UNIT 10

SIMPLE HARMONIC MOTION AND WAVES

After studying this unit, the students will be able to:

- **a.** State the conditions necessary for an object to oscillate with SHM.
- **b.** Explain SHM with simple pendulum ball and bowl examples.
- **c.** Draw forces acting on a displaced pendulum.
- **d.** Solve problems by using the formula $T=2\pi\sqrt{L/g}$ for simple pendulum.
- **e.** Understand that damping progressively reduces the amplitude of oscillation.
- **f.** Describe wave motion as illustrated by vibrations in rope, slinky spring and by experiments with water waves.
- **g.** Describe that waves are means of energy transfer without transfer of matter.
- **h.** Distinguish between mechanical and electromagnetic waves.
- **i.** Identify transverse and longitudinal waves in mechanical media stinky and springs.
- **j.** define the terms speed (v), frequency (f), wavelength (Z), time period (T) amplitude crest, trough, cycle, wave front, compression and rarefaction.
- **k.** Derive equation $v=f\lambda$.
- **l.** Solve problems by applying the relation $f=\frac{1}{t}$ and $v=f\lambda$.
- **m.** Describe properties of waves such as reflection, refraction and diffraction with the help of ripple tank.

Q1. What is simple harmonic motion? What are the necessary conditions for a body to execute simple harmonic motion?

Answer

Simple harmonic motion

Definition:

The motion in which the acceleration of a body is directly proportional to the displacement from the mean position and always directed towards the mean position is called simple harmonic motion.

Necessary conditions for a body to execute simple harmonic motion.

- **i)** A body executing SUM 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 the mean position i.e. acceleration will be zero at the mean position while it will be maximum at the extreme position
- **iv)** Its velocity is maximum at the mean position and zero on the extreme position

Q.2 Prove that the motion of mass attached to g spring is SHM?

Answer

Fig.10.1 SHM of a mass-spring system

One of the simplest types of oscillatory motion is that 'of horizontal mass spring system.

If the spring is stretched or compressed through a small 'x' from its mean position, it exerts a force 'F' on the mass.

According to, Hook's law this force is directly proportional to the change in length 'x' of the spring.

i.e.

$$F=-kx……….(i)$$

For your Information

Although the molecules in a solid are held together, they can still move and vibrate, as though connected by springs.

Where 'x' is the displacement of the mass from its mean position 'O', and 'K' is a spring constant defined as

The value of 'k' is a measure of the stiffness of the spring. Stiff springs have large 'k.' values and soft springs have small 'k' values.

The negative. sign in equation (1) means that the force exerted by the spring' is always directed opposite to the displacement of the mass. Because the spring force always acts towards the mean position.

It is sometimes called a restoring force.

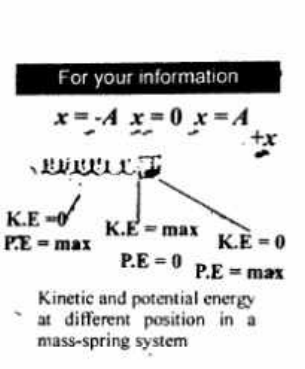
Restoring force:

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

Explanation:

Initially the mass 'm' is at rest in mean position '0' and the resultant force on the mass is zero. Suppose the mass is pulled through a distance 'x' up to extreme position 'A' and then released.

For your information



Kinetic and potential energy at different position in a mass-spring system

The restoring 'orce exerted by the spring on the mass will pull it towards the mean position '0. Due to the restoring force the mass moves back towards the mean position 00 the magnitude of the restoring force decreases with the distance from the mean position and becomes zero at 0. However, the mass gains speed as it moves towards the mean position and becomes maximum at O. Due to inertia the mass does not stop at the mean position 'O' but continues its motion and reaches the extreme position 'B'. As the mass moves

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

This process is repeated, and the mass continues to oscillate back and forth about the mean position '0'.

Such motion of a mass attached to a spring on horizontal frictionless surface is known as simple harmonic motion. The time period T of the simple harmonic motion of a mass 'm' attached to a spring is,

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

Q.3 Does the system of ball and bowl execute simple harmonic motion? Explain.

Answer

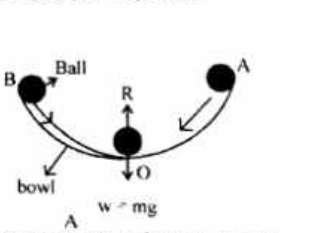


Fig. 10.2 When a ball is gently displaced from the entre of a bowl it starts oscillating about the centre due to force of gravity which acts as a restoring force.

The motion of a ball placed in a bowl is an example of simple harmonic motion.

When the ball is at the mean position '0' that is, at the center 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. Now if webring the ball to position 'A' and then release it, the ball will start moving towards the mean position '0' due to the restoring force caused by its weight At position '0' the ball gets maximum speed

and due to inertia it moves towards the extreme position '8'. While going towards the position 'B' the speed of the ball decreases due to the restoring force which acts towards the mean position. At the position 'B' the ball stops for a while and then again moves towards the mean position 'O' all its energy is lost due to friction. Thus, the to and fro motion of the 'ball about a mean position placed in' a bowl is an example of simple harmonic motion.

Q.4 Is the motion of a simple pendulum a simple harmonic motion. Write in detail.

For your information

The period of a pendulum is independent of its mass and amplitude.

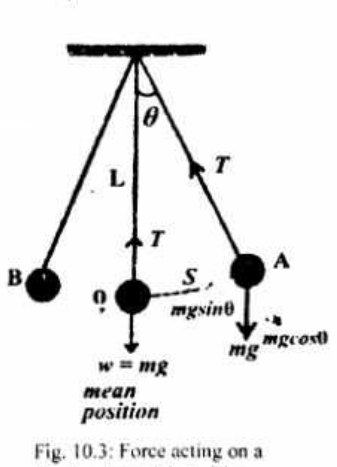


Fig. 10.3: Force acting on a displaced pendulum. The restoring force that causes the pendulum to undergo simple harmonic motion is the component of gravitational force mg sin tangent to the path of motion.

