Chapter: 10

# Simple Harmonic Motion and Waves

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## Objective



1. In SHM, velocity at extreme position is:
   - (A) Maximum
   - (B) Minimum
   - **(C) Zero**
   - (D) Sometime maximum sometime minimum

2. The unit of frequency is:
   - (A) Pa
   - **(B) Hz**
   - (C) M
   - (D) N

3. Formula for the time period of mass attached to spring is:
   - (A) $T=2\pi\sqrt{\frac{m}{4}}$
   - (B) $T=2\pi\sqrt{\frac{l}{m}}$
   - **(C) $T=2\pi\sqrt{\frac{m}{k}}$**
   - (D) $T=2\pi\sqrt{\frac{k}{m}}$

4. The spring's constant is:
   - **(A) K = -F/X**
   - (B) F=ma
   - (C) K = -x/m
   - (D) w =mg

5. The equation of Hook's Law is:
   - (A) F=-kx
   - (B) K = -2F/x
   - **(C) F=-1/kx**
   - (D) F=-x/k

6. In motion of a simple pendulum restoring force is provided by:
   - (A) Tension in string
   - (B) Inertia
   - (C) Resistance
   - **(D) Force of gravity**

7. Frequency is equal to:
   - **(A) F = 1/T**
   - (B) $T = 2\pi\sqrt{\frac{l}{g}}$
   - (C) F = 1/g
   - (D) f = kx

8. If length of simple pendulum on earth is 1 m then its time period is:
   - (A) 6 sec
   - (B) 1 sec
   - **(C) 2 sec**
   - (D) 10 sec

9. When l= 1.0 m then time period of simple pendulum is:
   - (A) 1.88 sec
   - (B) 2.11 sec
   - (C) 1.89 sec
   - **(D) 1.99 sec**

10. If mass of the body is increased by the factor of 2, the period of pendulum:
    - **(A) Remains same**
    - (B) Increased by the factor 2
    - (C) Decreased by the factor 2
    - (D) Decreased by the factor 4

11. For simple pendulum the formula of time period is:
    - (A) Hz
    - (B) cm
    - **(C) m**
    - (D) sec

12. For simple pendulum the formula of time period is:
    - (A) $T=2\pi\sqrt{\frac{m}{g}}$
    - (B) $T=2\pi\sqrt{\frac{g}{1}}$
    - **(C) $T=2\pi\sqrt{\frac{1}{g}}$**
    - (D) $T=2\pi\sqrt{\frac{m}{k}}$

13. Which of the following is an example of simple harmonic motion?
    - **(A) The motion of simple pendulum**
    - (B) A bouncing ball on floor
    - (C) The motion of ceiling fan
    - (D) The spinning of earth on its axis

14. If mass of the body is increased by the factor of 3, the period of pendulum's motion will:
    - (A) Be decreased by a factor of 2
    - **(B) Remain same**
    - (C) Be decreased by a factor of 4
    - (D) Be increased by a factor of 2

15. A human eardrum can oscillate back and forth up to……. Times in a second.
    - **(A) 20000**
    - (B) 200
    - (C) 200000
    - (D) 2000

16. ..... invented the first pendulum clock?

(A) Christian Huygens (B) Newton (C) Galileo (D) Hooke's

17. Christian Huygens invented the pendulum clock in .....

(A) 1856 (B) 1656 (C) 1956 (D) 1756

18. If the time period is given then frequency is calculated as:

(A) f = 1/T (B) f = 3/T (C) f = 4/T (D) f = 2/T

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

(A) Amplitude (B) Frequency (C) Wavelength (D) Displacement

20. The example of shock absorber of the vehicles are:

(A) Vibratory motion (B) Motion (C) SHM (D) Damped Motion

21. Which waves do not require medium for their propagation:

(A) Sound waves (B) Electromagnetic waves
(C) Mechanical waves (D) All of them



22. Which of the following characteristics of a wave is independent of others?

(A) Amplitude (B) Wavelength (C) Frequency (D) Speed

23. Waves transfer:

(A) Wavelength (B) Velocity (C) Frequency (D) Energy

24. Main types of waves are:

(A) 4 (B) 2 (C) 3 (D) 1

25. Radio waves are:

(A) Transverse waves (B) Electromagnetic waves
(C) Longitudinal waves (D) All of these

26. Mechanical waves are classified into ..... types.

(A) 4 (B) 2 (C) 3 (D) 1

27. ..... waves move faster in solids.

