FORM 4 PHYSICS

Introduction to Vyasa Purnima Term

Instructions:

1. This handout should be printed and pasted into your books (if possible) or it should be written.

2. All the questions MUST be answered.

3. Please be reminded that all outstanding work will be dued immediately on the first day of school.

What is Wave Motion?

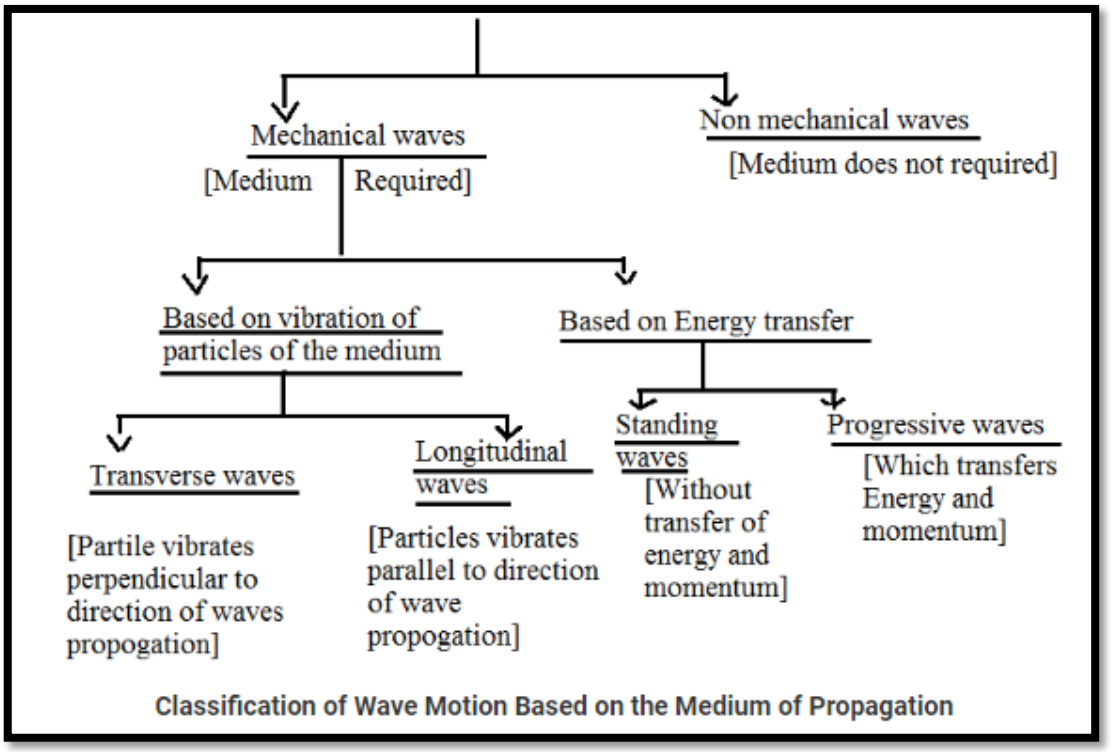
Wave motion is the transfer of energy and momentum from one point of the medium to another point of the medium without actual transport of matter between two points. Wave motion is classified into three different ways they are,

- The medium of propagation,
- The dimensions in which a wave propagates energy,
- The energy transfer

Classification of Wave Motion

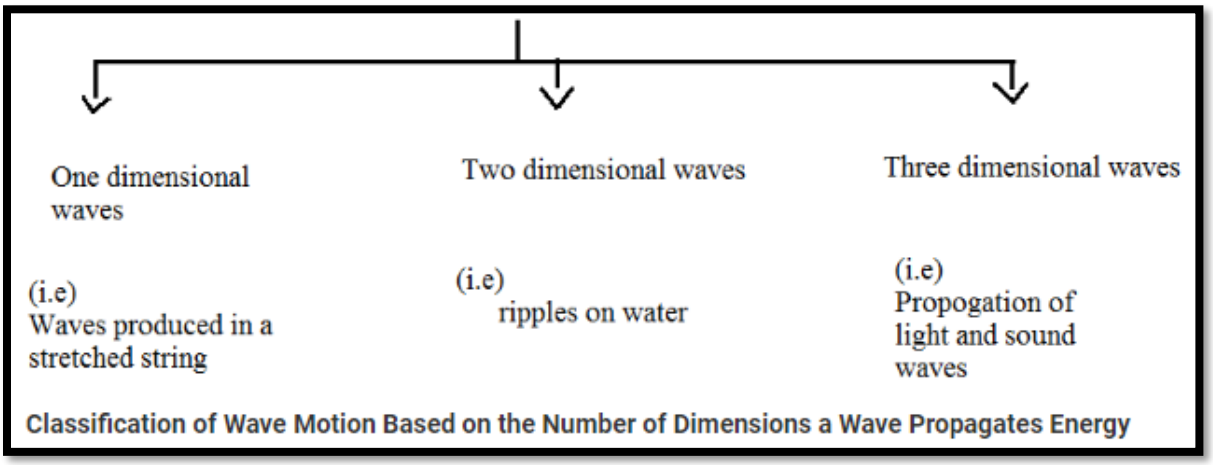
Based on the Medium of Propagation

Medium of propagation is the means by which a wave is produced.