Answer

A simple pendulum exhibits SHM. It consists of a small bob of mass 'm' suspended from a light string of length 'L' fixed at its upper end in the equilibrium position '0'the net force on the bob is zero and the bob is stationary. Now if we bring the bob to extreme position 'A' the net force is not zero. There is no force acting along the string as the tension in the string cancels the component of the weight mg Cos θ. Hence there is no motion along this direction. The component of the weight mg Sine is directed towards the mean position and acts as a restoring force. Due to this force the bob starts moving towards the mean position '0'. At '0' the bob has gat the maximum velocity and due to inertia 'it does not stop at '0'rather it continues to move towards the extreme position 'B'.

During its motion towards point 'B', the velocity of the bob decreases due to restoring force. The velocity of the bob becomes zero as it reaches the point 'B'. The restoring force. 'mg Sinθ' still acts towards the mean

position '0' and due to this force, the bob again starts moving towards the mean position '0'. In this way, the bob continues its to and fro motion about the mean position '0'.

It shows that the speed of the bob increases while moving from point 'A' to'0'due to the restoring force which acts towards '0'. Therefore, acceleration of the bob is also directed towards '0'.

Similarly, when the bob moves from '0' to '8'. Its speed decreases due to restoring force which again acts towards '0'. Therefore, acceleration of the bob is always directed towards '0'. It follows that the acceleration of the bob is always directed towards the mean position '0'. Hence the motion of a simple pendulum is SHM.

The formula for the time period of simple pendulum is:

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

Q.5 Define the following terms which characterize simple harmonic motion?

Vibration, Time period, Frequency, Amplitude.

Answer

Vibration:

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

Time period:

The time taken by a vibrating body to complete one vibration is called time period.

Frequency:

The number of vibrations per cycle of a vibrating in one second is called its frequency.

Amplitude:

The maximum displacement of a vibrating body on either side from its mean position is called its amplitude.

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

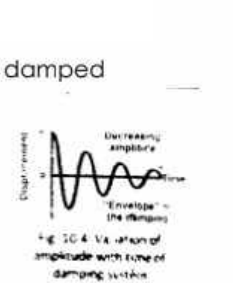
Q.6 What are damped oscillations? How dumbing progressively reduces the amplitude of oscillation?

Answer

Damped oscillations

Definition:

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



Explanation:

Vibratory motion of Ideal systems in the absence of any friction or resistance continuous indefinitely under the action of a restoring force. Practically, in all systems the force of friction retards the motion, so the system do not oscillate indefinitely.

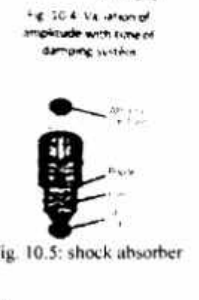


Fig. 10.5: shock absorber

The friction reduces the mechanical energy of the system as time passes and the motion is said to be damped. This damping progressively reduces the amplitude of the motion as shown in the figure. Shock absorbers in automobiles are one practical application of

damped motion. The shock absorber consists of a piston moving through a liquid such as oil. The upper part of the shock absorber is firmly attached to the body of the car.

When the car travels over a hump on the road, the car may vibrate violently. The shock absorbers damp these vibrations and convert their energy into heat energy of the 'oil.

Q.7 Define the terms "wave" and "wave motion"? Write different activities to describe the generation and propagation of wave?

Answer

Wave (definition):

Fig. 10.6: Waves produced by dipping a pencil in a water tub

A wave is a disturbance that propagates away from the source (travels) through any medium usually by transference of energy.

Wave motion (definition):

The process by which a disturbance at one with no net transport of the particles of the medium is called a wave motion.

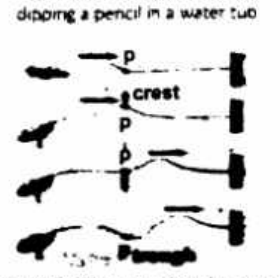


Fig. 10.7: Waves produced on a string

Waves are carrier of energy and information over large distances.

The production and generation of different waves with the help of vibratory motion of object are demonstrated by the activities below.

Activity 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 but 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 2:

Take a rope and mark a point 'P' on it. 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 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.

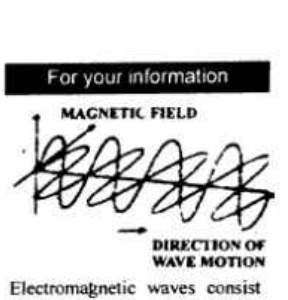
Q.8 Describe the types of waves?

Answer

There are three types of waves:

1. Mechanical waves
2. Electromagnetic waves
3. Matter waves

For your information



Electromagnetic waves consist of electric and magnetic fields oscillating perpendicular to each other.

1) Mechanical waves:

Waves which require any medium for their propagation are called mechanical waves. In such types of waves, the particles of the medium vibrate about their respective mean position and propagate disturbance in the forward direction.

Examples of mechanical waves are water waves sound waves and waves produced on the springs or

2) Electromagnetic waves:

Waves which do not require any medium for their propagation are called electromagnetic waves.

Such Waves are consisted of electric and magnetic other fields.

Radio waves, television waves, x-rays, heat and light waves are some examples of electromagnetic waves.

3) Matter waves:

Such waves in which the particles of the medium actually move from one position to other by carrying energy.

Examples are ocean waves and electron waves when electrons move at a very high-speed approaching speed of light.