(A) Electromagnetic waves (B) Longitudinal waves
(C) Transverse waves (D) All of them

28. The distance between two consecutive compressions is called:

(A) Rarefaction (B) Amplitude (C) Frequency (D) Wavelength

29. Which of the following devices can be used to produce both transverse and longitudinal waves?

(A) A helical Spring (B) A ripple Tank (C) A tuning Fork (D) A string

30. Which of the following is a method of energy transfer?

(A) Radiation (B) Wave motion (C) Conduction (D) All of these

31. Wave equation is:

(A) $V / \lambda$ (B) $f \lambda$ (C) $f v$ (D) $1 / \lambda v$

32. The relation between velocity, frequency and wavelength for waves is given by:

(A) $V = \lambda / f$ (B) $V\lambda = f$ (C) $Vf = \lambda$ (D) $f\lambda = v$

33. Wavelength of waves can be defined by ratio of:

(A) Distance and speed (B) Speed and frequency

Ⓒ Time period and frequency Ⓓ Frequency and speed

34. Frequency of wave is 4 Hz and wavelength is 0.4 m then its speed will be:

Ⓐ 1.6 m/s **Ⓑ 1.6 m** Ⓒ 16 m Ⓓ 16 m/s

35. If the speed of a wave is 340 m/s and wavelength is 0.5 m, then frequency will be:

Ⓐ 340 Hz Ⓑ 3400 Hz Ⓒ 170 Hz **Ⓓ 680 Hz**

36. Which of the following characteristics of a wave is independent of the others?

Ⓐ Wavelength **Ⓑ Amplitude** Ⓒ Speed Ⓓ Frequency

37. In a vacuum, all electromagnetic waves have the same:

Ⓐ Frequency **Ⓑ Speed** Ⓒ Wavelength Ⓓ Amplitude

38. The relation between time, speed and distance is:

Ⓐ $v = t^2/d$ Ⓑ $v = dt$ Ⓒ $v = t/d$ **Ⓓ $v = d/t$**

39. Generating high frequency requires more:

Ⓐ Frequency **Ⓑ Energy** Ⓒ Displacement Ⓓ Wavelength

40. Earth quake produces ..... waves.

Ⓐ Electromagnetic **Ⓑ Seismic** Ⓒ Transverse Ⓓ Longitudinal

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

**Ⓐ 60 cm/s** Ⓑ 750 cm/s Ⓒ 1500 cm/s Ⓓ 53 cm/s

42. A ripple tank is a device used to produce:

Ⓐ Radio waves **Ⓑ Mechanical waves**
Ⓒ Electromagnetic waves Ⓓ Light waves

43. When the water waves enters the region of shallow water their wave length:

Ⓐ Becomes zero **Ⓑ Decreases** Ⓒ Remains same Ⓓ Increases

44. The bending of waves around the corners is called:

Ⓐ Refraction **Ⓑ Diffraction** Ⓒ Interference Ⓓ Reflection

## Chapter : 10 Simple Harmonic Motion and Waves

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## Subjective

*Q1:* ***What is simple harmonic motion? What is necessary condition for a body to execute simple harmonic motion?***

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

- a=0 *at mean position and maximum at extreme position.*
- *A body always vibrates about its mean position.*
- *The velocity is maximum at mean position and minimum at extreme position.*
- *Acceleration is always directed towards mean position.*

*Q2:* ***Think of several examples in everyday life of motion that are simple harmonic?***

*Ans:* *Think of several examples in everyday life of motion that are simple harmonic are:*

- *Motion of vibrating prongs of tuning fork.*
- *Motion of swing.*

- *Motion of plucked string fixed at the both ends.*
- *Up and down motion a leaf in water.*

*Q3:* ***What are damped oscillations? How damping progressively reduces the amplitude of oscillation?***

*Ans:* ***Damped oscillations:***

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

*Practically, in all systems, the force of friction retards the motion, so the system does not oscillate indefinitely. 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.*