Classification of Wave Motion Based on the Medium of Propagation

Number of Dimensions a Wave Propagates Energy



Based on the Transfer of Energy

- **Standing waves (or stationary waves)**

  Standing wave, also called stationary wave, combination of two waves moving in opposite directions, each having the same amplitude and frequency. Standing waves remain Confined to a region without any transfer of energy and momentum.

- **Progressive wave**

  A progressive wave is a term given to a wave that travels from a specific point A in the medium to another point B. In simple terms, a wave that continuously travels in a medium in the same direction. Progressive waves transfer energy and momentum between the particles of the medium.

Mechanical waves (Elastic waves)

Waves that require a medium for their propagation are called mechanical waves or elastic waves. The particles of the medium execute periodic motion about a mean position when the wave propagates through the medium.

For Example, waves on a string

A mechanical wave is produced due to a disturbance at a point in a medium.

- The disturbed particle interacts with the neighboring particle and its energy is handed over to the next particle (due to the inertia of the medium).
- The disturbed particles retune to the equilibrium position (due to the elasticity of medium).

Properties of Medium for Mechanical Wave Propagation

- The medium must possess **inertia** so that its particles can store kinetic energy.
- The medium must possess **elasticity**.
- The **minimum frictional force** between the particles of the medium.

Non-Mechanical Waves

Waves which do not require a medium for their propagation are called a non-mechanical wave. These types of waves can propagate through vacuum also. These are **transverse in nature**. For example, electromagnetic waves and matter waves.

Transverse Wave Motion

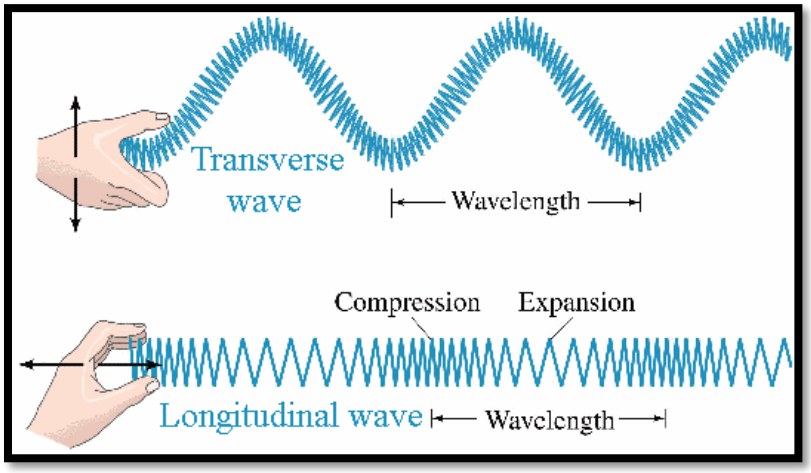
A transverse wave is a moving wave that is made up of oscillations happening perpendicular to the direction of energy transfer. Examples of transverse waves include: ripples on the surface of water, vibrations in a guitar string, electromagnetic waves – e.g. light waves, microwaves, radio waves.

Longitudinal Wave Motion

The particles of the medium vibrate about their equilibrium position in a direction parallel to the direction of propagation of the wave is called a longitudinal waves.

Longitudinal waves require a medium with only **elasticity of volume (or Bulk modulus)** for its propagation. In this type of wave motion, the waves travel through a medium in the form of compression and rarefaction.

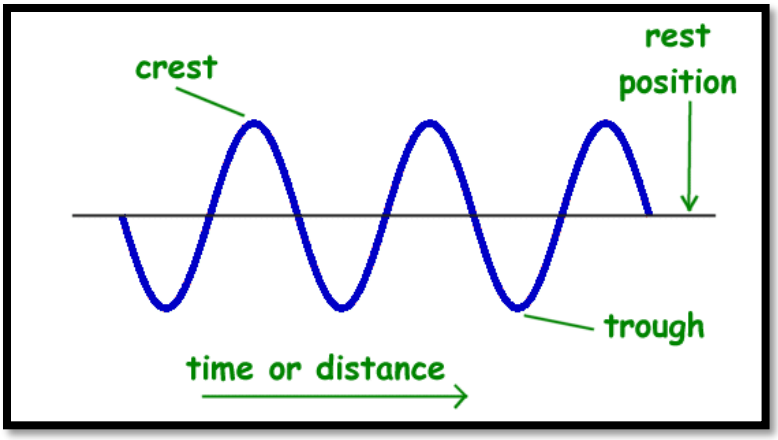
The region of high pressure is called compression and the region of low pressure is called rarefaction (expansion). For example, Sound waves in the tube.