Q.9 Distinguish between longitudinal and transverse waves with suitable examples?

Answer

Depending upon the direction of displacement of medium with respect to the direction of motion of the wave itself, mechanical waves may be classified as longitudinal or transverse.

Longitudinal (Compressional) waves:

Longitudinal waves can be produced on a spring (slinky) placed on a smooth floor or along bench. Fix one end of the slinky with a rigid support and hold another end into your hand. Now give it a regular push and pull quickly in the direction of its length.

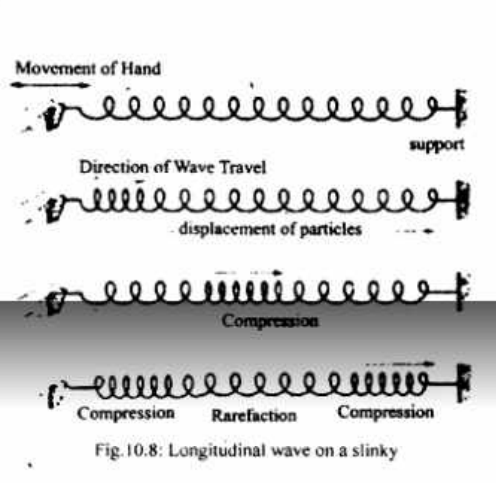


Fig.10.8: Longitudinal wave on a slinky

A series of disturbances in the form of waves will start moving along the length of the slinky. Such a wave consists of regions called "compressions", where the loops of the spring are close together, alternating with regions called "rarefactions" (expansions), where the coils are spaced apart.

In the regions of compressions, particles of the medium are closer together while in the regions of rarefaction particles of the medium are spaced apart.

The compression and rarefactions move back and forth along the direction of motion of the wave.

Definition:

In longitudinal or compressional waves, the particles of the medium move back and forth along the direction of propagation of Wave.

Transverse waves:

Transverse waves can be produced with the help of slinky (flexible spring). Stretch out a slinky along a smooth floor or a long bench with one end fixed. Grasp the other end of the slinky 'and move it up and down quickly. A wave in the form of alternative crests and troughs will start travelling towards the fixed end.

The crests are the highest points while the troughs are the lowest points of the particles of the medium from the mean position.

The crests and troughs move perpendicular to the direction of the wave.

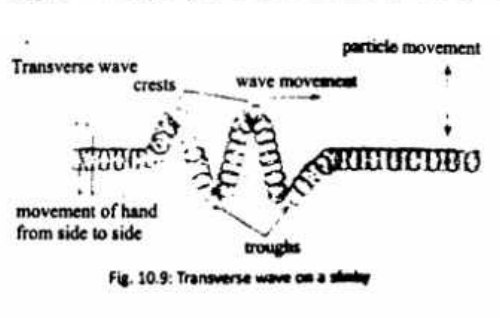


Fig. 10.9: Transverse wave on a slinky

Definition:

In the case of transverse waves, the motion of particles of the medium is perpendicular to the motion of wave.

Q.10 Waves are the means of energy transfer without transfer of matter. Justify this statement with the help of a simple experiment.

Answer

Energy can be transferred from one place to another through waves.

For example; when we shake the stretched spring up and down, we provide our muscular energy to the string. As a result, a set of waves can be seen travelling along the string. The vibrating force from the hand disturbs the particles of the 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 the other in the form of wave.

The amount of energy Carried by the wave depends upon the distance of the stretched string from its rest position. That is, the energy in a wave depends on the wave amplitude of the wave.

If we shake the string faster, we give more energy per second to produce wave of higher frequency and the wave delivers more energy per second to the particles of the string as it moves forward. Water waves also transfer energy from one place to another as explained below.

Activity:

Drop a stone into a pond of water. Water waves will be produced on the surface of water and will travel outwards as shown in the fig. 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 activity shows that water waves like other waves transfer energy from one place to other without transferring matter. i.e. water.

Q.11 Derive a relationship between speed, frequency and wave length of a wave. Write a formula relating speed of a wave to its time period and wave length?

Answer

The relation between the velocity, frequency and wave length of the wave is known as wave equation.

Wave is infecting a disturbance in a medium which travel from one place to another and hence have a specific velocity of travelling. This is called the velocity of wave which is defined by,

$$velocity=\frac{distance}{time}$$

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

If time taken by the wave in moving from one point to another is equal to the time period then the distance covered by the wave will be equal to one Wave length, hence we can write;

But time period 'T' is reciprocal of the frequency 'P, i.e.,

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

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

Therefore, $v=f\lambda$

This equation is called the wave equation which is true for all type of waves, _i.e. longitudinal, transverse etc.

Q.12 What is a ripple tank? Write its construction and use to study the wave properties?

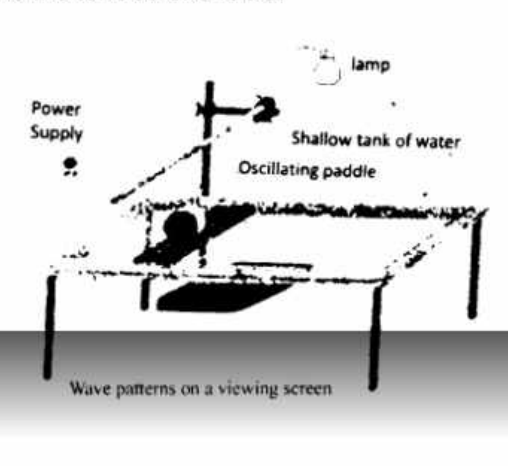
Answer

Ripple Tank: [redacted]

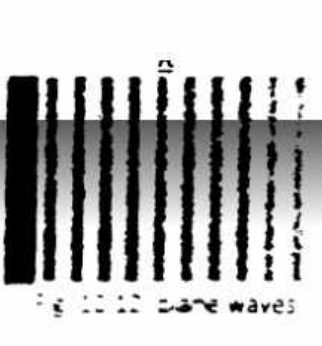
Ripple tank is a device to produce water waves and to study then [redacted] characteristics.