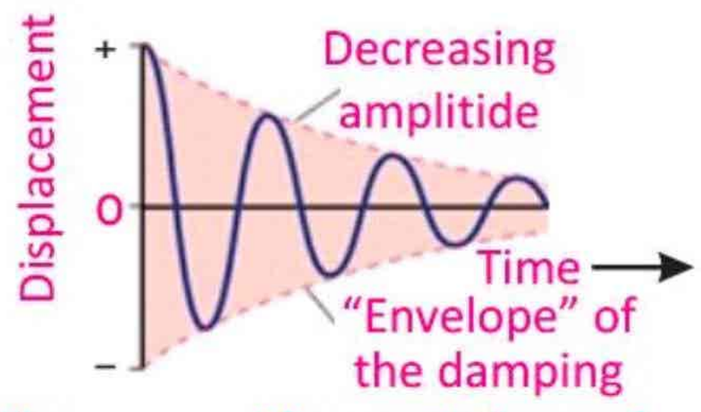



**Fig.** The variation of amplitude with time of damping system

*Q4:* ***How can you define the term wave? Elaborate the difference between mechanical and electromagnetic waves?***

*Ans:* ***Wave:***

*A wave is a mechanism in which energy is transferred from one place to another due to disturbance in the medium.*

***Mechanical Waves:***

*The types of waves which require material medium for their propagation are called mechanical waves.*

***Example:***

- *Water waves, waves in rope, waves in spring, sound waves etc.*

***Electromagnetic Waves:***

*The types of waves which don't require material medium for their propagation are called electromagnetic waves.*

***Example:***

- *X-rays, radio waves, microwaves, Laser etc.*

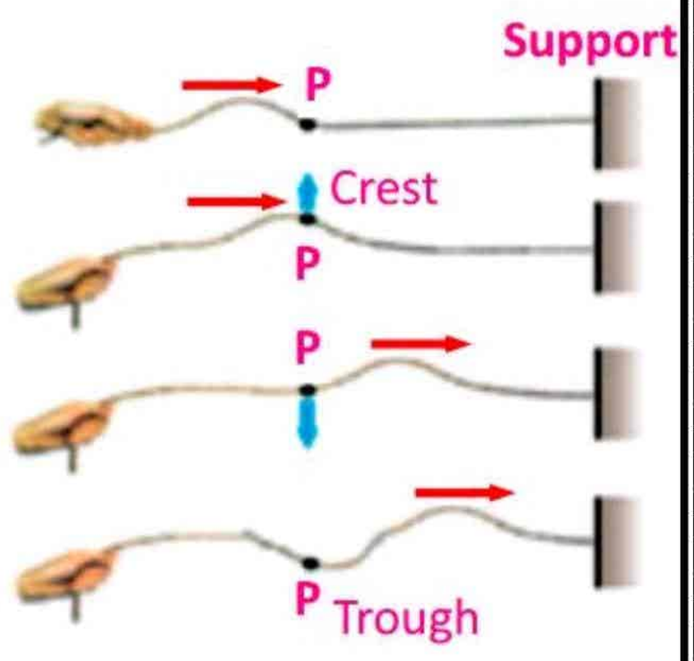
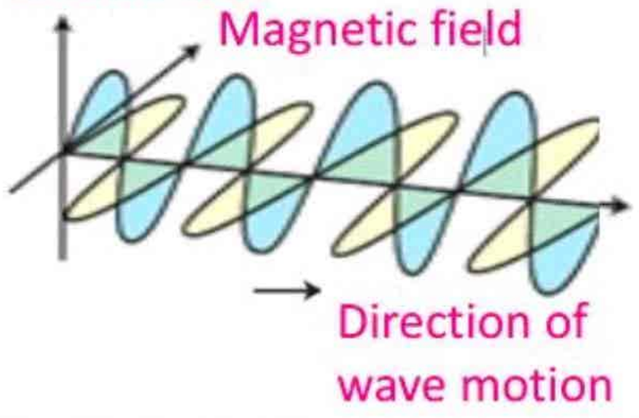



**Fig.** Waves produced in a rope

**For your information**




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

*Q5:* ***Distinguish between longitudinal and transverse waves.***

*Ans:* ***Longitudinal Waves:***

- *In longitudinal waves particles move parallel to the motion of waves.*
- *These waves consist of compressions and rarefactions.*

