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"What one man calls God, another calls the laws of physics."

-Nikola Tesla

TOPIC 12: GENERAL WAVE PROPERTIES

THE ABOUT

CHAPTER ANALYSIS

LEARNING

- 3 **key** concepts
- General wave properties, transverse, longitudinal
- 1 **advanced** concept
- Graphical analysis

EXAM

- Tested quite frequently
- Need for subsequent chapters in Electromagnetic Waves & Sound
- However, questions are tricky and concepts confusing.

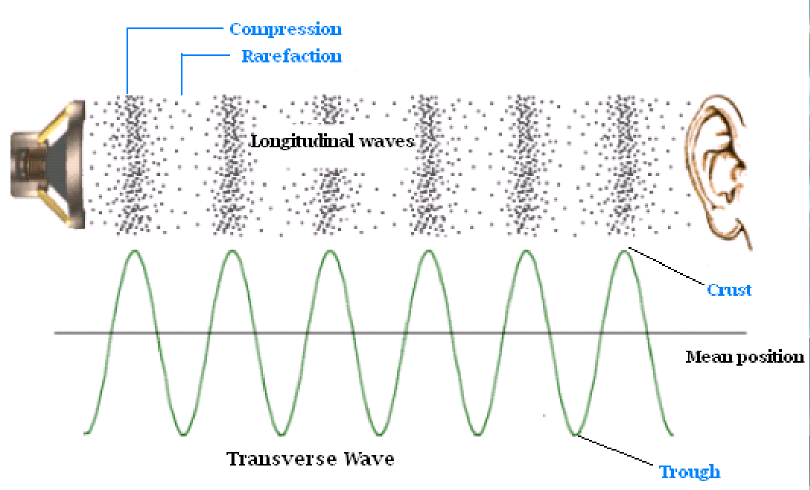
WEIGHTAGE

- Light-medium overall weightage
- Constitute to around **3.5%** of marks for past 5 year papers

KEY CONCEPT

GENERAL WAVE PROPERTIES
TRANSVERSE WAVE
LONGITUDINAL WAVE

GENERAL WAVE PROPERTIES



Scenario:
Imagine a busy e-commerce warehouse. When there is a shipment, the warehouse gets busy and workers move around up & down the warehouse. But eventually the shipment gets delivered elsewhere down the line. Once that happens, the workers in the warehouse settles back into their default state. The workers themselves do not move out of the warehouse.

GENERAL WAVE PROPERTIES

Definition:

A wave is a disturbance that **transfers energy** through vibrations from one place to another, **without the transfer of particles/matter itself.**

Two key properties of waves:

- Carries energy away from the wave source
- Transfers energy without transferring matter

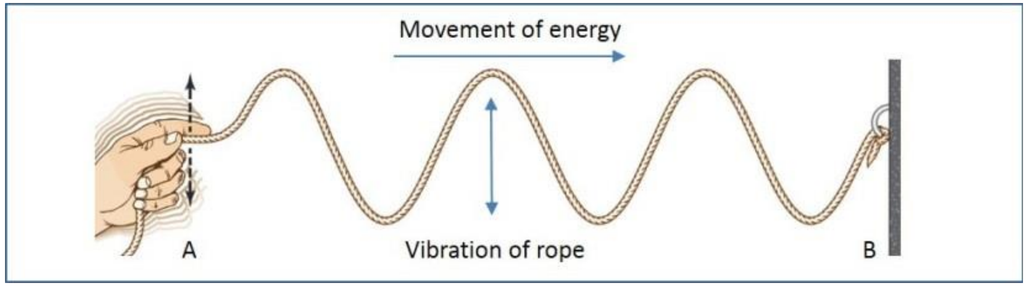
UNDERSTAND THIS CONCEPT!

Particles will oscillate about their equilibrium position and in the process transfer energy. However after the wave have passed, the particles themselves **do not shift away from their equilibrium position.**

For example, transverse waves' particles oscillate up and down when a wave is going through. After the wave have passed, that particle will return to its equilibrium position.