Construction & Use:

Ripple tank consists 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 vibrator (paddle).



This vibrator is on 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 plane water waves.

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

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

Q.13 Explain the following properties of waves with reference to ripple tank experiment?

a) Reflection b) Refraction c) Diffraction

Answer

a) Reflection:

To study the reflection of water waves, place a barrier in the ripple tank. The water waves will reflect from the barrier. If the barrier is placed at an angle to the wave front, the reflected waves can be seen to obey the law of reflection i.e. the angle of the incident wave along the normal 'will be equal to the angle of the reflected wave as shown in fig 10.13.

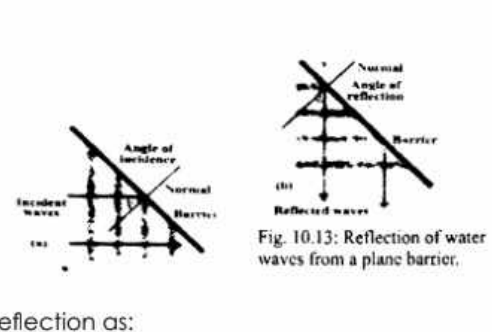
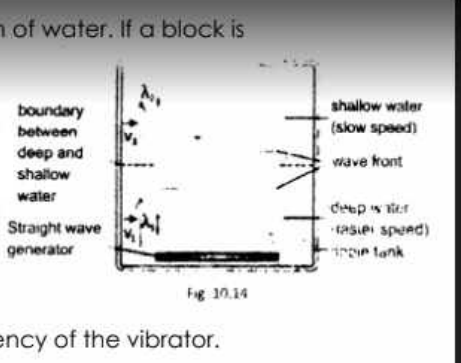


Fig. 10.13: Reflection of water waves from a plane barrier.

Thus, we define reflection as:

"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. The phenomenon is called reflection of waves."



boundary between deep and shallow water
Straight wave generator
shallow water (slow speed)
wave front

Fig 10.14

The speed of a wave in Water depends on the 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 wave length decreases. But the frequency of the water waves remains the same in _both parts of water because it is equal to the frequency of the vibrator.

b) Refraction:

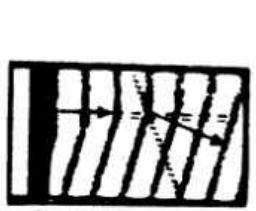


Fig. 10.15: Refraction of water waves

For the observation of refraction of water waves, we repeat this experiment such that the boundary between the depend the shallower water is at some angle to the wave. front as shown in fig. 10.15. -Now we will observe that in addition to the change in wave length the waves change their direction of propagation as well.

The direction of propagation is always normal to the wave fronts.

This change of path of water waves while passing from a region of deep water to that of shallower is called refraction which is defined as,

"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 water waves."

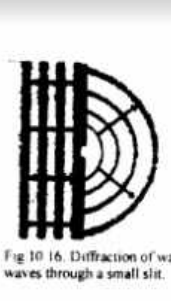


Fig 10.16: Diffraction of water waves through a small slit.

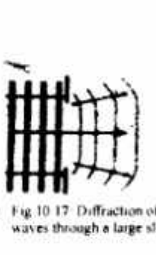


Fig 10.17 Diffraction of water waves through a large slit.

Fig 10.8

c) Diffraction:

To observe the phenomena of diffraction of water waves, generate plane waves in a ripple tank and place two obstacles in line in such a way that separation between them is equal to the wave length 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.

Diffraction of waves can only be observed clearly if the size-of the obstacle is comparable with the wave length of the Wave Fig 10.17 shows the diffraction of waves while passing through a slit with size larger than the wave length of the wave.

Only a small diffraction occurs near the corners of the obstacle.

"'The bending or spreading of waves around 'the sharp edges or comers of obstacles is called diffraction."

MULTIPLE CHOICE QUESTIONS

Choose the correct answer from the following choices:

i) Which of the following is an example of simple harmonic motion?

a) Motion of a simple pendulum **b)** The motion of ceiling fan

c) The spinning of the Earth on its axis **d)** A bouncing ball on a floor

ii) If the mass of the bob of a pendulum is increased by a factor of 3, the period of the pendulum's motion will:

a) be increased by a factor of 2 **b)** remain the same

c) be decreased by a factor of 2 **d)** be decreased by a factor of 4

iii) Which of the following devices can be used to produce both a transverse and longitudinal wave?

a) a string **b)** a ripple tank

c) a helical spring (slinky) **d)** a tuning fork

iv) Waves transfer:

a) Energy **b)** frequency

c) wavelength **d)** velocity

v) Which of the following is a method of energy transfer?

a) Conduction **b)** Radiation

c) Wave motion **d)** All of these

vi) In a vacuum all electromagnetic waves have the same:

a) Speed **b)** frequency

c) amplitude **d)** wavelength

vii) A large ripple tank with a vibrator working at a frequency of 30 Hz produces 25 complete waves in a distance of 50cm. The velocity of the wave is:

a) 53 cms^{-1} **b)** 60 cms^{-1}

c) 750 cms^{-1} **d)** 1500 cms^{-1}

viii) Which of the following characteristics of a wave is independent of the others:

a) speed **b)** frequency

c) amplitude **d)** wavelength

ix) The relation between v, f and A of a wave is:

a) $vf = \lambda$ **b)** $f\lambda = v$

c) $v\lambda = f$ **d)** $v = \frac{\lambda}{f}$

Answers

(i) a **(ii)** b **(iii)** c **(iv)** a **(v)** d **(vi)** a

(vii) b **(viii)** a **(ix)** b

Conceptual Questions

10. 1 If the length of a simple pendulum is doubled what will be the change in its time period?