***Example:***

- *Sound waves and waves in spring.*

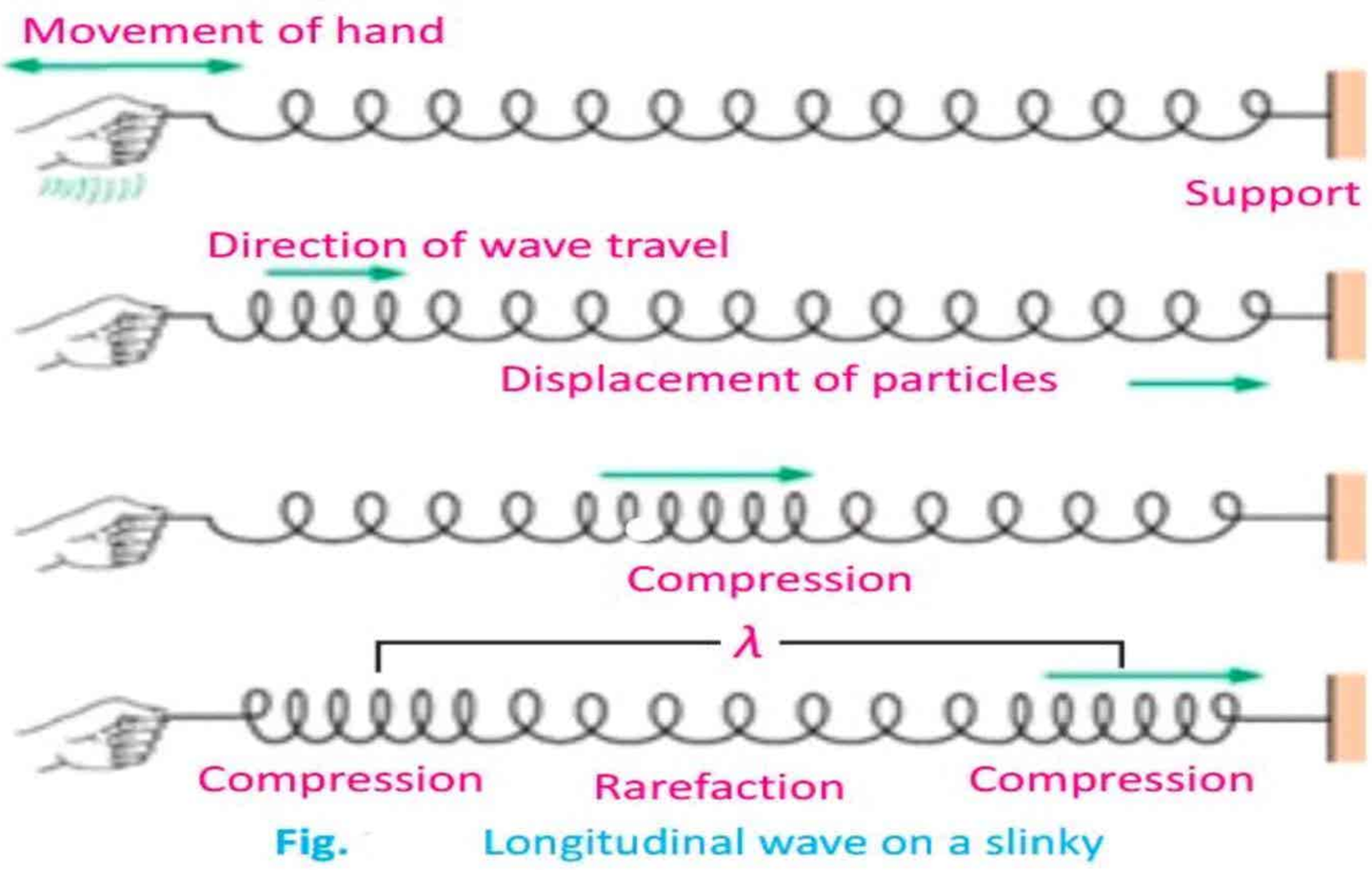



**Fig.** Longitudinal wave on a slinky

***Transverse Waves:***

- *In transverse waves particles move perpendicular to the motion of waves.*
- *These waves consist of crests and troughs.*