BASICS

WAVE MOTION



WAVE MOTION

A wave motion is a method of transferring energy from one point to another, without any physical transfer of material.

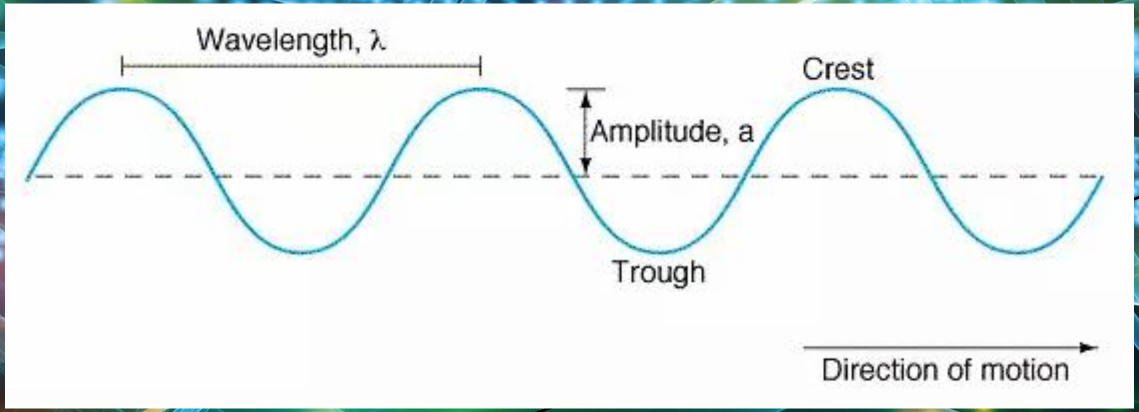
The hand generates kinetic energy, hence it is the source.

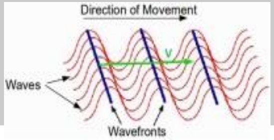
The kinetic energy is transferred in the form of a wave motion to the other end of the rope.

Kinetic energy is transferred but the rope is unchanged.

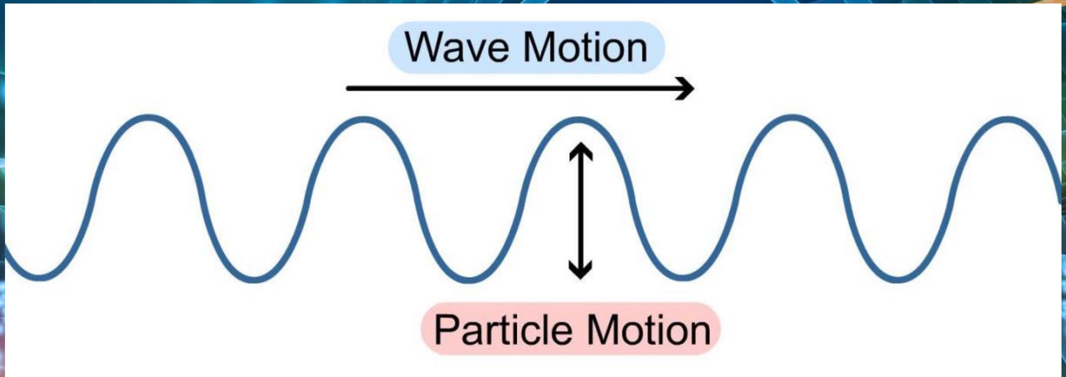
There are two types of waves: **transverse waves & longitudinal waves.**

KEY TERMINOLGIES



Terminology	Formula	Definition
Crest		High points on a wave.
Trough		Low points on a wave.
Phase		When 2 particles are moving in the same direction from the same relative position, they are in phase. The distance between 2 points in phase is the wavelength , **λ.**
Amplitude		Magnitude of the maximum displacement from the rest position (height of crest or depth of trough).
Wavelength	**λ**	Distance between 2 successive crests/troughs (or any 2 successive points "in phase").
Period	**T = 1 / f**	Time taken for any given point on the wave to move a distance of one wavelength, ie the time taken to generate one complete wave.
Frequency	**f = 1 / T**	Number of crests or troughs that pass a point per second, i e the number of complete waves generated per second.
Speed of wave	**v = fλ**	Distance moved by a wave per unit time.
Wavefront		A wavefront is an imaginary line joining all the crests (or all points in phase) on a wave.