Answer

Let the initial length of simple pendulum is ' l ', and after making it double, it becomes

'l' ', i.e. L' = 2l.

Time period of simple pendulum is given by,

$$T = 2\pi\sqrt{\frac{l}{g}}\text{..........(1)}$$

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

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

$$T' = \sqrt{2}\left[2\pi\sqrt{\frac{l}{g}}\right]$$

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

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

$$T' = 1.41T$$

It shows that the time period of simple pendulum will increase by 1.41 times by making the length double.

10. 2 A ball is dropped from a certain height onto the floor and keeps bouncing. Is the motion or the ball simple harmonic? Explain.

Answer

No, in case of a bouncing ball, when it hits the floor then there will be no restoring force or acceleration opposite to the downward displacement. So, it does not fulfil the condition of simple harmonic motion. Secondly, in case of bouncing ball, the acceleration due to gravity remains the same, while for SHM the acceleration should vary at different points during the motion of the body.

10. 3 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?

Answer

Time period of simple pendulum only depends upon the length of simple pendulum as given in its formula, i.e.

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

The value of 'g' will remain constant up to a certain height. So, by changing mass of the bob or amplitude, there will be no effect on the time period, of simple pendulum.

10. 4 What type at waves do not require any material medium for their propagation?

Answer

Mechanical waves: like sound waves, water waves, waves produced in strings or springs etc.

10. 5 Plane waves in the ripple tank undergo refraction when they move from deep to shallow water. What change occurs in the speed of the waves?

Answer

In case of plane waves in the ripple tank when refraction takes place while moving from deep to shallow water. The speed of the wave is decreased due to decrease in wave length while frequency remains the same, as given by wave equation below.

$$v = f\lambda$$

Review Questions

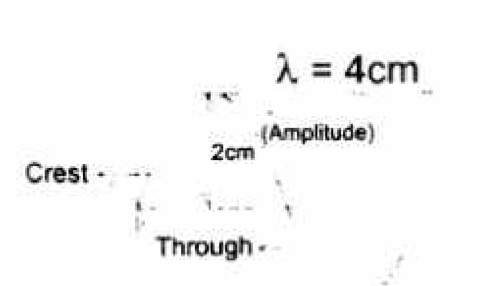
10. 2 Think of several examples in our daily life of motion that are simple harmonic?

Answer

1. Pendulum used in a clock.
2. A boy swinging on a swing.
3. See-saw; when his moved up & down.
4. Human ear drum oscillating back & forth.

10. 6 Draw a transverse wave with an amplitude of 2cm and a wavelength of 4cm. Label a crest and trough on the wave.

Answer



10.10 Does increasing the frequency of a wave also increase its wave length? If not, how are these quantities related?

Answer

No, by increasing frequency, the wave length decreases as given by the following relation,

$$v = f\lambda$$

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

Or $$f \propto \frac{1}{\lambda}$$ (for constant value of velocity)

[Note: The answer of the remaining questions is given in the topics.]

OBJECTIVE TYPE QUESTIONS & ANSWERS

Q2. Give short Answers.

1. What is a wave?

Answer

The wave is a source of transferring energy from one place to another.

2. Differentiate between time period and frequency.

Answer

Time period

The time required by a body to complete one vibration is called its time period. It is denoted by T and measured in second.

Frequency

It is denoted by f and its unit is cycles per second or Hertz (Hz).

3. Give some importance of waves.

Answer

Some importance of waves is:

- Sound waves produce sensation of hearing.
- Heat and light reach us from the sun.
- Broadcasting of radio and television programmes is also in the form of waves.

- Help of waves can detect the defects in the human body.

4. Find the time period of one metre length of simple pendulum on the surface of earth?

Answer

$$l=1m, g=10ms^{-2}$$

$$T=2\pi\sqrt{\frac{1}{g}}=2\times3.14\sqrt{\frac{1}{10}}$$

$$T=2\sec$$

5. Find the time period of one metre length of simple pendulum on the surface of moon?

Answer

$$l=1m, g=1.6ms^{-2}$$

$$T=2\pi\sqrt{\frac{1}{g}}=2\times3.14\sqrt{\frac{1}{10}}$$

$$T=4.9\sec$$

6. Is there connection between F and x in mass spring system?

Answer

If a force F acts on a body which is displaced through a displacement x. Then according to Hook's law.

$$F\ \alpha\ x$$

$$F=kx$$

Where K is a spring constant

7. Give some characteristics of SHM.

Answer

Some characteristics of SHM are:

- A body executing SHM always vibrates about its position of equilibrium.
- Its acceleration is always directed towards its mean position.
- Its acceleration is directly proportional to its displacement from the mean position.
- Its velocity is maximum at the mean position and zero on the extreme positions.

8. State Hooke's law.

Answer

According to Hooke's law

"The external force acting on the spring is directly proportional to the increase in length of the spring" Mathematically.

$$F\ \alpha\ x$$

$$F=kx$$

Where K is a spring constant.

9. Give relation between the frequency and time period.

Answer

Consider a body, which performed f vibrations in one second.

So, the time period for one vibration = $\frac{1}{f}$

We know that time for one vibration is called time period. It Is denoted by T and is given by:

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

Or

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

This equation gives the relation between frequency and time period.

10. Explain the relation Fr= -Kx.

Answer

This is the relation for elastic restoring force. The negative sign shows that restoring is always directed towards the mean position or rest. Thus, acceleration is always directed towards the mean position.

