Unit - 10

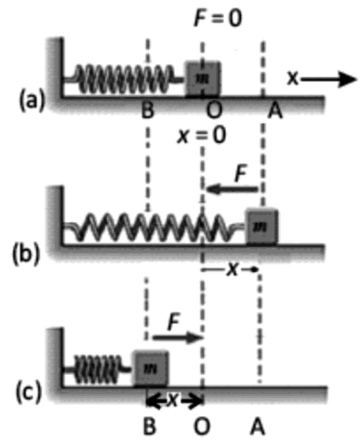
Simple Harmonic Motion And Waves

Q.1: Prove that the motion of a mass attached to a spring is SHM?

Ans: Simple Harmonic Motion: Simple harmonic motion occurs when the net force is directly proportional to the displacement from the mean position and is always directed towards the mean position.

Motion of mass attached to a spring: One of the simplest type of oscillatory motion is that of horizontal mass spring system.

Increase in length: If the spring is stretched or compressed through a small displacement x from its mean position, it exerts a force F on the mass. According to Hooke's law this force is directly proportional to the change in length x of the spring i.e.



SHM of a mass – spring system

$$F \propto -x$$

$$F = -kx \quad \ldots\ldots\ldots\ldots \text{(i)}$$

The negative sign means that force exerted by the spring is always directed opposite to the displacement of mass. Because the spring force always acts towards the mean position. In the following equation x is the displacement of mass from mean position O and K is a constant defined as:

"The ratio between external force acting on a spring and increase in its length is known as spring constant.

$$k = \frac{-F}{x}$$

The unit of spring constant is Nm^{-1}.The value of K is a measure of the stiffness of spring. Stiff springs have large K value, and soft springs have small value of K.

According to 2^{nd} law of motion.

$$F = ma \quad \ldots\ldots\ldots\ldots \text{(ii)}$$

Compare equation (i) and (ii)

$$ma = -kx$$

$$a = \frac{-kx}{m}$$

$$a \propto -x$$

It means that the acceleration of a mass attached to a spring is directly proportional to its displacement from the mean position. Hence, the horizontal motion of a mass spring system is an example of simple harmonic motion.

Restoring force: A restoring force always pushes or pulls the object performing oscillatory motion towards mean position.

Mass at rest: Initially the mass is at rest at mean position O and the resultant force on the mass is zero.

When mass is pulled through displacement "x" to extreme position A: Suppose the mass is pulled through a distance x up to extreme position A and then released. The restoring force exerted by spring on mass will pull it towards mean position O. Due to restoring force the mass moves back, towards the mean position O. The magnitude of the restoring force decrease with the distance from mean position and become zero at O However, the mass gains speed as it moves towards the mean position and its speed become maximum at O.

Mass at extreme position B: Due to inertia the mass does not stop at mean position O but continues its motion and reaches the extreme position B.

As the mass moves from mean position O to extreme position B, the restoring force acting on it towards the mean position steadily increases in strength. Hence speed of mass decrease as it moves towards the extreme position B. The mass finally comes briefly to rest at extreme position B. Ultimately the mass returns to the mean position due to the restoring force.

This process is repeated, and the mass continues to oscillate back and forth about mean position O. Such motion of a mass attached to a spring on a horizontal frictionless surface is SHM.

The time period of the simple harmonic motion of a mass "m" attached to a spring is given by the following equation.

$$Time\,Period = T = 2\pi\sqrt{\frac{m}{K}}$$

Q.2: Discuss the K.E and P.E at different positions in a mass spring system?

Ans: The K.E and P.E of mass spring system at different positions are given below:

(i) Initially the mass m is at rest at mean position O thus its K.E and P.E both are zero.

(ii) When the mass m is pulled from mean position O to extreme position A its P.E become maximum at A.

(iii) Now from position A when mass m is released it tends to move towards mean position O. Now at mean position K.E becomes maximum and P.E becomes zero.

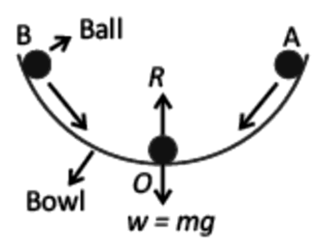
(iv) Due to inertia mass "m" does not stop at mean position "O" and continues its motion towards extreme position B, thus when mass "m" moves from O to B its K.E decreases and P.E increases. At position B, K.E becomes zero and P.E becomes maximum.

Q.3: Prove that the motion of a ball in a bowl is the example of SHM?

Ans: Simple harmonic motion: "Simple harmonic motion occurs when the net force is directly proportional to the displacement from the mean position and is always directed towards the mean position"

Ball and bowl system: The motion of a ball placed in a bowl is an example of simple harmonic motion. To and fro motion of ball about mean position is simple harmonic motion.

Ball at rest: When the ball is at the mean position O, that is, at the centre of the bowl, net force acting on the ball is zero. In this position, weight of the ball acts downward and is equal to the upward normal force of the surface of the bowl. Hence, there is no motion and the ball is at rest.



Ball and Bowl System

By bringing the ball to extreme position A: Now if we bring the ball to position A and then release it, the ball will start moving toward the mean position O due to the restoring force caused by its weight. At position O the ball get maximum speed and due to inertia it moves towards extreme position B.

Ball going towards the extreme position B: Ball is going towards the position B, the speed of ball decreases due to restoring force which acts when towards mean position.

Ball at position B: Ball at position B stops for a while and then again moves towards the mean position O under the action of the restoring force. At B position the speed of ball is zero. To and fro motion of a ball continuous about mean position O till all of energy is lost due to friction.

Q.4: Explain that the motion of bob of a simple pendulum is an example of SHM?

