Physics 10

Unit 10 – Simple Harmonic Motion And Wave

Solved Exercise

MULTIPLE CHOICE QUESTIONS

i. Which of the following is an example of simple harmonic motion? *(K.B)*

(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 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: *(U.B)*(FSD-G1)-2014

(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 waves? *(K.B)* (MTN-G1)-2014 / (FSD-G2)(SGD-G2)-2015

(a) a string (b) a ripple tank

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

iv. Waves transfer: *(K.B* (FSD-G1)(BWP-G2)(GRW-G1)-2015 / (RWP G2)(GRW-G1)(FSD-G1 / G2)-2016 / (SWL-G2)(GRW-G1)(RWP-G1)

(a) energy (b) frequency

(c) wavelength (d) velocity

v. Which of the following is a method of energy transfer? *(K.B)* (FSD-G1)(SGD-G1)(LHR-G2)-2015 / (MTN-G1)(GRW-G1)-2016 / (RWP-G2)(BWP-G2)

(a) conduction (b) radiation

(c) wave motion (d) all of these

vi. In a vacuum all electromagnetic waves have the same: ***(K.B)***

(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 50 cm. The velocity of the wave is: ***(U.B+A.B)*** (BWP-G1)(LHR-G2)(SGD-G2)-2014 / (RWP-G1)-2016

(a) 53 cm^{-1} (b) 60cms^{-1}

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

viii. Which of the following characteristics of a wave is independent of the others? *(K.B)*

(MTN-G1)(SGD-G1)-2014 / (RWP-G1)(FSD-G2)-2015 / (FSD-G2)(DGK-G1)-2016 / (LHR-G2)-2017

(a) speed (b) frequency

(c) amplitude (d) wavelength

ix. The relation between v, f and λ of a wave is: *(U.B+A.B)*

(GRW-G1 / G2)(FSD-G1)-2014 / (MTN-G2)(LHR-G1)-2015 / (RWP-G1)(MTN-G1)(FSD-G1)(DGK-G2)-2016 / (SGD-G2)-2017

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

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

ANSWER KEY

i	ii	iii	iv	v	vi	vii	viii	ix
a	b	c	a	d	a	b	c	b

REVIEW QUESTIONS

10.1 What is simple Harmonic Motion? What are the necessary conditions for a body to execute simple harmonic motion? *(K.B)*

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**"**.

Conditions/Requirements for SHM:

The conditions/requirements for a system executing SHM are summarized as:

The oscillating system must have inertia.

The oscillating system must have restoring force.

The oscillating system must obey the Hook's law.

The system should be frictionless.

10.2 Think of several examples in everyday life of motion that are simple harmonic. *(U.B)*

Ans:

Examples of SHM in daily life

- Motion of a body attached to one end of spring.
- Motion of bob of simple pendulum.
- Motion of ball in bowl system.
- Motion of the prong of the tuning Fork.

10.3 What are damped oscillations? How damping progressively reduces the amplitude of oscillation? *(K.B + U.B)*

Ans:

Damped Oscillations:

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

In ideal systems, vibratory motion continues indefinitely without friction. However, in real systems, friction slows the motion, preventing indefinite oscillation. This friction reduces the system's mechanical energy over time, causing the motion to be damped and the amplitude to decrease.

10.4 How can you define term wave? Elaborate difference between mechanical and electromagnetic waves. ***(K.B)***

Ans:

Wave:

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

MECHANICAL WAVES

"Waves which require any medium for their propagation are called mechanical waves**"**.

Examples:

- Waves produced on water surface
- Sound waves

ELECTROMAGNETIC WAVE

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

Examples:

- Radio waves,
- X-rays, heat and light waves

10.5 Distinguish between longitudinal and transverse waves with suitable examples. ***(K.B)***

Ans:

Longitudinal Wave:

"In longitudinal waves the particles of the medium move back and forth along the direction of the propagation of wave**"**.