***Example:***

- *Water waves and waves produced in slinky by up and down motion.*

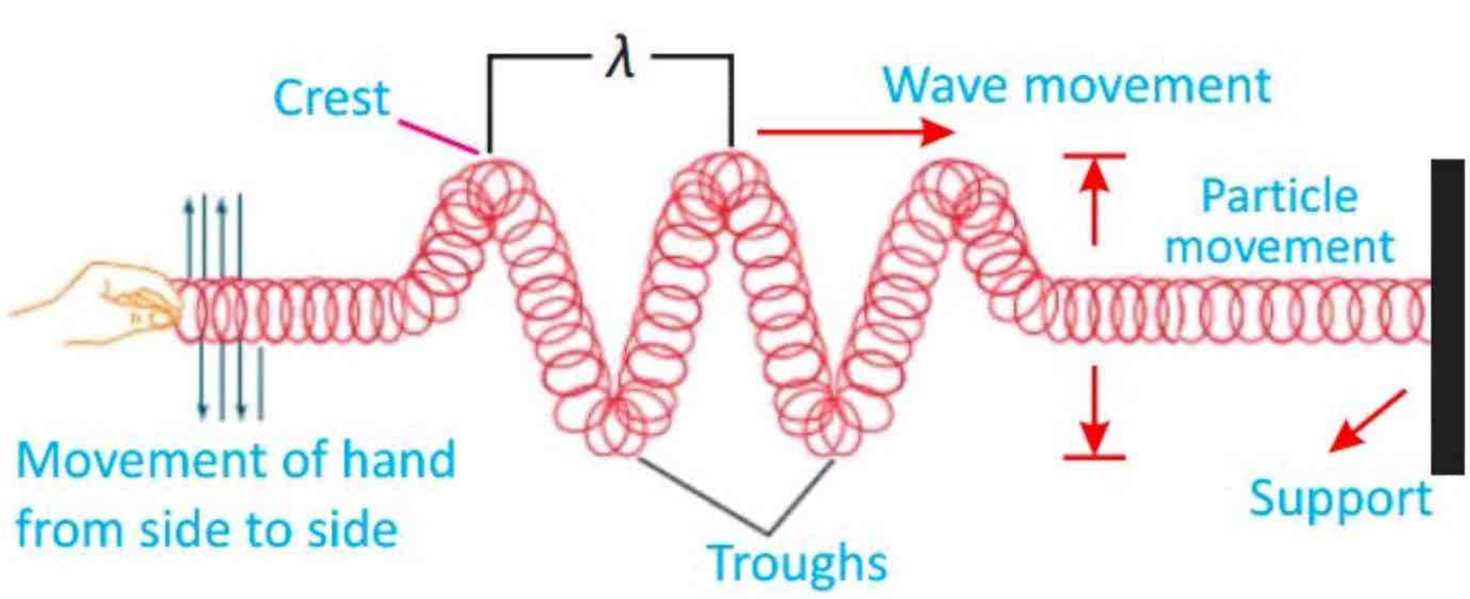



**Fig.** Transverse wave on a slinky

*Q6:* ***What is wave equation? Derive relation between velocity, frequency, and wavelength of a wave.***

*Ans:* ***Wave Equation:***

*The relation between the velocity, frequency, and wavelength of a wave is called wave equation.*

***Derivation:***

*Wave travelling in a medium has specific velocity which is defined as:*

$$v = \frac{d}{t} \longrightarrow (1)$$

*If the time taken by the wave to move from one point to other is equal to time period 'T' then the distance covered is equal to wavelength 'λ':*

$$v = \frac{\lambda}{T} \longrightarrow (2)$$

*But* $f = 1/T$ *so equation 2 becomes*

$$v = f\lambda \longrightarrow (3)$$

*Q7:* ***Does increasing the frequency of wave also increases its wavelength? If yes, how are these quantities related?***

*Ans: On increasing the frequency of a wave, the wavelength of the wave does not increase; but it decrease.*

*Thus, frequency and wavelength are inversely proportional to each other.*

## Conceptual Question

*Q1:* ***If the length of simple pendulum is doubled, what will be change in time period?***

*Ans: As we know that time period of simple pendulum is:*

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

*When l' = 2l then*

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

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

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

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

*Q2:* ***A ball is dropped from a certain height onto the floor and keeps bouncing. Is the motion of the ball simple harmonic motion? Explain.***

*Ans:* ***No,*** *the motion of the ball is not SHM because bouncing ball moves with linear motion while SHM is the vibratory motion. During the bouncing of ball mean position is not specified and it does not fulfill the condition of simple harmonic motion.*

*Q3:* ***A student performed two experiments with a simple pendulum. He used two bobs of different masses by keeping other parameters constant. To his astonishment the time period of the pendulum did not change! Why?***

*Ans:* *Time period of simple pendulum does not change, with the change of mass, because it does not depend upon mass of the body as:*

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

*Q4:* ***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. For example radio waves, microwaves and X-rays etc.*

