a spring then restoring force is:**
   a) F = ma b) F = kx
   c) F = - kx d) F = ma

7. **The ratio of external force applied on the spring to displacement is called:**
   a) Hook's Law
   b) Constant
   c) Spring constant
   d) None of these
8. **The time required to complete one round trip (vibration) about mean position is called:**
   a) Time period b) Frequency
   c) Amplitude d) None of these
9. **The time period of mass attached with a spring can be calculated by:**
   a) $T = 2\pi\sqrt{l/g}$ b) $T = \frac{l}{T}$
   c) $T = 2\pi\sqrt{g/l}$ d) $T = 2\pi\sqrt{\frac{m}{k}}$
10. **The time period of simple pendulum can be calculated by:**
   a) $T = 2\pi\sqrt{l/g}$ b) $T = 2\pi\sqrt{\frac{m}{k}}$
   c) $T = 2\pi\sqrt{g/l}$ d) $T = 2\pi\sqrt{\frac{K}{m}}$
11. **The maximum displacement from mean position is called:**
   a) Maximum height
   b) Time period
   c) Amplitude
   d) Interval
12. **The displacement produced in the spring is directly proportional to force is called:**
   a) Hook's law
   b) Boyle's law
   c) Newton's law
   d) both 'b' and 'c'
13. **At mean position of pendulum, the potential energy of the pendulum is:**
   a) Maximum b) Minimum
   c) Much more d) both a and c
14. **At mean position kinetic energy of the ball is _______.**
   a) Minimum b) Less
   c) Maximum d) None of these
15. **At extreme position potential energy of the pendulum is**
   a) Maximum b) Minimum
   c) a and b d) Zero
16. **In simple harmonic motion, the acceleration of the body is_____ proportional to the displacement.**
   a) Inversely
   b) Directly
   c) Equally
   d) None of these
17. **The value of acceleration in simple harmonic motion at mean position is**
   a) Maximum b) Zero
   c) 10N d) Minimum
18. **The waves in which particles of the medium vibrate parallel to the direction of waves are called.**
   a) Longitudinal waves
   b) Transverse waves
   c) Electro magnetic waves
   d) both 'b' and 'c'
19. **The waves in which particles of the medium vibrate perpendicular to the waves are:**
   a) Electromagnetic waves
   b) Mechanical waves
   c) Both 'a' and 'b'
   d) Transverse waves
20. **The sound waves are the example of**
   a) longitudinal waves
   b) Transverse waves
   c) Electromagnetic waves
   d) None of these
21. **The energy is transferred from one place to another:**
   a) Through matter
   b) through waves
   c) both 'a' and 'b'
   d) None of these

22. The energy of bullet fired from gun is:
a) Kinetic b) Potential
c) Electric d) Magnetic

23. The energy of stored water in the dam is:
a) Potential
b) Kinetic
c) both 'a' and 'b'
d) None of these

24. The waves have properties
a) Reflection b) Refraction
c) Diffraction d) all of these

25. The instrument used to freeze the moving waves is
a) Ripple tank b) Vibrator
c) Stroboscope d) None

26. The instrument used to study the properties of waves is.
a) Ripple tank b) Stroboscope
c) Pendulum d) None of these

27. The part of waves at which particles of the medium are below the normal position are called.
a) Extreme position
b) Crest
c) Trough
d) None of these

28. The distance between two consecutive troughs or crests is called:
a) Wave length b) Frequency
c) Time period d) None

29. The number of waves passing through a point in one second is called:
a) Time period b) Cycle
c) Frequency d) None of these

30. The unit of frequency is:
a) Hertz
b) Vibration per second
c) Cycle per second
d) all a, b, c,

31. The speed of waves can be calculated by:
a) Vt b) S / T
c) fλ d) Tf

32. The water waves after striking the hurdle will
a) Reflect b) Refract
c) Diffract d) All a,b,c

33. The wavelength of stationary waves is how many times the distance between two consecutive nodes or antinodes?
a) Three time b) Four times
c) Two times d) Five time

34. The part of stationary waves at which amplitude is maximum is:
a) Antinode b) Nodes
c) Amplitude d) None of these

35. The interference of waves is of two types i.e.
a) Constructive
b) Destructive
c) Both 'a' and 'b'
d) None of these

36. Time period is reciprocal of
a) Frequency b) Cycle
c) Wave length d) Amplitude

37. The water waves obey the laws of
a) Reflection b) Refraction
c) Diffraction d) all of these

38. The maximum potential energy of a vibrating mass attached to a spring is at:
a) equilibrium position
b) extreme position
c) between equilibrium and extreme position
d) all of them