Examples:

- Sound Waves
- Waves produced in a spring

Transverse Wave

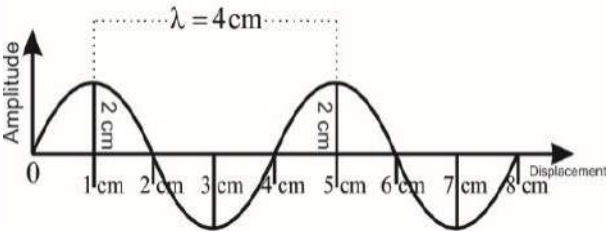
"In the case of transverse waves, the vibratory motion of particles of the medium is perpendicular to the direction of propagation of wave**"**.

Examples:

- Waves produced on water surface
- Waves produced in a string
- Light Waves

10.6 Draw a transverse wave with an amplitude of 2 cm and a wavelength of 4cm. Label a crest and trough on the wave. ***(U.B)***

Ans: A transverse wave with an amplitude of 2 cm and a wavelength of 4 cm is drawn below:



10.7 Derive a relationship between speed, frequency and wavelength of a wave. Write a formula relating speed of a wave to its time period and wavelength. *(U.B + A.B)*

Ans: (See Topic 10.4, Long Question-3)

10.8 Waves are the means of energy transfer without transfer of matter. Justify this statement with the help of a simple experiment. *(K.B + U.B + A.B)*

Ans: Waves transfer energy without moving matter. For example, shaking a stretched string creates waves. The hand's energy moves through the string, disturbing particles which then transfer energy to adjacent particles. Similarly, dropping a stone into a pond creates waves that travel outward. A cork placed at a distance moves up and down as the waves pass, showing energy transfer without moving the water itself.

10.9 Explain the following properties of waves with reference to ripple tank experiment.

a. Reflection b. Refraction c. Diffraction *(K.B + A.B)*

Ans:

a. <u>Reflection</u>:

"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**"**.

b. <u>Refraction</u>

"When a wave from one medium enters into the second medium at some angle, its direction of travel changes. This phenomenon is called refraction of waves.**"**

c. <u>Diffraction</u>

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

10.10 Does increasing the frequency of a wave also increase its wavelength? If not, how are these quantities related? *(K.B + U.B)*

Ans. **RELATION BETWEEN FREQUENCY & WAVELENGTH**

No, wavelength does not increase with increase of frequency of waves because frequency depends upon the source which produces waves per second. But the wavelength of the wave depends on the magnitude of vibrating particles.

Relationship of frequency (f) and wavelength (λ)

Generally, frequency (f) and wavelength (λ) are inversely related to each other when speed kept constant by the following equation.

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

Hence from this equation we conclude that when frequency (f) of waves increases then their wavelength (λ) decreases.

CONCEPTUAL QUESTIONS (A.B)

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

(LHR-G1)-2015 / (DGK-G2), (MTN-G1)-2017

Ans: **VARIATION IN TIME PERIOD**

When the length of simple pendulum is increased its time period increases as we know that

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

According to given condition

If $\ell = 2\ell$

$$T' = 2\pi\sqrt{\frac{2\ell}{g}} = \sqrt{2}\left(2\pi\sqrt{\frac{\ell}{g}}\right) \Rightarrow T' = \sqrt{2}T$$

Thus time period become $T' = \sqrt{2}T$

10.2 A ball is dropped from certain height onto the floor and keeps bouncing. Is the motion of the ball is simple harmonic motion.

Ans: **MOTION OF BALL**

No, the motion of the bouncing ball is not the example of SHM. Because it does not fit the definition of SHM which is as follows:

SHM occurs when the net force is proportional to the displacement from the mean position and is always directed towards the mean position.

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?

Ans: **EFFECT ON TIME PERIOD**

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

Above formula clearly shows that the time period of the simple pendulum is independent of mass therefore, when a student performed two experiments with the simple pendulum by using two bobs of different mass by keeping other parameters constant. Then time period of simple pendulum remains same.

10.4 What types of waves do not require any material medium for their propagation?

Ans: Electromagnetic waves do not require any material medium for their propagation. They can travel through a vacuum, such as light, radio waves, and X-rays.

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

Ans: As we know that

$$V=f\lambda$$

In ripple tank frequency of waves is constant because it is equal to the frequency of vibrator Hence wave speed is directly proportional to wave length. With increase of wavelength, speed will also be increased similarly with decrease in wavelength, wave speed also decreases. As the water wave enter into the shallow region from deep region its wavelength (λ) decreases, due to this speed of wave also decreases.