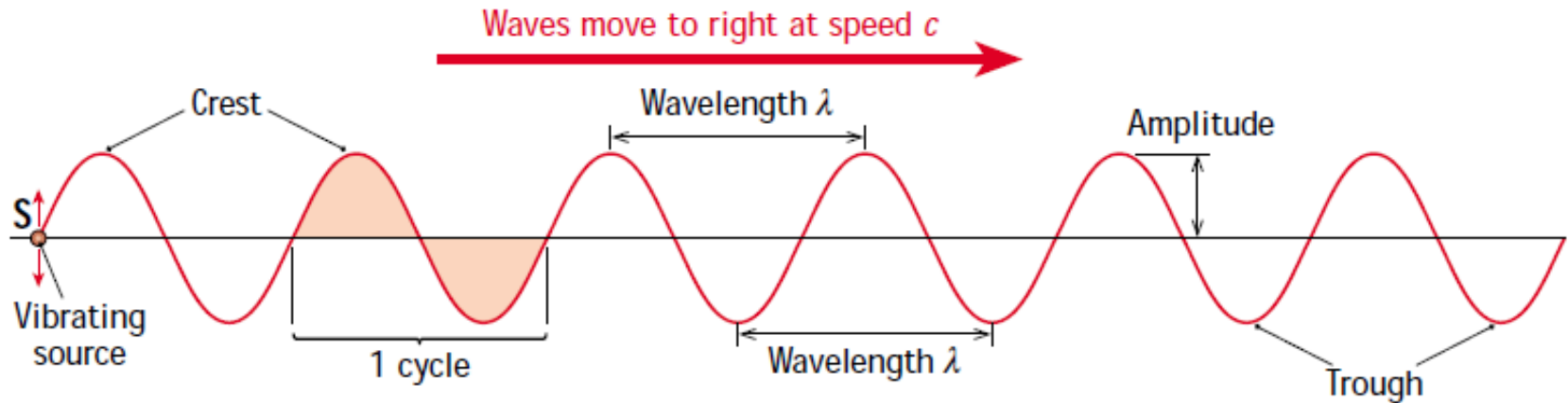


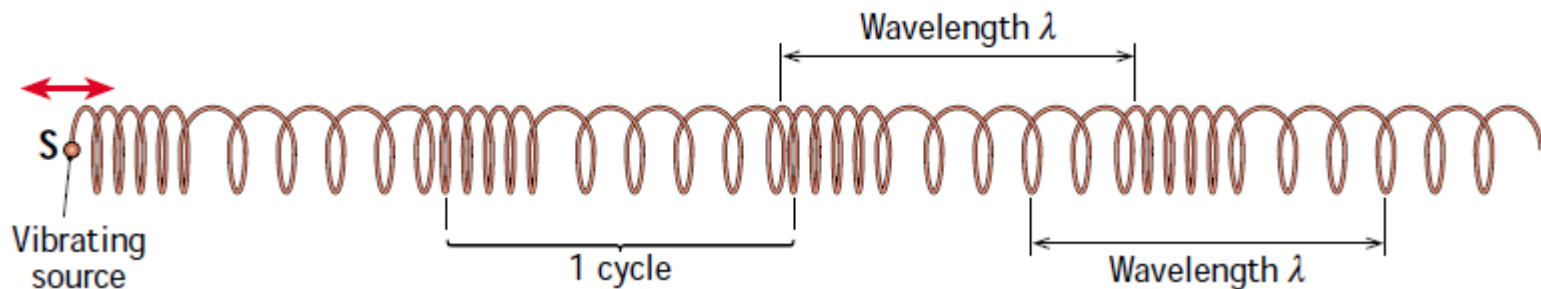
# Chapter 16: Waves and Wave Motion

Def: A wave is a disturbance that carries energy from one place to another.

Def: Transverse wave are waves which travel perpendicular to the direction of the vibration of the medium. e.g. Light waves, radio or water waves.



Def: Longitudinal waves are waves which travel in the same direction as the vibration of the medium. e.g. Sound waves.