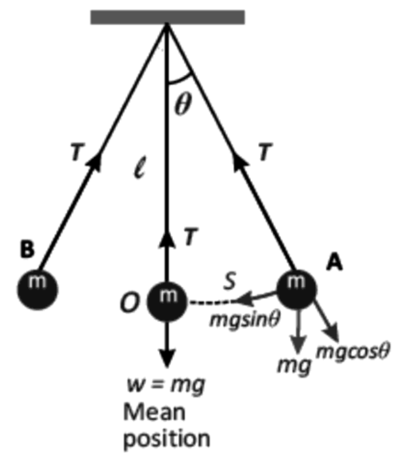
Ans: SHM: Simple harmonic motion occurs when the net force is directly proportional to the displacement from the mean position and is always directed towards the mean position.

Simple pendulum: A simple pendulum consists of a small bob of mass "m" suspended from a light string of length "ℓ" fixed at its upper frictionless end.

(i) Bob at mean position: In the mean position O, the net force on the bob is zero and the bob is stationary.

(ii) Motion of bob from extreme position A towards O:

If we bring the bob to extreme position A, the net force is not zero.



SHM of Simple Pendulum

There is no force acting along the string as the tension in the string cancels the component of the weight mgcosθ. Hence there is no motion along this direction.

The component of the weight mgsinθ is directed towards the mean position and acts as a restoring force. Due to this force the bob starts moving toward the mean position O. The restoring force mg sinθ still acts towards the mean position O and due to this force the bob again starts moving towards the mean position O. In this way, the bob continues its to and fro motion about the mean position O.

Motion of bob from point O to B: At position O the bob has got maximum velocity and due to inertia, it does not stop at O rather it continues to move towards the extreme position B. During its motion towards point B, the velocity of the bob decreases due to the restoring force. The velocity of the bob becomes zero as it reaches the point B.

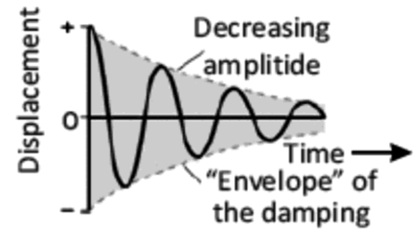
Explanation: It is clear from the motion of the bob that the speed of the bob increases while moving from point A to O due to the restoring force which acts toward O. Therefore acceleration of bob is directed towards O.

Similarly, when the bob moves from O to B, its speed decreases due to restoring force which again acts toward O Therefore acceleration of the bob is again directed towards O it follow that the acceleration of the bob is always directed towards the mean position O. Hence the motion of pendulum is SHM.

$$Time\,Period = T = 2\pi\sqrt{\frac{l}{g}}$$

Q.5: Write a note on Damped Oscillation?

Ans: Damped Oscillations: **"**The oscillations of a system in the presence of some resistive force are called damped oscillations."



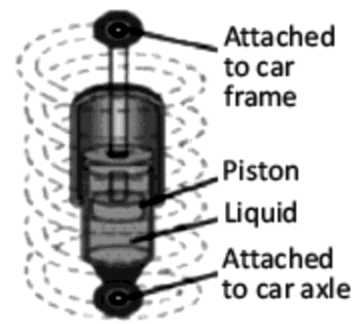
The variation of amplitude with time

Vibratory Motion of Ideal system: Vibratory motion of an ideal systems in the absence of any friction or resistance continues indefinitely under the action of a restoring force.

Damping: Practically, in all systems, the force of friction retards the motion, so the systems do not oscillate indefinitely.

The friction reduces the mechanical energy of the system as the time passes and the motion is said to be damped. This damping progressively reduces amplitude of the vibrations.

Shock Absorbers: Shock absorbers in automobiles are one practical applications of damped motion. A shock absorber consists of a piston moving through a liquid such as oil. The upper part of shock absorber is firmly attached to the body of car. When the car travels over a bump on the road, the car may vibrate violently.



Shock absorber

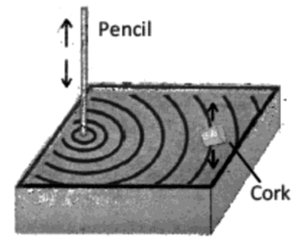
The shock absorbers dampe these vibrations and convert their energy into heat energy of the oil.

Q.6: Define waves and explain wave motion?

Ans: Wave: "A wave is a disturbance in the medium which causes the particles of medium to undergo vibratory motion about their mean position in equal intervals of time"

Wave Motion: Waves play an important role in our daily life. It is because waves are carrier of energy and information over large distances.

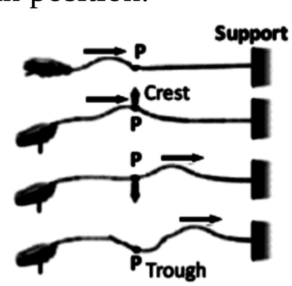
Wave require some oscillating or vibrating source. Here we demonstrate the production and propagation of different waves with the help of vibratory motion of objects.



Waves produced in water

Activity 10.1: Dip one end of a pencil into a tub of water, and move it up and down vertically. The disturbance in the form of ripples produces water waves, which move away from the source. When the wave reaches a small piece of cork floating near the disturbance, it moves up and down about its original position while the wave will travel outwards. The net displacement of the cork is zero. The cork repeats its vibratory motion about its mean position.

Activity 10.2: Take a rope and mark a point P on it. Tie one end of the rope with the support and stretch the string by holding its other end in your hand. Now, flipping the rope up and down regularly will set up a wave in the rope which will travel towards the fixed end. The point P on the rope will start vibrating up and down as the wave passes across it. The motion of point P will be perpendicular to the direction of the motion of wave.



Waves produced in a rope

There are two categories of waves:

(i) Mechanical waves

(ii) Electromagnetic waves

(i) Mechanical waves: Waves which require any medium for their propagation are called mechanical waves.

Examples: Waves produced on the strings and springs, water waves and sound waves.

(ii) Electromagnetic waves: Waves which do not require any medium for their propagation are called electromagnetic waves.

Examples: Radiowaves, television waves, X-rays, heat and light waves.