*Q5:* ***Plane waves in the ripple tank undergo refraction when they move from deep to shallow water. What change occur in the speed of the wave?***

*Ans:* *The water wave enter into the region of shallow water, their wavelength decreases as given by the formula* $v = f\lambda$ *as wavelength decreases the speed also decreases.*

## Additional Question



*Q1:* ***Define Simple Harmonic Motion (SHM).***

*Ans:* ***Simple Harmonic Motion (SHM).***

*The type of vibratory motion in which net force is directly proportional to the displacement from the mean position and always directed towards mean position is called simple harmonic motion.*

*Q2:* ***Write down any three conditions for S.H.M.***

*Ans:* ***Conditions for SHM:***

- *The system should be frictionless and body must have inertia and restoring force.*
- *Acceleration of the body is directly proportional to the displacement from mean position.*
- *Acceleration of the body is always directed towards mean position.*

*Q3:* ***What is Hook's law?***

*Ans:* ***Hook's Law:***

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

$$F \alpha - \quad \text{of} \quad F = -kx$$

*Q4:* ***Define spring constant and write down its formula and unit.***

*Ans:* ***Spring Constant:***

*"The ratio of external force acting on a spring to the increase in length of the spring is called spring constant."*

***Formula:***

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

***Unit:*** $Nm^{-1}$

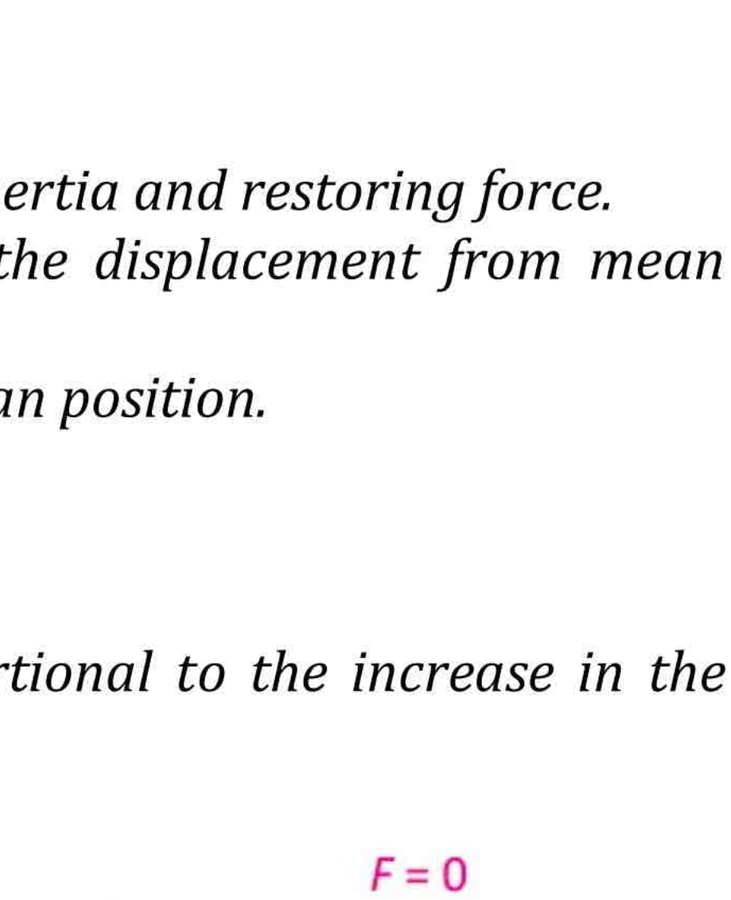



Fig. SHM of a mass-spring system

*Q5:* ***Define restoring force.***

*Ans:* *Restoring Force:*

*"The force which always pushes or pulls the body executing SHM toward its mean position is called restoring force."*

*Q6:* ***Define the following terms: i. Amplitude ii. Time period iii. Frequency iv. Vibration.***

*Ans:* ***Amplitude:***

*"The maximum displacement of the vibrating body from either side of its mean position is called amplitude."*

***Time Period:***

*"Time taken by the vibrating body to complete one vibration is called time period."*

***Frequency:***

*"The number of vibrations completed by the vibrating body in one seconds is called frequency."*

***Unit:*** *Its unit is hertz (Hz) and formula* $f = \frac{1}{T}$

***Vibration:***

*"One complete round trip of a body about its mean position is called vibration."*