TRANSVERSE WAVES



<u>Particles vibrate in a direction perpendicular to the direction of the wave motion:</u>

Notice how the particle is oscillating up & down?

The wave, however, is travelling sideways.

Hence, the direction of oscillation of the particle is perpendicular to the wave travel.

<u>TRANSVERSE WAVES</u>

<u>Definition:</u>

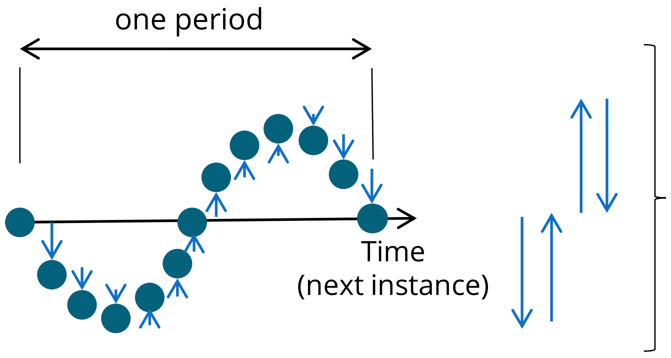
Transverse waves are waves whose particles **vibrate in a direction perpendicular to** the direction of the **wave motion.**

Examples:

- Water waves
- Electromagnetic waves *(learn more in chapter "electromagnetic waves")*
- Light waves
- Radio waves

*Please understand the particle **never moved sideways.** (Assuming transverse wave)

It only moves up and down. Over time, the graph captures that cycle.

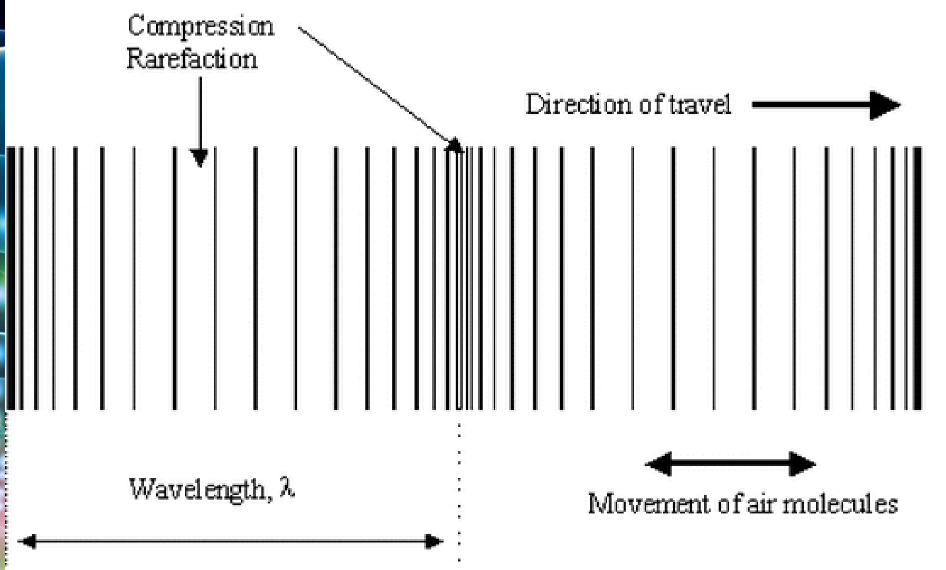


The ● is a particle.

The blue arrows shows the journey of one particle over time.

Over one period*, first it moved down till min amplitude, then up to equilibrium, up again to max amplitude, and down to equilibrium again.