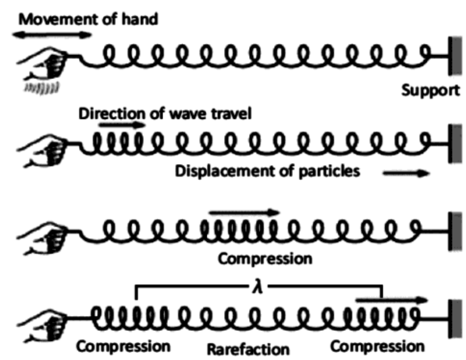
Q.7: Write a note on types of mechanical waves?

Ans: Types of Mechanical Waves: Depending upon the direction of displacement of medium with respect to the direction of the propagation of wave itself, mechanical waves may be classified as: (i) Longitudinal waves (ii) Transverse waves

(i) Longitudinal Waves: "In Longitudinal waves the particles of the medium move back and forth along the direction of the propagation of wave"

Example: Sound waves

Explanation: Longitudinal waves can be produced on a spring (slinky) placed on a smooth floor or a long bench. Fix one end of the slinky with a rigid support and hold other end into your hand. Now give it a regular push and pull quickly in the direction of its length. The motion of spring will be parallel to the direction of motion of waves.



Longitudinal wave on a slinky

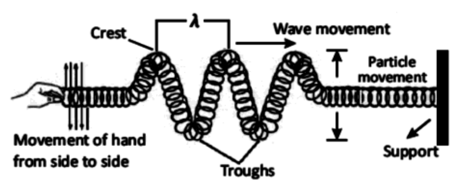
Compressions: **"**The regions in which the loops of spring are close together are called compressions"

Rarefaction: "The regions in which the loops of spring are space apart are called rarefaction"

Motion of Particles of medium: In the region of compression particle of the medium are closer together while in the region of refraction particles of the medium are space apart.

(ii) Transverse Waves: **"**In the case of transverse waves, the vibratory motion of particles of the medium is perpendicular to the motion of waves"

Examples: The examples of transverse waves are water and light waves.



Transverse wave on a slinky

Explanation: Take a rope, Tie one end of the rope with a hook and stretch the string by holding its other end in your hand.

Now, flipping the rope up and down regularly will set up a wave in the rope which will travel towards the fixed end. The rope will start vibrating up and down as the wave passes across it. The motion of rope will be perpendicular to the direction of the motion of wave.

Crest: **"**The parts of transverse waves which move above the mean position are called crest"

Troughs: **"**The parts of transverse waves which move below the mean position are called troughs"

Wavelength: The distance between two consecutive crests or troughs is called wavelength.

Q.8: Write a note on Waves as carriers of Energy?

Ans: Waves as carriers of Energy: Energy can be transferred from one place to another through waves.

Explanation: When we shake the stretched string up and down, we provide our muscular energy to the string. As a result, a set of wave can be seen travelling across the string. The vibrating force from the hand disturbs the particles of string and sets them in motion. These particles then transfer their energy to the adjacent particles in the string. Energy is thus transferred from one place of the medium to other.

Dependence: The amount of energy carried by the wave depends on the distance of the stretched string from its rest position. That is the energy in a wave depends on the wave amplitude of wave. If amplitude and frequency are greater then more energy will be transfer.

Example: If we shake the string faster, we give more energy per second to produce wave of higher frequency, and wave delivers more energy per second to the particles of the string as it moves forward.

Energy Transfer in Water: Water waves also transfer energy from one place to another.

Example: If we drop a stone into pond of water. Water waves will be produce on the surface of water and will travel outward. Now if we place a cork at some distance from the falling stone. When waves reach the cork, it will move up and down along with the motion of the water particles by getting energy from the wave. This shows that water waves like other waves transfer energy from one place to another without transferring in matter.

Q.10.9: Derive relation b/w velocity, frequency and wavelength.

Ans: Velocity of wave: Wave is the disturbance in a medium which travels from one place to another and hence has a specific velocity of travelling, called as velocity of wave.

Which can be defined mathematically as:

$$\text{velocity} = \frac{\text{displacement}}{\text{time}}$$

$$v = \frac{d}{t}$$

If time taken by wave in moving from one point to another is equal to its time period T, then distance covered by wave will be equal to one wavelength λ, hence we can write

$$d = \lambda \quad , \quad t = T$$

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

Time period T, is reciprocal of frequency f i.e $T = \frac{1}{f}$

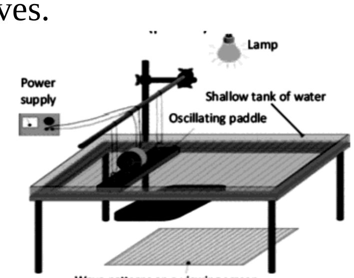
So, $$v = f\lambda$$

Note: This equation is true for both transverse and longitudinal waves.

Q.10: Write a note on Ripple Tank?

Ans: Ripple Tank: "Ripple tank is a device to produce water waves and to study their characteristics"

Apparatus: This apparatus consist of a rectangular tray having glass bottom and is placed nearly half meter above the surface of a table. Waves can be produced on the surface of water present in the tray by means of vibrator (paddle).



Ripple tank apparatus

Working of vibrator: The vibrator is an oscillating electric motor fixed on a wooden plate over the tray such that its lower surface just touches the surface of water. On setting the vibrator ON, this wooden plate starts vibrating to generate water waves consisting of straight wavefronts.

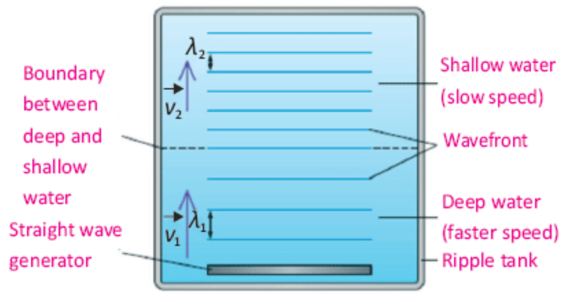
Working of electric bulb: An electric bulb is hung above the tray to observe the image of water waves on the paper or screen.