## Terms:

- Periodic travelling waves are a regular repeating cycle that appears in the direction of the wave.
- A **crest** is the highest point of a transverse wave.
- A **trough** is the lowest point of a transverse wave.
- An **oscillation** or cycle is one complete vibration of the source.
- **Wavelength ( $\lambda$ )** is the distance from a point on a wave to the corresponding point on an adjacent wave. *Unit: metre (m)*
- **Frequency (f)** is the number of waves passing a point per second. *Unit: hertz (Hz)*
- **Amplitude (A)** is the maximum distance from the undisturbed position. *Unit: metre (m)*

**Formula:**

To find the speed of the wave coming from a source, we use the formula

$$c = f\lambda$$

**Example:**

Calculate the speed of a tsunami, of wavelength 200 km and frequency  $1.25 \times 10^{-3}$  Hz

$$\begin{aligned} c &= f\lambda \\ &= (1.25 \times 10^{-3}) (200 \times 10^3) \\ &= 250 \text{ m s}^{-1} \end{aligned}$$

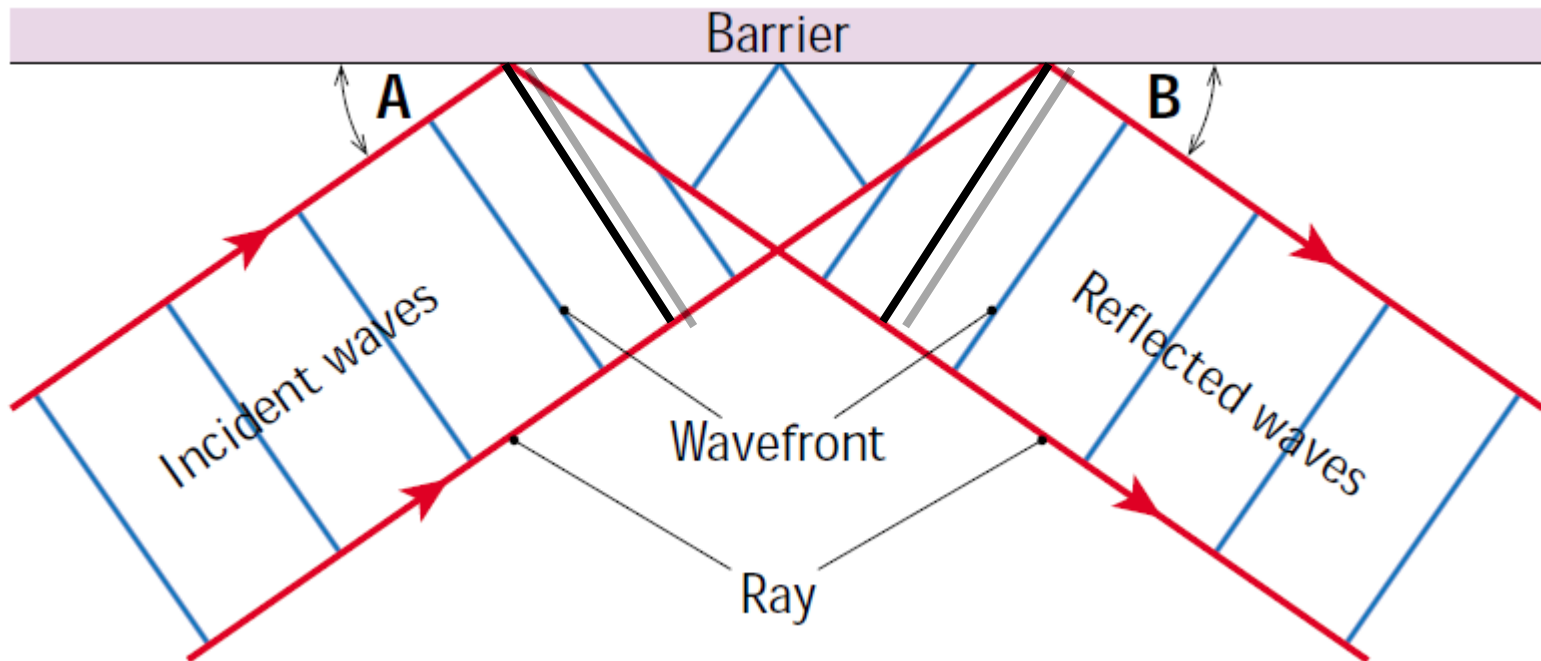
Or 900 km per hour!!