LONGITUDINAL WAVES



Particles vibrate in a direction parallel to the direction of the wave motion:

Notice how the particle is oscillating sideways?

The wave is also travelling sideways.

Hence, the direction of oscillation of the particle is parallel to the wave travel.

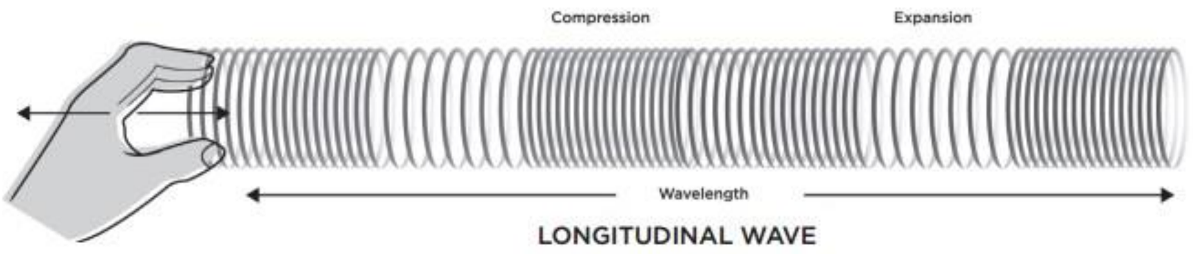
LONGITUDINAL WAVES

Definition:

Longitudinal waves are waves whose particles **vibrate in a direction parallel to** the direction of the **wave motion.**

Examples:

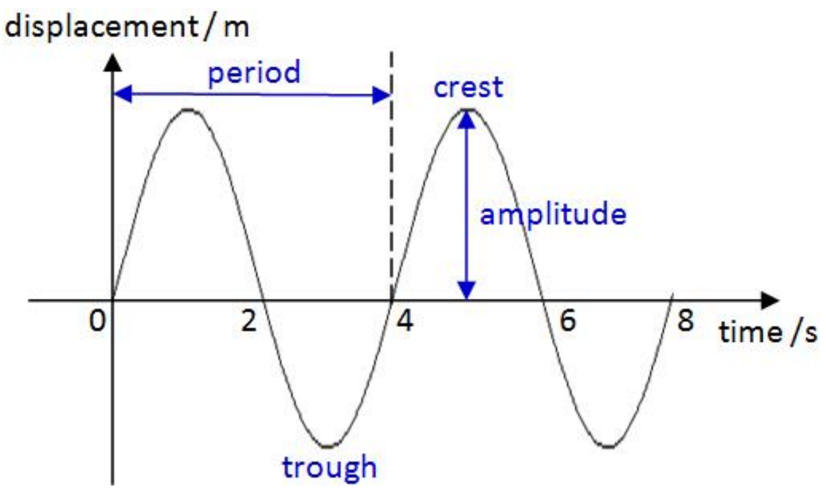
- Sound wave
- Silky coil



ADVANCED CONCEPT

GRAPHICAL ANALYSIS
DISPLACEMENT- TIME GRAPH
DISPLACEMENT- DISTANCE GRAPH

DISPLACEMENT - TIME GRAPH



The graph applies to both transverse and longitudinal waves. Direction of displacement will differ.

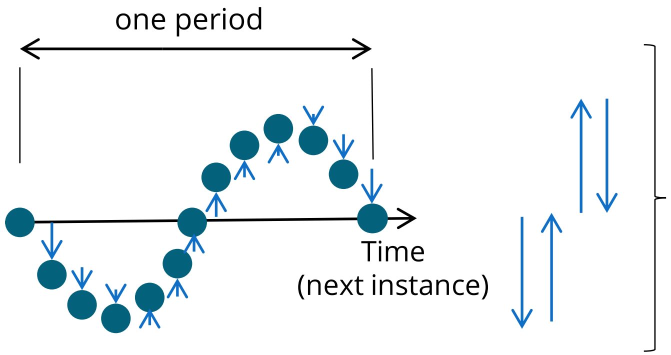
DISPLACEMENT-TIME GRAPH

A displacement-time graph shows the displacement of a particle as a wave pass through.