Crest and Trough: The crests and troughs of the waves appear as bright and dark lines respectively, on the screen.

Q.11: Explain reflection with the help of Ripple Tank?

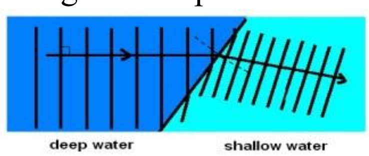
Ans: Reflection of wave: "When waves moving in one medium fall on the surface of another medium they bounce back into first medium such that angle of incidence is equal to the angle of reflection this is called reflection of waves"

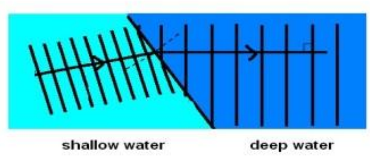
Explanation: Place a barrier in ripple tank. The water waves will reflect from barrier. If a barrier is placed at an angle to wavefront reflected waves can be seen to obey law of reflection i.e. the angle of incident wave along the normal will be equal to angle of reflected wave.



Q.12: Explain refraction with the help of Ripple Tank?

Ans: Refraction of wave: "When wave from one medium enters into the second medium at some angle, its direction of travel changes. This phenomenon is refraction of wave"





Refraction of wave

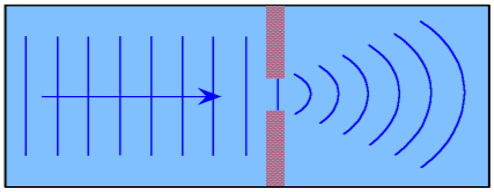
Explanation: The speed of wave in water depends on depth of water. If a block is submerged in the ripple tank, the depth of water in the tank will be shallower over the block than elsewhere.

When water waves enter the region of shallow water their wavelength decreases. But the frequency of water waves remains same in both parts of water because it is equal to frequency of vibrator.

Change in Wavelength: We repeat experiment such that boundary between deep and shallower water is at some angle to wavefront. Now we will observe that in addition to the change in wavelength, the waves change their direction of propagation as well. The direction of propagation is always normal to wavefronts. This change of path of water waves while passing from a region of deep water to that of shallower is called refraction.

Q.13: Explain diffraction with the help of Ripple Tank?

Ans: Diffraction: The bending or spreading of wave around the sharp edges or corners of obstacles is called diffraction"



Diffraction of wave

Explanation: Now we observe the phenomenon of diffraction of water waves. Generate straight waves in a ripple tank and place two obstacles in the line in such a way that separation between them is equal to the wavelength of water waves. After passing through a small slit between the two obstacles, the waves will spread in every direction and change into almost semicircular pattern.

Necessary Condition: Diffraction of waves can only observed clearly if the size of the obstacle is comparable with the wavelength of the wave.

Note: It shows the diffraction of waves while passing through a slit with size larger than the wavelength of the wave. Only a small diffraction occurs near the corners of the obstacle.

EXAMPLES

Example 1: Find the time period and frequency of a simple pendulum 1.0m long at a location where g =10.0ms^{-2}.

Given Data:

l=1.0m

g=10.0ms^{-2}

Required:

(i) T=?

(ii) f=?

Solution:

(i) T=?

By using formula,

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

$$T = 2\pi\sqrt{\frac{1}{10}}$$

T=1.99sec

(ii) f =?

we know that

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

$$f = \frac{1}{1.99}$$

f = 0.5Hz

Example 2: A wave moves on a slinky with frequency of 4Hz and wavelength of 0.4m. What is the speed of the wave?

Given Data:

f=4Hz

λ=0.4m

Required:

v=?

Solution:

we know that

$v = f\lambda$

v= (4) (0.4)

v= 1.6ms^{-1}

Example 3: A student performs an experiment with waves in water. The student measures the wavelength of a wave to be 10 cm. By using the stopwatch and observing the oscillations of a floating ball, the student measures a frequency of 2Hz. If the student starts a wave in one part of a tank of water, how long will it take the wave to reach the opposite side of the tank 2 m away?

Given Data:

$\lambda = 10cm$

$f = 2Hz$

$S = 2m$

Required:

$t = ?$

Solution:

we know that:

$$v = \frac{S}{t}$$

$$t = \frac{S}{v} \quad \ldots\ldots\ldots\ldots\text{(A)}$$

$$v = f\lambda$$

$$v = (2)(0.1)$$

$$v = 0.2ms^{-1}$$

Putting the value of "v" in eq. (A)

$$t = \frac{2}{0.2}$$

t =10sec

NUMERICAL PROBLEMS

10.1: The time period of a simple pendulum is 2sec. What will be its length on the Earth? What will be its length on the Moon if $g_m = \frac{g}{6}$? Where $g_e = 10ms^{-2}$.

Given Data:

$T = 2$ sec

$g_e = 10\,ms^{-2}$

$$g_m = \frac{g_e}{6}$$

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

Required:

(a) $l_e = ?$

(b) $l_m = ?$

Solution:

(a) $l_e = ?$

10.2: A pendulum of length 0.99m is taken to the Moon by an astronaut. The period of the pendulum is 4.9sec. What is the value of g on the surface of the Moon?

Given Data:

$\ell = 0.99m$

$T = 4.9sec$

Required:

$g = ?$

Solution:

As we know that:

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

Taking squaring both sides we get.