# Wave Phenomena.

## 1. Reflection

**Def: The bouncing of waves off an obstacle in their path is called reflection of waves.**

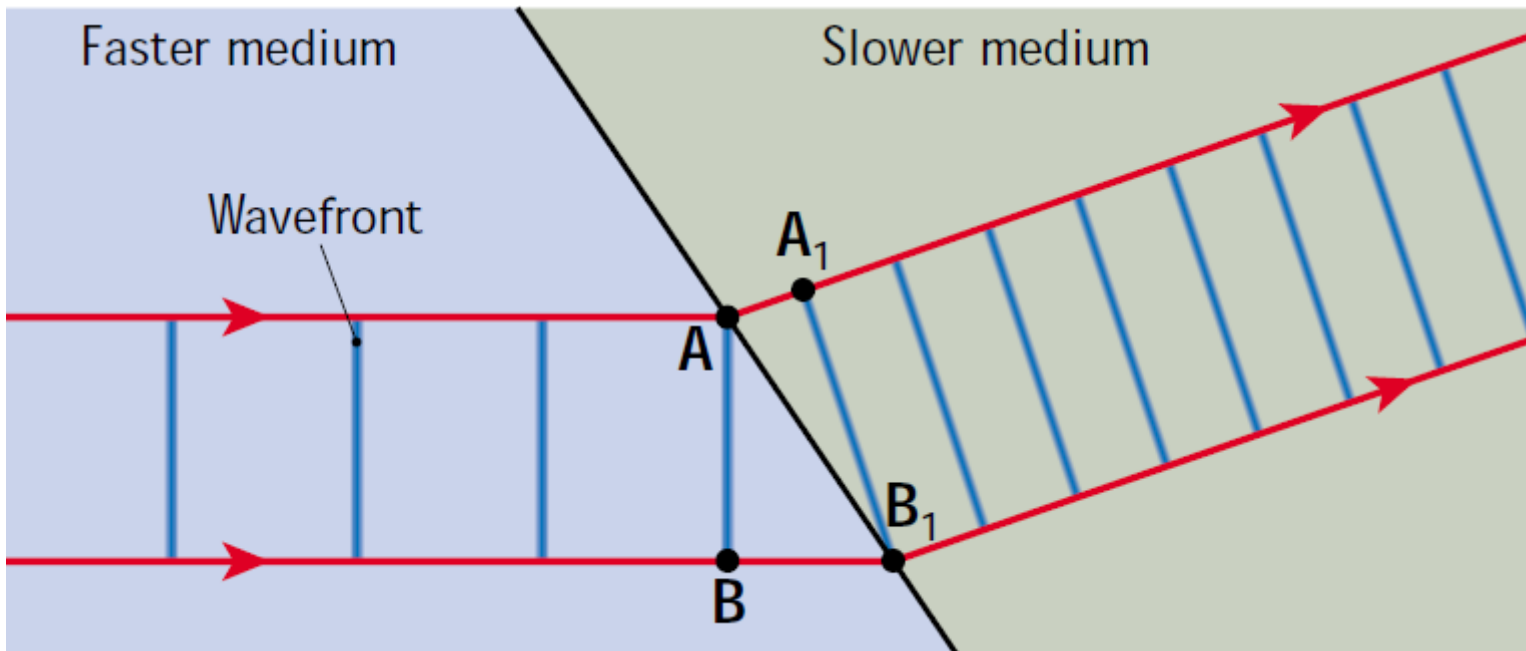
In the diagram below, when the wave hits the barrier, it gets reflected. The wave front XY hits the surface, X gets reflected but Y continues on to the point Z. In the same time, X has reached K.



## 2. Refraction

**Def: Refraction is the changing of direction of a wave when it goes from one medium to another.**

- occurs when a wave travels from one medium to another (except  $90^\circ$ )
- the speed of each waves are different in each media.
- A enters the slower medium, in the time B reaches  $B_1$ , A has only moved to  $A_1$ .
- once the entire wave is in the slower medium, it continues in a straight line but in a different direction.