Just visual this one particle riding a sky drop. Over time, it goes up and down and repeats.

KEY ANALYSIS:

You can identify the **period, T** and the **amplitude, a** from displacement-time graphs.

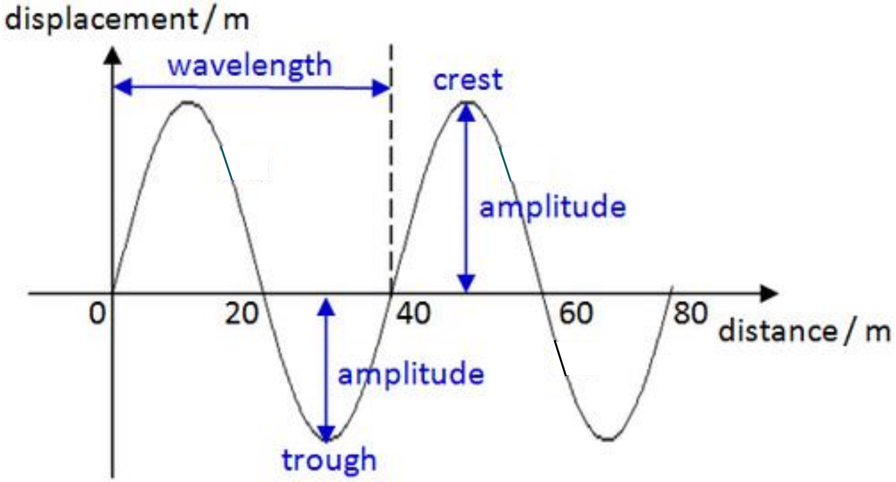


The ● is a particle.

The blue arrows shows the journey of one particle over time.

Over one period*, first it moved down till min amplitude, then up to equilibrium, up again to max amplitude, and down to equilibrium again.

DISPLACEMENT- DISTANCE GRAPH



The graph applies to both transverse and longitudinal waves. Direction of displacement will differ.

DISPLACEMENT-DISTANCE GRAPH

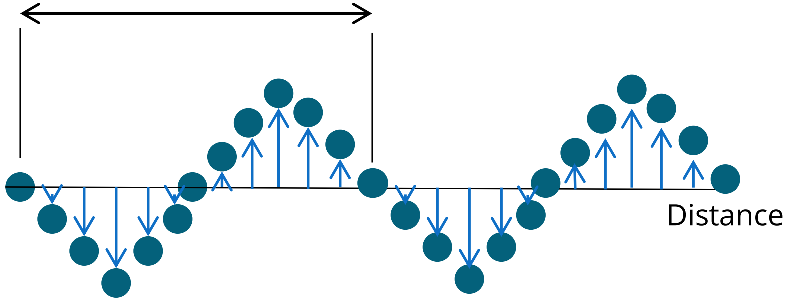
(AKA as displacement-position graph)

A displacement-distance graph shows the displacement of particles at one specific instance.

(Think of Kallang wave! The wave is formed by stream of people's varying positions.)

KEY ANALYSIS:

You can identify the **wavelength** and the **amplitude** from displacement-position graphs.



The ● are the particles.

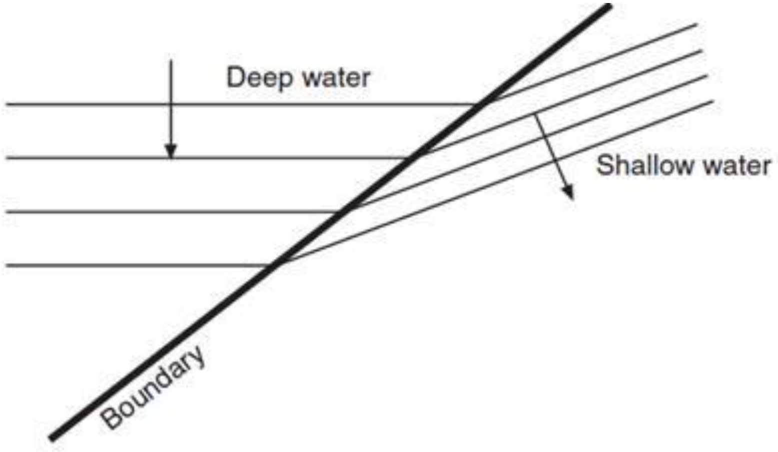
The blue arrows shows the displacement of each particle from their equilibrium position.