We know that

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

$$T = 2\pi\sqrt{\frac{l_e}{g_e}}$$

By squaring both sides we get:

$$T^2 = \frac{4\pi^2 l_e}{g_e}$$

$$l_e = \frac{T^2 g_e}{4\pi^2}$$

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

$$l_e = \frac{40}{39.44}$$

$$\mathbf{l_e = 1.01m}$$

b) $l_m = ?$

We know that

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

$$T = 2\pi\sqrt{\frac{l_m}{g_m}}$$

By squaring both sides we get

$$T^2 = \frac{4\pi^2 l_m}{g_m}$$

$$l_m = \frac{T^2 g_m}{4\pi^2}$$

$$l_m = \frac{(2)^2 \times 1.67}{4\times(3.14)^2}$$

$$l_m = \frac{6.68}{39.44}$$

$$\mathbf{l_m = 0.17m}$$

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

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

$$g = \frac{4\times(3.14)^2\times 0.99}{(4.9)^2}$$

$$\mathbf{g = 1.63\ ms^{-2}}$$

10.3: Find the time period of a simple pendulum of 1m length, placed on Earth and Moon. The value of g on the surface of Moon is $\frac{1}{6^{th}}$ of its value on Earth, where g_e is $10ms^{-2}$.

Given Data:

l = 1m

$g_e = 10\ ms^{-2}$

10.4: A simple pendulum completes one vibration in two seconds. Calculate its length when g = 10 ms^{-2}.

Given data:

T = 2sec

g = 10 ms^{-2}

Required:

l =?

Solution:

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

Required:

(i) T_m =?

(ii) T_e =?

Solution:

(i) T_m =?

we know that

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

$$T_m = 2\pi\sqrt{\frac{l}{g_m}}$$

$$T_m = 2(3.14)\sqrt{\frac{1}{1.67}}$$

$\mathbf{T_m = 4.9sec}$

(i) T_e =?

we know that

$$T_e = 2\pi\sqrt{\frac{l}{g_e}}$$

$$T_e = 2(3.14)\sqrt{\frac{1}{10}}$$

$\mathbf{T_e = 2sec}$

we know that

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

By squaring both sides we get

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

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

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

$$l = 1.02m$$

10.5: If 100 waves pass through a point of a medium in 20 seconds, what is the frequency and the time period of the wave? If its wavelength is 6cm, calculate the wave speed.

Given Data:

Number of waves = 100

t = 20sec

λ= 6cm

$\lambda = \frac{6}{100} = 0.06m$

Required:

(i) f =?

(ii) T =?

(iii) v =?

Solution:

(i) f =?

we know that

$$f = \frac{\text{Number of waves}}{\text{Time}}$$

$$f = \frac{100}{20}$$

10.6: A wooden bar vibrating into the water surface in a ripple tank has a frequency of 12Hz. The resulting wave has a wavelength of 3cm. what is the speed of the wave?

Given Data:

f = 12Hz

λ = 3cm

$\lambda = \frac{3}{100} = 0.03m$

Required:

v =?

Solution:

we know that

$v = f\lambda$

v = (12) (0.03)

$\mathbf{v = 0.36}\ ms^{-1}$

f = 5Hz

(ii) T =?

we know that

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

$T = \frac{1}{5}$

T = 0.2sec

(iii) v =?

v = f λ

v = (5) (0.06)

v = 0.3 ms^{-1}

10.7: A transverse wave produced on a spring has a frequency of 190Hz and travels along the length of the spring of 90m, in 0.5sec.

(i) What is the period of wave?

(ii) What is the speed of wave?

(iii) What is the wavelength of wave?

Given Data:

f = 190 Hz

d = 90 m

t = 0.5 sec

Required:

(i) T =?

(ii) v=?

(iii) λ =?

Solution:

we know that

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

T =? $T = \frac{1}{190}$

T= 0.0053sec

(ii) v =?

we know that

$v = \frac{d}{t}$

$v = \frac{90}{0.5}$

v = 180 ms^{-1}

10.8: Water waves in a shallow dish are 6cm long. At one point, the water moves up and down at a rate of 4.8 oscillations per second.

(a) What is the speed of the water waves?

(b) What is the period of the water waves?

Given Data:

λ = 6cm

$\lambda = \frac{6}{100}$

λ = 0.06m

f = 4.8Hz

Required:

(a) v =?

(b) T =?

Solution:

(a) v =?

we know that

v = f λ

v = (4.8)(0.06)

v = 0.29 ms^{-1}

(b) T =?

we know that

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

$T = \frac{1}{4.8}$

T = 0.21sec

(iii) λ =?

we know that

$v = f\lambda$

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

$\lambda = \frac{180}{190}$

$\lambda = 0.95m$

10.9: At one end of a ripple tank 80cm across, a 5Hz vibrator produces waves whose wavelength is 40mm. Find the time the waves need to cross the tank.

Given data:

$\lambda = 40$ mm

$\lambda = 40 \times 10^{-3}$ m

f = 5Hz

d = 80cm

$d = \frac{80}{100}$

d = 0.8m

Required:

t = ?

Solution:

we know that

$v = \frac{d}{t}$

$t = \frac{d}{v}$ ------------- (a)

v =?

$v = f\lambda$

$v = (5)(40 \times 10^{-3})$

$v = 0.2\ ms^{-1}$

Putting the value of **v** in eq **(a)** we get

$t = \frac{0.8}{0.2}$

t = 4sec

10.10: What is the wavelength of the radiowaves transmitted by an FM station at 90MHz? Where 1M = 10^6 and speed of radiowaves $3 \times 10^8\ ms^{-1}$.

Given Data:

f = 90MHz

$f = 90 \times 10^6$Hz

$v = 3 \times 10^8\ ms^{-1}$

Required:

λ=?

Solution:

we know that

$v = f\lambda$

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

$\lambda = \frac{3\times10^8}{90\times10^6}$

$\Rightarrow$ 3333.33×10^{-6}

$\lambda = 3.33m$

SHORT QUESTIONS

1. **Define simple harmonic motion? What are the necessary conditions for a body to execute SHM?**

Ans: Simple harmonic motion occurs when the net force is directly proportional to the displacement from the mean position and is always directed towards the mean position.

Conditions to execute SHM: Conditions to execute simple harmonic motion as under:
(i) Vibrating body has inertia.
(iii) Vibrating body possess restoring force.