*Q7:* ***What is difference between longitudinal and transverse waves?***

*Ans:* *Difference between longitudinal and transverse waves:*

| Longitudinal Waves | Transverse Waves |
|---|---|
| ❖ In longitudinal waves particles move parallel to the motion of waves.<br>❖ These waves consist of compressions and rarefactions.<br>❖ For example sound waves and waves in spring. | ❖ In transverse waves particles move perpendicular to the motion of waves.<br>❖ These waves consist of crests and troughs.<br>❖ For example water waves and waves produced in slinky by up and down motion. |

*Q8:* ***Define the following terms: i. Crest ii. Trough iii. Wavelength***

*Ans:* ***Crest:***

*"The part of the transverse wave where particles of the medium above the normal position is called crest."*

***Trough:***

*"The part of the transverse wave where particles of the medium below the normal position is called crest."*

***Wavelength:***

*"The distance between two consecutive crests or two consecutive troughs is called wavelength."*

*Q9:* ***Define: i. Reflection ii. Diffraction iii. Refraction***

*Ans:* ***Reflection:***

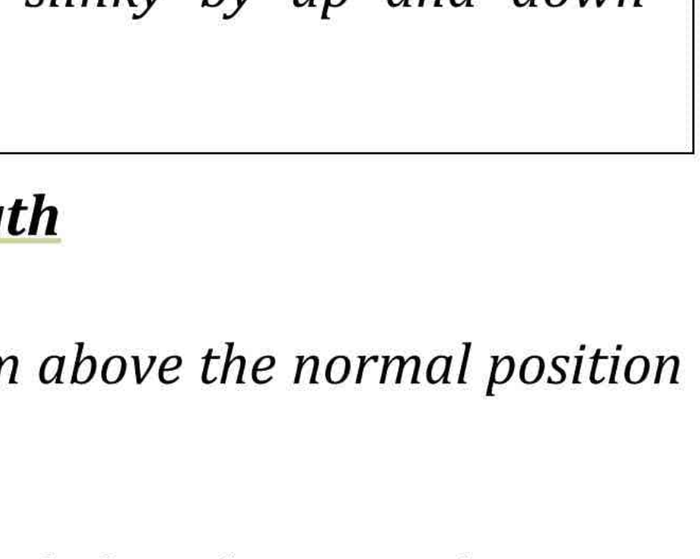
*When waves moving in one medium fall on the surface of another medium they bounce back into the first medium such that angle of incidence is equal to the angle of reflection. The phenomenon is called reflection of waves.*

***Diffraction:***

*The bending or spreading of waves around the sharp edge or corners of obstacles is called diffraction.*

***Refraction:***

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



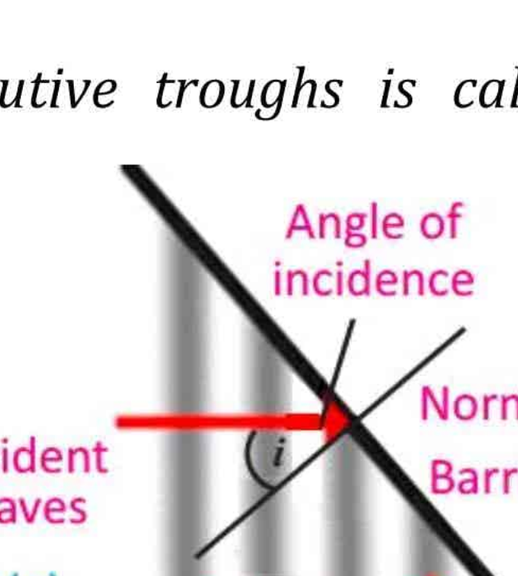




**Fig.** Reflection of water waves from a plane barrier

*Q10:* ***What is the function of ripple tank?***

*Ans:* ***Ripple tank:***

*Ripple tank is a device used to produce water waves and to study their characteristics like reflection, refraction and diffraction.*

*Q11:* ***What changes occur when water waves enter into shallow water from deep water?***

*Ans:* *When water waves enter the region of shallow water their wavelength decreases but frequency of the water waves remains the same in both parts of water because it is equal to the frequency of the vibrator*