Each particle moves a certain distance from equilibrium and together they form a wave motion.

*Remember that one wavelength is distance between 2 points in phase.

BONUS KILLER QUESTION REVIEW

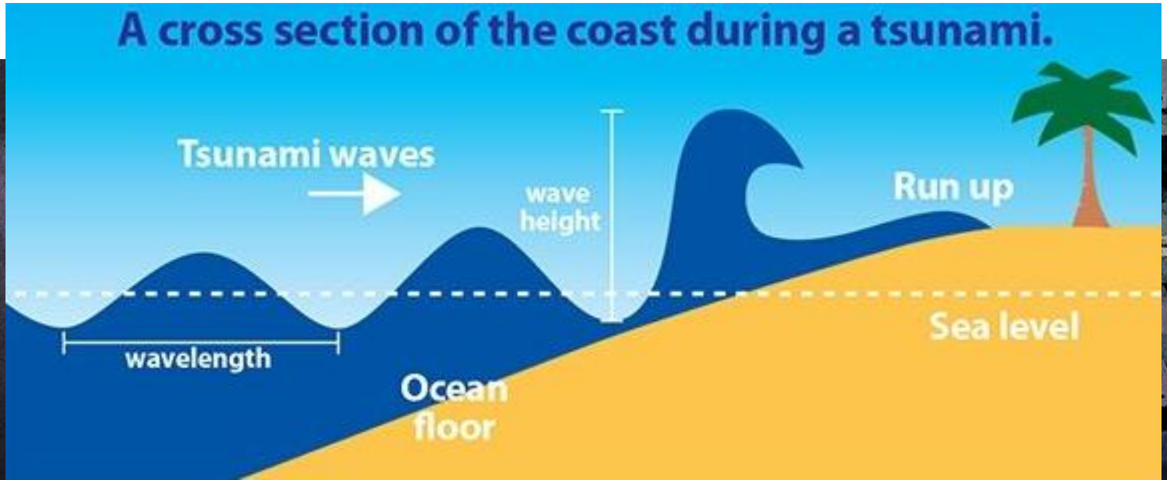
The diagram show a water wave moving from a deep region to a shallow region. Why does the wavelength, **λ**, changes?



FUN FACT

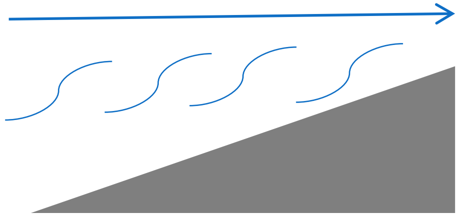
This is the reason behind tsunamis. A underwater earthquake is the source of energy that propel water waves. When from far, the waves look seemingly safe as the height of the wave is short since wavelength is long.

As it approaches the shore, the friction slows down the wave and the wave is forced to squeeze together as wavelength is shorten. It will cause these huge and tall waves that contains devastating destruction power.



EXPLANATION

As water waves moves from a deeper region to a shallower region, the wavelength changes.



As the water waves approach the **shallower region,** it experiences **more friction.**

As a result, the **wave speed, v, is reduced**.

Since,

$$v = f\lambda$$

When v is lowered, the wavelength, **λ,** is also lowered.

Hence, as water waves moves from a deep region to a shallower region, its wavelength shortens.

*Please note that the frequency is unchanged as the frequency is dependable only on the source of the wave motion.