11. Write the basic conditions for SHM.

Answer

The conditions for SHM are given as follows:

- The system should have elastic restoring force.
- The system should have inertia.
- The system should be frictionless.

12. Which two forces are acting on the particle when is at the extreme position?

Answer

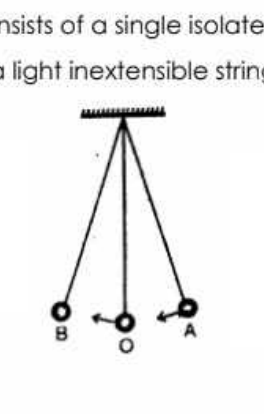
When the particle is at the extreme position, two forces are acting on it.

- The weight mg of the point mass acting vertically downward. '
- The tension T along the string.

13. What is simple pendulum?

Answer

A simple pendulum consists of a single isolated bob suspended from a frictionless support by a light inextensible string.



14. What are factors upon which the time period of simple pendulum depends?

Answer.

The relation for time period of simple pendulum Is given by

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

The time period of simple pendulum depends upon:

- The length of the string:

- The value of acceleration due to gravity.
- The time period of simple pendulum is independent of the mass of the bob.

15. Does the time period depends on the amplitude of the pendulum?

Answer

The relation for time period of simple pendulum is given by

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

This relation shows that time period of simple pendulum is Independent of the amplitude of the pendulum.

16. Which type of forces comes into play an important role in simple pendulum?

Answer

When a bob of simple pendulum moves to and fro, these forces come into play:

- Weight of the bob.
- Tension in the string.
- Air friction.

17. Give some examples of motion that shows SHM in nature.

Answer

- Motion of the bob of a simple pendulum.
- Motion of stretched string when it is plucked from its mean position.
- Vibratory motion of stretched string of musical instrument.

18. Why does a pendulum lose time in summer and gain time in winter?

Answer

The relation for time period of simple pendulum is given by;

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

This relation shows that the time period of a simple pendulum is directly proportional to the square root of the length.

In summer due to increase in temperature the length of simple pendulum increases and the time period of simple pendulum also increases.

In winter due to decrease in length, its time period decreases and hence it gains time.

19. What happens to the frequency of pendulum, as its oscillations die down from large amplitude to small?

Answer

In the oscillations of simple pendulum. The dissipation effect due to frictional forces is present. The amplitude of motion of bob gradually becomes smaller and smaller due to air friction. Hence the friction has also affected in reducing the frequency slightly

20. What is the use of simple pendulum?

Answer

Simple pendulum can be used to determine the value of g because the time period T and the length of the pendulum can be directly measured. If we take proper precautions during the experiment." the accurate value of g can be determined by using Simple pendulum.

21. Do the oceanic waves contain a form of energy?

Answer

Yes. Oceanic waves contain kinetic energy. Sometimes the huge energy of oceanic waves causes the destruction of ships and coastal areas, This, waves energy is also used to produce tidal energy.

22. What is the frequency of seconds pendulum?

Answer

In SHM, the frequency and time period are related as

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

As the time period of seconds pendulum is 2 sec. Therefore, its frequency will be

$$F=\frac{1}{2}=0.5\text{ Hz}$$

23. How with the help of Ripple tank produces straight waves?

Answer

On setting vibrator on the plate starts vibrating and straight waves are generated on the water surface. With the help of light, the image of the water waxes is obtained on the white paper or screen. The crests of the waves appear as bright lines because they behave like, convex lens and they converge the light rays while the troughs of the waves appear as dark lines because they behave like concave lens and they converge the light rays while

the troughs of the waves appear as dark lines because they behave like concave lens and they diverge the light rays.

24. How with the help of ripple tank produces the circular waves?

Answer

It generates circular waves the vibrator bar is raised up and a knob 9 attached to its lowered in such a way that it touches the water surface. When the vibrator is set on, circular waves are produced.

25. Prove that the product of time period and frequency is unity.

Answer

In SHM, the frequency and time period are related as:

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

Or $T\times f=1$

26. Why the amplitude of simple pendulum is kept small?

Answer

The relation for the time period of simple pendulum is:

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

It was assumed that 6 is small then the relation sin $\theta\approx\theta$ holds good. The θ can be small only if amplitude is small. Thus, we must keep the amplitude small.

27. Show that the expression for acceleration of a body executing SHM.

In mass-spring system, the restoring force is given by:

$$F=-kx.........(i)$$

If the acceleration a is produced by force F, then according to Newton's second law of motion

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

By comparing (i) and (ii) then we get

$$ma=-kx$$

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

$$a=-(cons\tan t)\times x$$

$$a\ \alpha\ -x$$

Thus, acceleration at any instant of a body executing SHM is directly proportional to the displacement and is always directed towards its mean position.

28.How long must a simple pendulum be in order to have a period 01' one second?

Answer

$$T=1\sec$$

$$G=9.8ms^{-2}$$

$$l=?$$

We know that,

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

$$T^2=4\pi^2\times\frac{\lambda}{Y}$$

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

$$L=\frac{9.8\times(1)^2}{4\times(3.14)}$$

$$L=0.25m=25cm$$

29. Does the acceleration of simple harmonic oscillator remain constant during its motion?

The acceleration of simple harmonic oscillator is:

a = -(constant) x x

$a\ \alpha\ -x$

Where x is the displacement from the mean position.

This relation shows that:

- The acceleration is zero at the mean position i.e. x = 0.
- The acceleration is zero at the extreme position.

30. Can we realize an ideal simple pendulum?

Answer

We cannot realize an ideal simple pendulum. An ideal simple pendulum consists of heavy but small metallic bob suspended from a rigid frictionless support by means of long, weightless and inextensible?