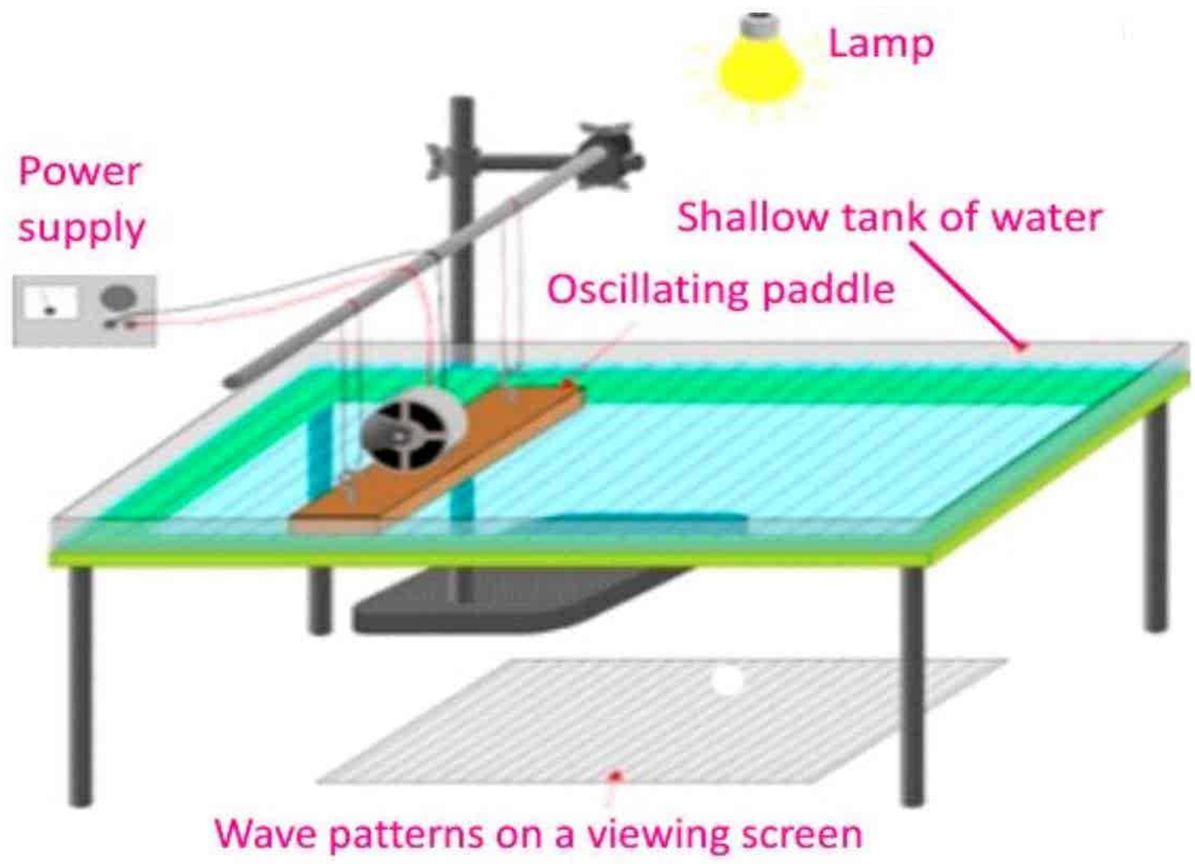



**Fig.** Ripple tank apparatus

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### Imp.Long Questions

*Q.1:* *Show that the motion of a mass attached to a spring is a simple harmonic motion.*

*Q.2:* *Explain the motion of ball in bowl perform simple harmonic motion.*

*Q.3:* *If* 100 *waves pass through a point of a medium in* 20 *seconds, what is the frequency and time period of the wave? If the wavelength is 6 cm, calculate the wave speed.*

*Q.4:* *What are damped oscillations? Explain with and example.*

*Q.5:* *Write a note on "waves as a carrier of energy". Also describe the factors upon which the energy of the waves depends.*

*Q.6:* *Find the time periods of a simple pendulum of 1 meter length, placed on earth and on moon. The value of g on the surface of Moon is 1/6th of its value on earth, where ge is* 10 $ms^{-2}$.

*Q.7:* *Explain the following properties of waves with reference to ripple tank. i. Reflection ii. Refraction iii. Diffraction.*

*Q.8:* *Find the time period and frequency of a simple pendulum 1m long at a location where* $g = 10\ ms^{-2}$.

*Q.9:* *The time period of a simple pendulum is 2 seconds. What will be its length on earth? What will be its length on the moon if* $g_m = g_e/6$ *where* $g_0 = 10\ ms^{-2}$.