2. Think several examples of motion in everyday life that are simple harmonic.

Ans: (i) Motion of Pendulum clock (ii) Motion of Ball in bowl
(iii) Motion of mass spring system (iv) Motion of the prong of the tuning fork

3. What is damped oscillations?

Ans: The oscillations of a system in the presence of some resistive force are called damped oscillations.

Examples:
(i) Oscillations of Shock absorbers in automobiles are one practical application of damped motion.
(ii) Vibration of real simple pendulum.

4. How damping progressively reduces amplitude of oscillations?

Ans: Practically, in all systems, force of friction retards motion, so system do not oscillate indefinitely. The friction reduces the mechanical energy of system as time passes, the motion is said to be damped. This damping progressively reduces amplitude of motion.

5. How can you define term wave?

Ans: **Wave**: A wave is disturbance in the medium which causes the particles of medium to undergo vibratory motion about their mean position in equal intervals of time.

6. Elaborate the difference between mechanical and electromagnetic waves. Give examples of each.

Mechanical waves	Electromagnetic waves
Waves which require any material medium for their propagation are called mechanical waves. **Examples:** 1. Water waves 2. Sound waves	Waves which don't require any material medium for their propagation are called electromagnetic waves. **Examples:** 1. X-Rays 2. Light Waves

7. Distinguish between longitudinal and transverse waves with suitable examples.

Transverse waves	Longitudinal waves
Waves in which particles of medium move perpendicular to the direction of propagation of waves are called transverse waves. **Example:** Water waves.	Waves in which particles of medium move parallel along the direction of propagation of waves are called longitudinal waves. **Example**: Waves of sound in air.

8. Define crust and trough.

Ans: **crest:** The part of the transverse wave where medium particle lie above the mean position is called crust.

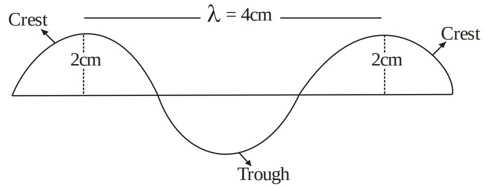
Trough: The part of transverse wave where medium particle lie below the mean position is called trough.

9. Which waves are produced by earthquake.

Ans: The waves produced during the earthquake are called seismie waves.

10. Draw a transverse wave with an amplitude of 2cm and a wavelength of 4cm. Label a crest and trough on the wave.

Ans:



11. Does increasing the frequency of a wave also increase its wavelength? If not, how are these quantities related.

Ans: If speed of waves is kept constant then frequency and wavelength of wave are inversely related i.e. by increasing frequency wavelength decreases.

$$f = \frac{v}{\lambda} \qquad f \propto \frac{1}{\lambda}$$

12. If the length of a simple pendulum is doubled. what will be the change in its time period?

Ans:

We know that

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

If $l = 2l$ then

$$T' = 2\pi\sqrt{\frac{2l}{g}}$$

$$T' = 2\pi\sqrt{\frac{l}{g}}.\sqrt{2}$$

$$T' = T\sqrt{2}$$

So, If the length of simple pendulum is doubled then the time period will be $T\sqrt{2}$.

13. A ball is dropped from a certain height onto the floor and keep bouncing. Is the motion of a ball simple harmonic motion? Explain

Ans: No, If a ball is dropped from a certain height it can't achieve its first position again and eventually stop. Its acceleration is not directly proportional to its displacement from mean position and is not directed towards the mean position. Therefore its motion is not simple harmonic.

14. A student performed two experiments with a simple pendulum. He/She used two bobs of different masses by keeping other parameters constant. To his/her astonishment the time period of the pendulum did not change! why?

Ans: As we know that:

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

According to the formula:

The time period of the simple pendulum does not depend upon the mass of bobs. Therefore the time period of the simple pendulum does not change with the change in mass.

15. What types of wave do not require any material medium for their propagation?

Ans: Electromagnetic wave does not require any material medium for their propagation.

Examples: Light waves and X- rays.

16. Plane waves in a ripple tank undergo refraction when they move from deep to shallow water. What change occurs in the speed of the waves?

Ans: When waves move from deep to shallow water undergo refraction their speed will be slow down.

17. What is the displacement of an object in SHM when K.E and P.E are equal?

Ans: In simple harmonic motion when K.E and P.E are equal then the displacement will be the half of amplitude of vibrating body.

18. Do mechanical waves pass through vacuum that is empty space?

Ans: No, mechanical waves can't pass through vacuum because mechanical waves require material medium for their propagation and there is no medium in space.

19. What do the dark and bright fringes on the screen of ripple tank represent?

Ans: Bright fringe represent the crest of the wave while dark fringe represent the trough of the wave.

20. What happens to the angle of refraction when water waves pass from deep to shallow part of the water?

Ans: When water waves pass from deep to shallow part of the water the angle of refraction decreases.

21. Do the magnitudes of angle of incidence and angle of refraction equal?

Ans: No, the magnitudes of angle of incidence and angle of refraction are not equal.

22. Prove that v = fλ

Ans: We know that:

$$S = vt$$

$$\lambda = vT$$ Where λ is distance covered by wave and T is its time period.

$$\lambda = v\frac{1}{f}$$

$$\left(T = \frac{1}{f}\right)$$

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

The product of frequency and wavelength are equal to the velocity.

23. Give relation between frequency and time period?

Ans: The relation between frequency and time period is given below.

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

24. Define vibration?

Ans: One complete round trip of vibrating body about its mean position is called one vibration.

25. Define time period?

Ans: The time taken by vibrating body to complete its one vibration is called time period.
Note: It is denoted by T. Its unit is second. Formula for simple pendulum is $T = 2\pi\sqrt{\frac{l}{g}}$

26. Define frequency?

Ans: The number of vibration or cycle of a vibrating body in one second is called its frequency.
Note: It is reciprocal of time period i.e. $f = \frac{1}{T}$. Its unit is hertz (Hz).