Characteristics of Wave Motion

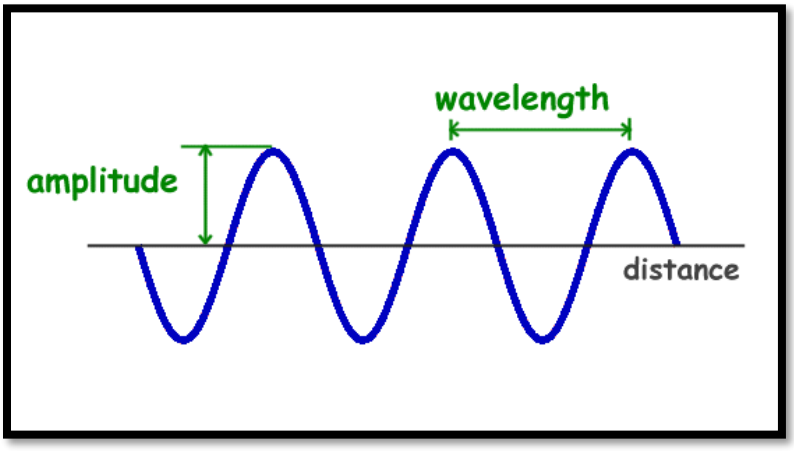
There are many properties that scientists use to describe waves. They include amplitude, frequency, period, wavelength, speed, and phase. Each of these properties is described in more detail below.

Graphing a Wave
When drawing a wave or looking at a wave on a graph, we draw the wave as a snapshot in time. The vertical axis is the amplitude of the wave while the horizontal axis can be either distance or time.



In this picture you can see that the highest point on the graph of the wave is called the crest and the lowest point is called the trough. The line through the center of the wave is the resting position of the medium if there was no wave passing through. We can determine a number of wave properties from the graph.

Amplitude
The amplitude of a wave is a measure of the displacement of the wave from its rest position. The amplitude is shown on the graph below.



Amplitude is generally calculated by looking on a graph of a wave and measuring the height of the wave from the resting position.

The amplitude is a measure of the strength or intensity of the wave. For example, when looking at a sound wave, the amplitude will measure the loudness of the sound. The energy of the wave also varies in direct proportion to the amplitude of the wave.

Wavelength
The wavelength of a wave is the distance between two corresponding points. This can be measured between two crests of a wave or two troughs of a wave. The wavelength is usually represented in physics by the Greek letter lambda (λ).

Frequency and Period

The frequency of a wave is the number of times per second that the wave cycles. Frequency is measured in Hertz or cycles per second. The frequency is often represented by the lower case "f."

The period of the wave is the time between wave crests. The period is measured in time units such as seconds. The period is usually represented by the upper case "T."

The period and frequency are closely related to each other. The period equals 1 over the frequency and the frequency is equal to one over the period. They are reciprocals of each other as shown in the following formulas.

$$\text{Period} = 1/\text{frequency}$$

or

$$T = 1/f$$

$$\text{Frequency} = 1/\text{period}$$

or

$$f = 1/T$$

Speed or Velocity of a Wave

Another important property of a wave is the speed of propagation. This is how fast the disturbance of the wave is moving. The speed of mechanical waves depends on the medium that the wave is traveling through. For example, sound will travel at a different speed in water than in air.

The velocity of a wave is usually represented by the letter "v." The velocity can be calculated by multiplying the frequency by the wavelength.

$$\text{Velocity} = \text{frequency} * \text{wavelength}$$

or

$$v = f * \lambda$$

Answer the following questions.

1. When graphing a wave, what does the horizontal axis usually represent?
   a. Amplitude
   b. Trough
   c. Time or distance
   d. Crest
   e. Rest position

2. What does the horizontal line through the center of the wave on a graph represent?
   a. Amplitude
   b. Trough
   c. Time or distance
   d. Crest
   e. Rest position

3. When graphing a wave, what does the vertical axis usually represent?
   a. Amplitude
   b. Trough
   c. Time or distance
   d. Crest
   e. Rest position

4. What do we call the highest point of the wave on a graph?
   a. Amplitude
   b. Trough
   c. Time or distance
   d. Crest
   e. Rest position

5. What do we call the lowest point of the wave on a graph?
   a. Amplitude
   b. Trough
   c. Time or distance
   d. Crest
   e. Rest position

6. What wave measurement represents the number of times per second that the wave cycles?
   a. Wavelength
   b. Period
   c. Amplitude
   d. Frequency
   e. Velocity

7. What wave measurement would you find by measuring the distance between the crests of back-to-back wave cycles?

a. Wavelength
b. Period
c. Amplitude
d. Frequency
e. Velocity

8. What wave measurement would you find by measuring the time between the crests of back-to-back wave cycles?

a. Wavelength
b. Period
c. Amplitude
d. Frequency
e. Velocity

9. What wave measurement represents the strength or intensity of the wave?

a. Wavelength
b. Period
c. Amplitude
d. Frequency
e. Velocity

10. What wave measurement represents how fast the disturbance of the wave is moving?

a. Wavelength
b. Period
c. Amplitude
d. Frequency
e. Velocity

11. Wave motion is classified into three different ways. State and explain these various ways.

12. State one difference between the following and give two examples of each:

a. Mechanical and Non-mechanical waves
b. Longitudinal and Transverse waves
c. Standing and Progressive waves