31. What happens to the period of simple pendulum if its length is doubled?

Answer

The time period of simple pendulum is given by:

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

If its length is doubled, then T' = 1.41 T

This shows that the time period of simple pendulum increases 1.41 times, if the length of pendulum is doubled.

32. What will be the time period of simple pendulum at the center of the Earth?

Answer

When the length of pendulum is adjusted such that l =R, the bob will be at the center of the Earth. We know that at this position the value of g is zero i.e. g = 0

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

Thus, when length of simple pendulum is adjusted such that the bob is at the centre of the Earth. The time period of the simple pendulum will be infinity.

33. How refraction in wave occurs?

Answer

The refraction in wave occurs due to the change in speed of wave in the other medium.

34. What is vibratory motion? Give some examples.

Answer

Such a type of motion in which a body moves to and fro about a mean position is called Vibratory motion. Some examples of vibratory motion are given as

- Spring-mass system.
- Motion of pendulum.
- Rolling steel ball in a curved dish.

35. Why does the hub of a swinging pendulum comes to rest after sometime?

Answer

The bob of a simple pendulum comes to rest after some time due to following reasons:

- Some energy is lost due to friction in air.
- The energy lost goes into the surrounding air as the heat energy.

36. Why does they vibrating body move away from the mean position?

Answer

During vibratory motion the body experiences restoring force which brings it towards mean position where it has maximum velocity. According to law of inertia the body tries to continue its motion which moves it again away from mean position.

37. Explain the relation between velocity and acceleration of a body performing SHM?

Answer

The velocity and acceleration of a body performing SHM are inversely proportional to each other. At mean position velocity is maximum. Whereas acceleration is minimum.

At the extreme position the velocity is minimum whereas acceleration is maximum.

38. What is second pendulum?

Answer

A second pendulum is a pendulum, which completes one vibration in two seconds.

Thus, the time period of second pendulum is two seconds.

39. Why total energy of vibrating simple pendulum at its mean position is in kinetic energy form?

Answer

Total energy of vibrating simple pendulum at its mean position is in kinetic energy form because at the mean position.

The velocity of pendulum is maximum.

Its height is zero.

Thus, at the mean position vibrating pendulum has.

K.E = maximum and PE = minimum.

40. Define amplitude.

Answer

The maximum displacement on either side of the mean position of an oscillating body is called amplitude.

41. What is wave motion?

Answer

Wave in a medium is due to the generated disturbance which causes' the constituent particles to repeat its 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.

Example

Waves are produced when one cud of stringy_ is moved up and down.

42. Define spring constant. Give its unit?

Answer

Some energy is lost due to friction in air.

The energy lost goes into the surrounding air as the heat energy.

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

Its unit is Nm^{-1}

43. What is SHM?

Answer

The type of vibratory motion in which the acceleration of a body executing SHM is directly proportional to the displacement from the mean position and always directed towards the mean position.

44. What is elastic restoring force?

Answer

It is the force, which brings the body back towards the mean position.

45. Differentiate between mechanical wave and electromagnetic wave?

Answer

Mechanical waves

The waves, which require a material medium for their propagation, are known as mechanical waves.

Example

- ➢ Waves generated in rope
- ➢ Waves generated in water
- ➢ Waves generated in strings

Electromagnetic waves

The waves, which do not require a material medium for their propagation are known as electromagnetic waves.

Example

Heat waves, light waves, x-rays etc..

46. Write the differences between transverse and longitudinal waves?

Answer

No.	Transverse waves	No.	Longitudinal waves
1	In this type of wave, particles of the medium move perpendicular to the direction of propagation of the waves.	1	In this type of wave, particles of the medium move along the direction of propagation of the waves.
2	These waves consist of crests and troughs	2	These waves consist of compressions and rarefactions.
3	The distance between two consecutive crests or troughs is known as one wavelength.	3	The distance between two consecutive compressions or rarefactions, known as one wavelength.
4	Examples: water waves, light waves	4	Examples: sound waves, waves

47. Prove that $v=f\lambda$?

Answer

If the speed of wave is v and the time period' of producing wave is T second, then the distance covered by the wave will equal to the wavelength A, i.e.

$$\lambda=vT$$

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

$$f\lambda=v$$

$$v=f\lambda$$

[redacted]

48. What is refraction of a wave?

Answer

When waves enter from one medium to another, a part of it is reflected in the same medium while the other- part is transmitted into the other medium, is known as refraction.

49. Define diffraction?

Answer

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

50. What is the condition for diffraction?

Answer

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

51. What is interference?

Answer

When panicles of medium are subjected to two or more than two waves simultaneously, then effect being produced is called interference.

OBJECTIVE TYPE QUESTIONS & ANSWERS

Q1. Each question is followed by four options encircle the correct option.

1) 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

2) The product of frequency 'and time period is equal to:
a. 1/∞
b. b. I
c. 0
d. 1/0

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

4) If the length of a simple pendulum is halved its time period T will become:
a) T/2
b) T/√2
c) √2T
d) 2T

5) In terms of wave length (λ), the distance between two neighboring nodes or antinodes Is:
a) λ
b) λ /2
c) λ/4
d) 2 λ

6) Which of the following waves is not electromagnetic?
a. X-rays
b. radio waves
c. light waves
d. water waves

7) Which is the correct formula to find the frequency?
a. f=T
b. f=1/t
c. T=2π $\sqrt{L}/f$
d. T=2π $\sqrt{M}/f$

8) Hertz is the unit of:
a. frequency
b. wavelength
c. mass
d. acceleration

9) Which Is not the characteristic of simple harmonic motion of a body?
a. It always vibrates about its position of equilibrium
b. Its acceleration Is always directed towards its mean position
c. its velocity is minimum at mean position
d. its velocity IS maximum at its mean position