27. Define amplitude?

Ans: The maximum displacement of a vibrating body on either side from its mean position is called amplitude. OR The distance between mean position and extreme position is called amplitude.

28. Describe important features of SHM?

Ans: Important features of SHM are summarized as:

(i) A body executing SHM always vibrates about a fixed position.

(ii) Its acceleration is always directed towards the mean position.

(iii) The magnitude of acceleration is always directly proportional to its displacement from mean position.

(iv) Its velocity is maximum at the mean position and zero at the extreme position.

29. What is wave equation?

Ans: The relation between the velocity, frequency and wavelength of wave is known as wave equation. i.e

$$v = f\lambda$$

30. Define ripple tank?

Ans: Ripple tank is a device to produce water waves and to study their properties. Like reflection, refraction and diffraction.

31. Describe the structure of ripple tank?

Ans: Ripple tank consist of a rectangular tray having glass bottom and is placed nearly half meter above the surface of a table. Waves can be produced on the surface of water present in the tray by means of a vibrator.

32. What is reflection?

Ans: When waves moving in one medium fall on the surface of another medium they bounce back into the first medium such that the angle of incidence is equal to the angle of reflection. This phenomenon is called reflection of waves.

33. Define diffraction?

Ans: The bending or spreading of waves around the sharp edges or obstacles is called diffraction.

34. What is the necessary condition to observe clear diffraction?

Ans: Diffraction of waves can only be observed clearly if the size of the obstacle is comparable with the wavelength of the wave.

35. Define refraction of waves?

Ans: When waves from one medium enter in the second medium at some angle their direction of travel may change. This phenomenon is called refraction of waves.

36. Compare the speed of transverse and longitudinal waves through solids.

Ans: Transverse waves move through solids at a speed of less than half speed of longitudinal waves. It is because the restoring force exerted during this up and down motion of particles of medium is less than restoring force exerted by a back and forth motion of particles of medium in case of longitudinal waves.

38. Define spring constant of spring?

Ans: Spring constant is the ratio of external applied force to change in length produce by this force.

Formula:

$$K = \frac{F}{x}$$ **Unit**: Nm^{-1}

37. What is meant by wavefront?

Ans: **Wavefront:** The parts of waves where the motion of all particles of medium is same, these parts are called wavefronts.

Example: Crests.

38. How many times human ear oscillate in one second?

Ans: Human ear oscillates 20,000 times in one second.

39. State Hook's law.

Ans: According to Hook's law force is directly proportion to change in length x of spring i.e.

$$F \propto -x$$

40. Define restoring force.

Ans: **Restoring force:** A restoring force always pushes or pulls the object performing oscillatory motion towards mean position.

Q.41: Define waves and wave motion?

Ans: **Wave:** "A wave is a disturbance in the medium which causes the particles of medium to undergo vibratory motion about their mean position in equal intervals of time"

Wave Motion: Waves play an important role in our daily life. It is because waves are carrier of energy and information over large distances.

MULTIPLE CHOICE QUESTIONS

1. **Which of the following is an example of simple harmonic motion?**
   (a) Motion of simple pendulum (b) The spinning of the earth on its axis
   (c) The motion of ceiling fan (d) The bouncing ball on a floor
2. **The mass of the bob of a pendulum is increased by a factor of 3 the period of the pendulum motion will:**
   (a) Be increased by a factor of 2 (b) Be decreased by a factor of 3
   (c) Remain the same (d) Be decreased by a factor of 4
3. **Which of the following device can be used to produce both a transverse and longitudinal waves?**
   (a) A string (b) A helical spring(slinky)
   (c) A ripple tank (d) A tuning fork
4. **Waves transfer:**
   (a) Energy (b) Wavelength (c) Frequency (d) Velocity
5. **Which of the following is a method of energy transfer?**
   (a) Conduction (b) Radiation (c) Wave motion (d) All of these
6. **In a vacuum all electromagnetic waves have the same:**
   (a) Speed (b) Amplitude (c) Frequency (d) Wavelength
7. **A large ripple tank with a vibrator working at a frequency of 30Hz produce 25 complete waves in a distance of 50 cm the velocity of wave is:**
   (a) $53cms^{-1}$ (b) 750cms (c) $60cms^{-1}$ (d) 1500cms
8. **Which of the following characteristics of a wave is independence of others?**
   (a) Speed (b) Amplitude (c) Frequency (d) Wavelength
9. **The relation between v , f and λ of wave is:**
   (a) $vf = \lambda$ (b) $f\lambda = v$ (c) c. $\lambda = f$ (d) $v = \frac{\lambda}{f}$
10. **When water waves enter from deep to shallow region they:**
    (a) Bend away from the normal (b) Remain straight
    (c) Bend toward the normal (d) None of these
11. **When water waves enter from shallow region to deep region they:**
    (a) bend away from the normal (b) remain straight
    (c) bend toward the normal (d) none of these
12. **Bending of waves around corner is called:**
    (a) reflection (b) diffraction (c) refraction (d) interference
13. **In order to observe the diffraction of waves the size of the slit or obstacle is kept nearly equal to the**
    (a) frequency of waves (b) wavelength of waves
    (c) time period of waves (d) amplitude of waves
14. **The speed of water waves depend upon:**
    (a) nature of water (b) depth of water
    (c) volume of water (d) ass of water
15. **When water waves enter from deep to shallow region their wavelength:**
    (a) Decreases (b) remain unchanged
    (c) Increases (d) become zero

16. Earth quake produces waves through the body of earth in the form of:
(a) cosmic waves (b) water waves
(c) seismic waves (d) sound waves

17. Wave equation is defined as:
(a) $v = \frac{s}{t}$ (b) $v = f\lambda$ (c) $v = \frac{1}{T}$ (d) None

18. The wavelength of a wave passing through a medium is 0.1m, wave speed is 2ms^{-1} then the wave frequency will be:
(a) 50Hz (b) 20Hz (c) 10Hz (d) 30Hz