39. The product of frequency and time period is equal to:
a) v b) 1
c) 0 d) λ

40. If the mass of bob of a simple pendulum is doubled, its time period:
a) is doubled
b) becomes four times
c) remains same
d) none of the above

41. If the length of a simple pendulum is halved, its time period 'T' will become:
a) $\frac{T}{2}$ b) $\frac{T}{\sqrt{2}}$

c) $\sqrt{2}\,T$ d) $2T$

42. In terms of wavelength (λ), the distance between two neighbouring nodes and antinodes is:

a) λ b) $\frac{\lambda}{2}$

c) $\frac{\lambda}{4}$ d) 2λ

ANSWERS

1.	a	**2.**	b	**3.**	c	**4.**	a	**5.**	d	**6.**	c	**7.**	c
8.	a	**9.**	d	**10.**	a	**11.**	c	**12.**	a	**13.**	b	**14.**	c
15.	a	**16.**	b	**17.**	b	**18.**	a	**19.**	d	**20.**	a	**21.**	c
22.	a	**23.**	a	**24.**	d	**25.**	c	**26.**	a	**27.**	c	**28.**	a
29.	c	**30.**	d	**31.**	c	**32.**	a	**33.**	c	**34.**	a	**35.**	c
36.	a	**37.**	d	**38.**	b	**39.**	b	**40.**	c	**41.**	b	**42.**	b

SHORT ANSWERS

1. Define vibratory motion. Give condition of vibratory motion.

Ans. The to and fro motion of a body around its mean position is called vibratory motion, and the particle of the medium does not change their place. These are some conditions for vibratory motion.

1. The motion is under the action of some restoring force.
2. Vibratory motion repeats itself after regular intervals of time.
3. it satisfies law of conservation of energy.
4. Body moves to and fro about its means position.

2. Define simple harmonic motion.

Ans. The acceleration of the body executing S.H.M is directly proportional to the displacement from the mean position and always directed towards the mean position.

3. Write the properties of simple harmonic motion.

Ans. i) A body always vibrate about its mean position.

ii) Acceleration is always directed towards mean position.

iii) Acceleration is directly proportional to the displacement and $a = 0$ at mean position and 'a' is maximum at extreme position.

iv) 'v' is maximum at mean position and zero at extreme position.

4. What is meant by time period?

Ans. Time required to complete one round trip (vibration) is called time period.

5. What are mechanical waves?

Ans. The waves which require some medium for their propagation are called mechanical waves. For example sound waves, water waves, string waves.

6. Define transverse waves.

Ans. The waves in which particle of the medium vibrate perpendicular to the direction of propagation of waves. For example water waves.

7. Define crest and trough of a wave.

Ans. <u>Crest:</u> The point at which particle of the medium are above the normal position.

Trough: The point at which particle of the medium are below the normal position.

8. What is frequency? Write its unit.

Ans. The number of waves passing through a point in one second is called frequency. Its unit is cycle per Sec, Hertz (Hz) or vib/sec.

9. Define Hook's law.

Ans. The force applied on the spring directly is proportional to the increase in length is called Hook's law i.e. $F_{ext} \alpha x$.

10. What is meant by amplitude?

Ans. The maximum displacement from mean position to extreme position durning vibratory motion is called amplitude.

11. What are electromagnetic waves? Give examples.

Ans. The waves which do not require any medium for their propagation is called electromagnetic waves. Example is radio waves. Heat, Television waves.

12. Define compressional waves.

Ans. The waves in which particles of the medium vibrate parallel to direction of propagation of waves are called compressional waves.

13. What is reflection?

Ans. The bouncing back of water waves after striking the hurdle is called reflection of waves, and it also obeys the laws of reflection of light.

14. Define refraction.

Ans. When a ray of light enters from one transparent medium to another transparent medium, it bends away from its path the bending of waves from their incident path is called refraction.

15. Define diffraction.

Ans. The bending of waves around the corner or hurdles is called diffraction.

16. What is meant by interference?

Ans. When the particles of the medium are subjected to two waves simultaneously the phenomenon takes place is called interference.

17. Define constructive interference.

Ans. The interference in which crest of one wave fall on the crest of other wave or trough of one fall on the trough of other wave. This is called constructive interference.

18. What is meant by destructive interference?

Ans. The phenomenon in which crest of one wave falls on the trough of other wave, they cancel the each other effect and as a result surface of the medium remains undisturbed is called destructive interference.

19. Define stationary waves.

Ans. When two identical waves pass through a medium along the same line in opposite direction then stationary waves are produced at certain frequency.

20. Give an example, which explain that energy is transferred through waves.

Ans. Example of such waves is sound waves **i.e.** sound energy is transferred from one medium to another medium in the form of waves.