10) The Waves in which the particles of the medium vibrate perpendicular to the direction of motion of waves are called:
a. electromagnetic waves
b. transverse waves
c. compressional waves
d. longitudinal waves

11) Energy can be transferred from one place to another:
a. through matter
b. through waves
c. both of them
d. none of these

12) The apparatus used to study the properties of waves is:
a. ripple tank '
b. water tank
c. electric bulb
d. galvanometer

13) Which is concerned with bending of waves around corners?
a. reflection
b. refraction
c. diffraction
d. none of above

14) The up and down motion of hand produces waves in string known as:
a. Longitudinal waves
b. compressional waves
c. transverse waves
d. stationary waves

15) Which is not correct?
a. the number of loops on string depends upon the frequency of up and down motion of hand.
b. string makes single loop at the lowest frequency
c. the fundamental frequency is called second harmonics
d. the fundamental frequency is called first harmonics

16) Which is not the true statement?
a. water waves exhibit phenomenon of refraction
b. speed of water waves depends on the depth of water
c. speed of light is more in air than in glass
d. bending of waves from their incident path is called amplitude

17) Which is not a correct equation
a. λ=VT
b. V= λ /T
c. T= λ /V
d. V= λ T

18) Find the equation in which spr...g constant has been used:
a. $k=f_e/x$
b. a= f /m
c. $T=2\pi\sqrt{\mu g}$
d. $f = 1/T$

19) When where will the bob have maximum kinetic energy?
a. at its mean position
b. at its extreme position
c. when the bob is stationary
d. none of the above

20) .The sound waves in air are:
a. longitudinal
b. radio
c. stationary
d. none of the above

21) The 8.1. unit of spring constants K is:
a. Nm^2
b. Nm^{-2}
c. Nm^{-1}
d.Nm

22) In S.E.M. the acceleration of the vibrating body is directly proportional to the:
a. distance
b. displacement
c. amplitude
d. velocity

23) The motion which repeats itself in equal intervals of time is called:
a. rotatory motion
b. circular motion
c. angular motion
d. vibratory motion

24) A force of 20N, produces an extension of 10 cm in an elastic spring. Then the value of spring constant is:
a. 200 Nm^{-1}
b. 2Nm^{-1}
c. 20 Nm^{-1}
d. none of these

25) The number of vibrations completed in one second is called:
a. time period
b. frequency
c. amplitude
d. wavelength

26) One complete round trip of an object about mean position is called:
a. amplitude
b. frequency
c. Vibration
d. time period

27) In an elastic spring, SHM is produced due to:
a. K.E of spring
b. weight of spring
c. mass of spring
d. restoring force

28) The time period of the simple pendulum does not depend upon:
a. mass of object
b. length of string
c. value of g
d. tension in string

29) The time period of the spring depends upon:
a. length of spring
b. mass of object
c. value of g
d. none of these

30). At which place, the motion of simple pendulum becomes faster?
a. Lahore
b. Quetta
c. Murree
d. Karachi

31) How many times the' value of "g" on 'moon surface is less than the value of g on earth's surface?
a. 1/6
b. 2
c.4
d. 6

32) The waves which do not require a medium for their propagation are known as:
a. mechanical waves
b. electromagnetic waves
c. matter waves
d. transverse, waves

33) Which of the following is not electromagnetic wave?
a. ultraviolet
b. Microwave
c. water wave
d. radio wave

34) The speed of electromagnetic wave is:
a. 3.0×10^8 ms^{-1}
b. 332 ms^{-1}
c. 600 m/s
d. zero

35) The acceleration of a vibrating body is maximum at:
a. when v is maximum
b. mean position
c. extreme position
d. both a and b

36) At mean position, a vibrating object has maximum:
a. acceleration
b. velocity
c. time period
d. displacement

37) The time period of a spring executing S.H.M. is equal '0:
a. $\frac{1}{2\pi}\sqrt{\frac{m}{k}}$
b. $2\pi\sqrt{\frac{k}{m}}$
c. $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$.
d. $2\pi\sqrt{\frac{m}{k}}$

38) By increasing the load in the spring, the time period of spring:
a. Increases
b. decreases
c. remains unchanged
d. becomes zero

39) The time period of a simple pendulum is equal to:
a. $2\pi\sqrt{\frac{g}{\ell}}$
b. $\frac{1}{2\pi}\sqrt{\frac{g}{\ell}}$
c. $2\pi\sqrt{\frac{\ell}{g}}$
d. $\frac{1}{2\pi}\sqrt{\frac{\ell}{g}}$

40) The time period of simple pendulum is independent of:
a. length
b. mass
c. value of g
d. acceleration

41) Which of the following have maximum wavelength?
a. gamma rays
b. visible light
c. microwaves
d. radio waves

42) Which of the following have maximum frequency?
a. gamma rays
b. radio waves
c. x-rays
d. microwaves

43) Ripple tank is used to:
a. firing bomb
b. to study waves
c. swimming
d. none of these '

44) Bending of waves from their incident path is called.
a. reflection
b. diffraction
c. refraction
d. interference

45) According to the law of reflection:
a. sin i=sin y
b. <i=<y
c. n=1/sinc
d. <y≠<i

46) The radio transmission can be heard in such areas where the waves cannot reach directly due to:
a. reflection
b. refraction
c. interference
d. diffraction

47) When two identical waves travelling in opposite direction along the same line combine to form:
a. interference
b. diffraction
c. stationary waved
d. none of these '

48) Bending of waves around obstacles is called:
a. diffraction
b. interference;
c. reflection
d. refraction

49) The equation of wave speed is:
a. $f = c\lambda$
b. λ=fv
c. v=fλ
d. v=f/λ

50) The units of frequency are:
a. Hertz
b. S^{-1}
c. cycles per second
d. all of them