19. The wave in which particles of the medium vibrate perpendicular to the direction of propagation of waves are called:
(a) transverse waves (b) compression waves
(c) longitudinal waves (d) none of these

20. The wave in which particles of the medium vibrate along with the direction of motion of waves are called:
(a) transverse waves (b) compression waves
(c) longitudinal waves (d) both a and b

21. Those parts of the transverse waves where the particles of the medium are above the mean position are called:
(a) crests (b) rarefactions (c) compressions (d) trough

22. Which wave carries more energy?
(a) High frequency (b) Zero frequency (c) Low frequency (d) None of these

23. Which type of waves consists of compression and refraction?
(a) Longitudinal waves (b) Electromagnetic waves
(c) Transverse waves (d) Electromagnetic waves

24. The region of a longitudinal wave where the particle of the medium are closer together is called:
(a) Crest (b) Compression (c) Trough (d) Refraction

25. The region of longitudinal wave where the particles of the medium are spaced apart is called:
(a) Crest (b) Compression (c) Trough (d) Refraction

26. Longitudinal waves move faster through
(a) Liquids (b) Gases (c) Solids (d) All of these

27. Longitudinal waves consists of:
(a) Crests and troughs (b) Compressions and rarefaction
(c) Crests only (d) Compression only

28. Transverse waves consists of:
(a) Crests and trough (b) Compressions and rarefaction
(c) Crests only (d) Compression only

29. How many types of mechanical waves are there?
(a) Two (b) Three (c) Four (d) Five

30. A human ear drum vibrates back and forth ……… times in one second.
(a) 20 (b) 2000 (c) 20000 (d) None

31. In ball and bowl system which force act as restoring force.
(a) Tension (b) friction (c) Gravity (d) None

32. Christian Huygens invented pendulum clock in……….?
(a) 1765 (b) 1665 (c) 1656 (d) 1675

33. A spider detects its prey due to:
(a) Reflection of sound (b) Vibration in web
(c) Smelling (d) magnetic field

34. The product of frequency f and wavelength λ is equal to:

(a) Time period (b) amplitude (c) Wave speed (d) frequency

35. Formula for time period of mass spring system is:

(a) $T = 2\pi\sqrt{\frac{m}{k}}$ (b) $T = 2\pi\sqrt{\frac{l}{g}}$ (c) $T = 2\pi\sqrt{\frac{K}{m}}$ (d) $T = 2\pi\sqrt{\frac{g}{l}}$

36. When a body moves to and fro about a point, its motion is called:

(a) random motion (b) vibratory motion (c) linear motion (d) rotatory motion

37. Formula to calculate time period of pendulum is:

(a) $T = 2\pi\sqrt{\frac{m}{k}}$ (b) $T = 2\pi\sqrt{\frac{l}{g}}$ (c) $T = 2\pi\sqrt{\frac{K}{m}}$ (d) $T = 2\pi\sqrt{\frac{g}{l}}$

38. Formula of Hook's law is:

(a) $k = \frac{-2F}{x}$ (b) F = kx (c) –Fx (d) k = –Fx

39. Unit of frequency is:

(a) Hz (b) meter (c) second (d) joule

40. Distance between consecutive compression and refraction is called:

(a) time period (b) frequency (c) wavelength (d) focal length

41. If time period is given then frequency can be calculated as:

(a) $f = \frac{4}{T}$ (b) $f = \frac{3}{T}$ (c) $f = \frac{2}{T}$ (d) $f = \frac{1}{T}$

42. If ℓ = 1m, then period of simple pendulum is:

(a) 1.88s (b) 1.89s (c) 2.11s (d) 1.99s

43. K.E of spring mass system is maximum at:

(a) extreme position (b) mean position (c) both a and b (d) none

44. Number of waves passing through a point in one second is called:

(a) frequency (b) displacement (c) wavelength (d) amplitude

45. Waves are of _____ types.

(a) 2 (b) 3 (c) 4 (d) 5

46. Product of frequency and time period is:

(a) 0 (b) speed (c) 1 (d) wavelength

47. Radio waves are:

(a) mechanical (b) electromagnetic (c) sound waves (d) all of these

48. Example of mechanical waves is:

(a) Radio waves (b) X-Ray (c) Light waves (d) sound waves

49. The spring's constant is:

(a) $k = -\frac{F}{x}$ (b) F = mu (c) w = mg (d) $k = \frac{x}{m}$

50. Frequency is equal to:

(a) f = kx (b) $f = 2\pi\sqrt{\frac{l}{g}}$ (c) $f = 2\pi\frac{l}{g}$ (d) $f = \frac{1}{T}$

51. The relation between velocity, frequency and wavelength of a wave is.

(a) $vf = \lambda$ (b) $f\lambda = v$ (c) $v\lambda = f$ (d) $v = \frac{\lambda}{f}$

52. In motion of a simple pendulum, restoring force is provided by:

(a) air resistance (b) tension in the string (c) force of gravity (d) inertia

53. ……… is an example of Longitudinal waves.

(a) Sound Waves (b) Light waves (c) Radio waves (d) Water waves

54. Waves which donot required medium for their propagation.

(a) Sound Waves (b) Mechanical waves
(c) electromagnetic waves (d) all of these

ANSWERS

1	a	**2**	c	**3**	b	**4**	a	**5**	d	6	a
7	c	**8**	b	**9**	b	**10**	c	**11**	a	12	b
13	b	**14**	b	**15**	a	**16**	c	**17**	b	18	b
19	a	**20**	c	**21**	a	**22**	a	**23**	a	24	b
25	d	**26**	c	**27**	b	**28**	a	**29**	a	30	c
31	c	**32**	b	**33**	b	**34**	c	**35**	a	36	b
37	b	**38**	b	**39**	a	**40**	c	**41**	d	42	d
43	b	**44**	a	**45**	a	**46**	c	**47**	b	48	d
49	a	**50**	d	**51**	b	**52**	d	**53**	a	54	c