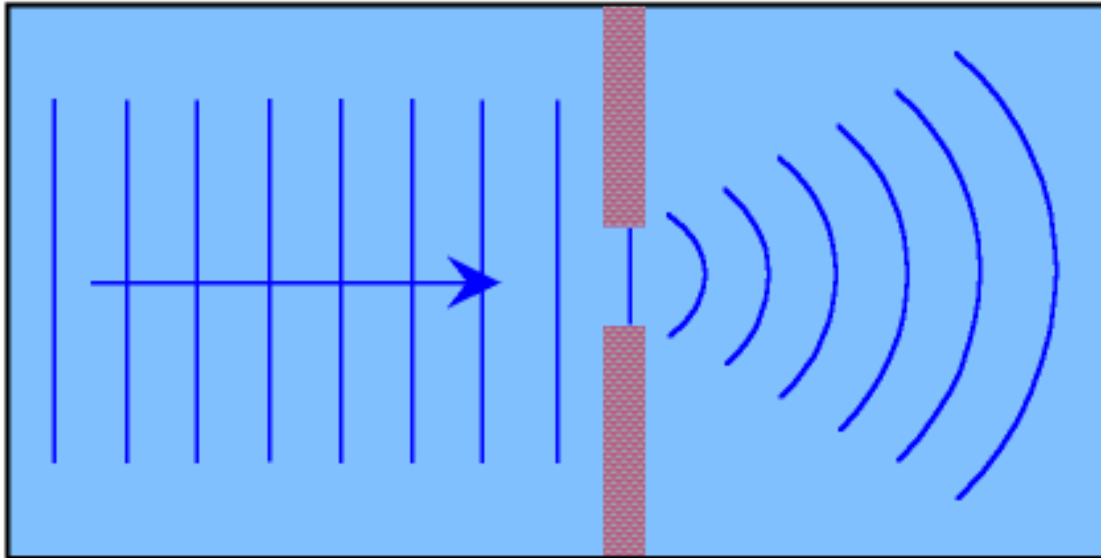


### 3. Diffraction

**Def: Diffraction is the spreading out of a wave into a space beyond a barrier.**

This barrier could be an obstacle or an opening.

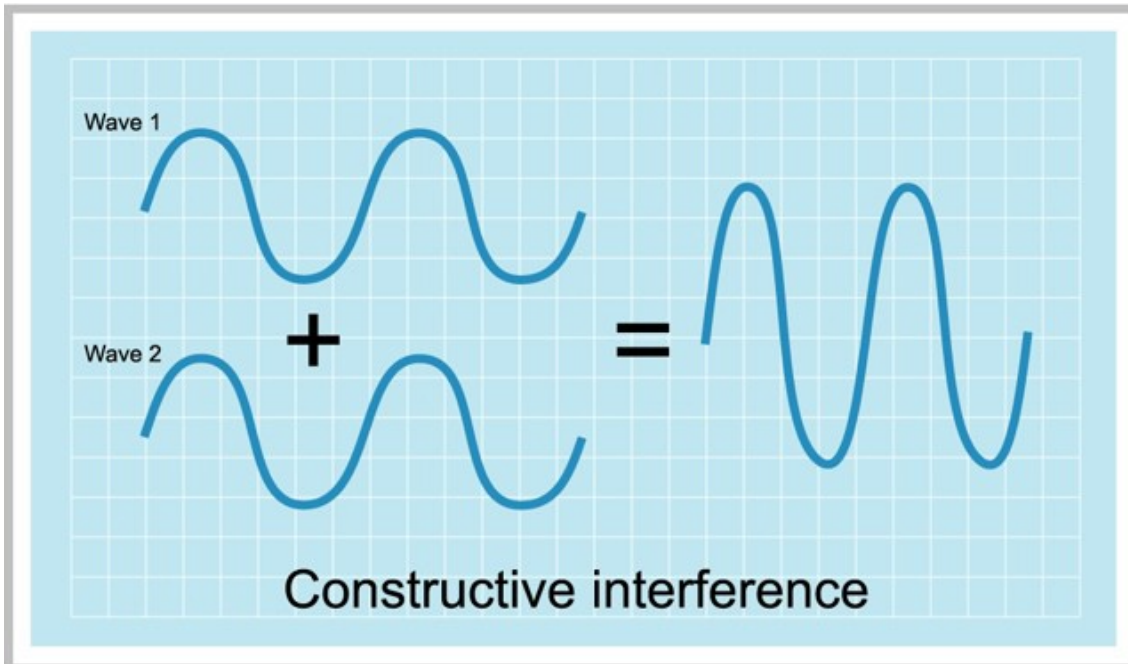
The wavelength of sound is roughly 1 m, while visible light is half a millionth of a metre. That is why sound diffracts around corners and windows but light doesn't.



## 4. Interference of Waves

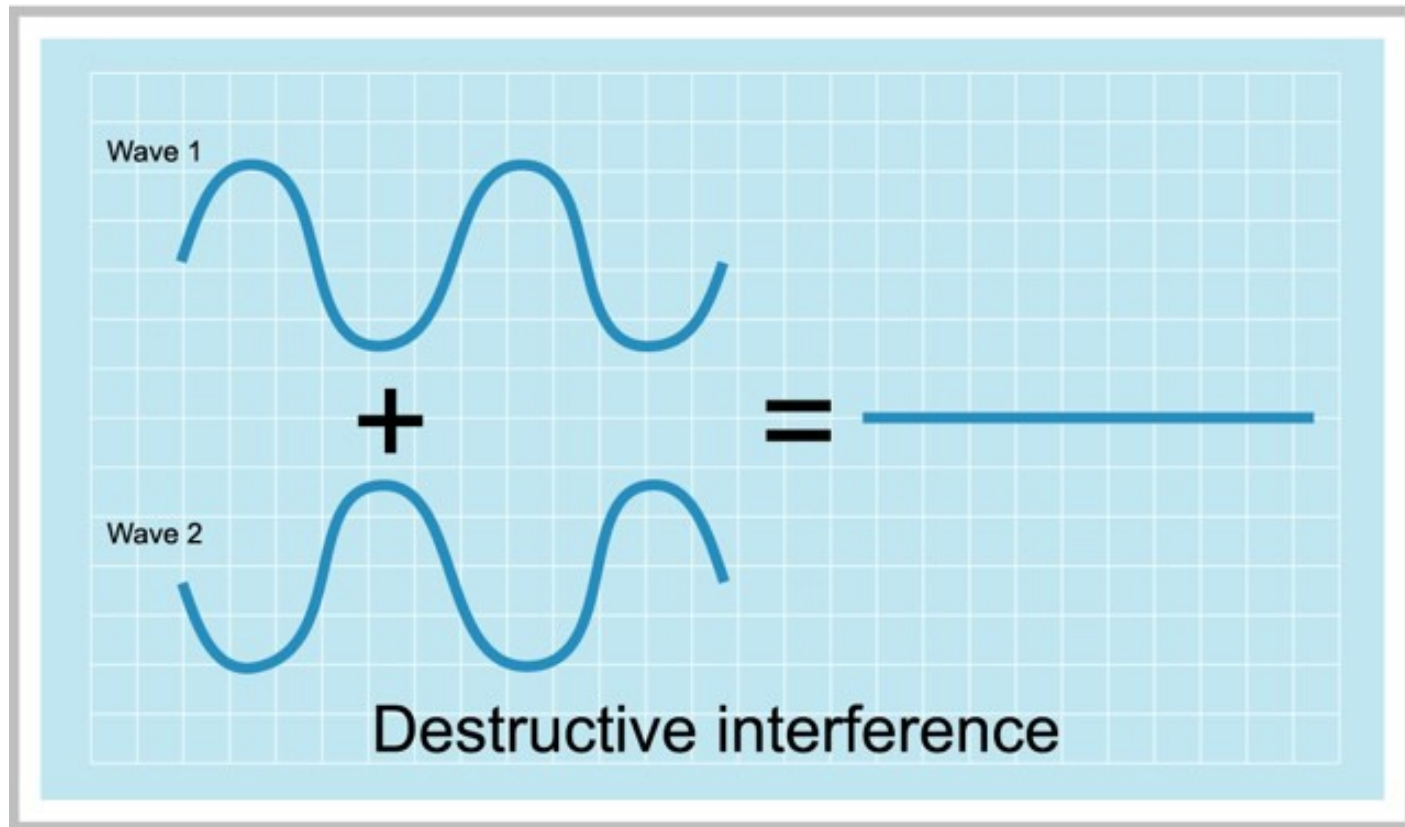
**Def: Interference occurs when waves from two sources meet to produce a wave of different amplitude.**

Two wave of the same frequency and amplitude meet. If the crests and troughs overlap perfectly, they will interfere with each other. The crests will combine to give a new wave with an amplitude twice the height. The frequency of the new wave will be the same as the original two.



**Def: Constructive interference is when 2 or more waves combine, resulting in a single wave of greater amplitude than the source waves.**

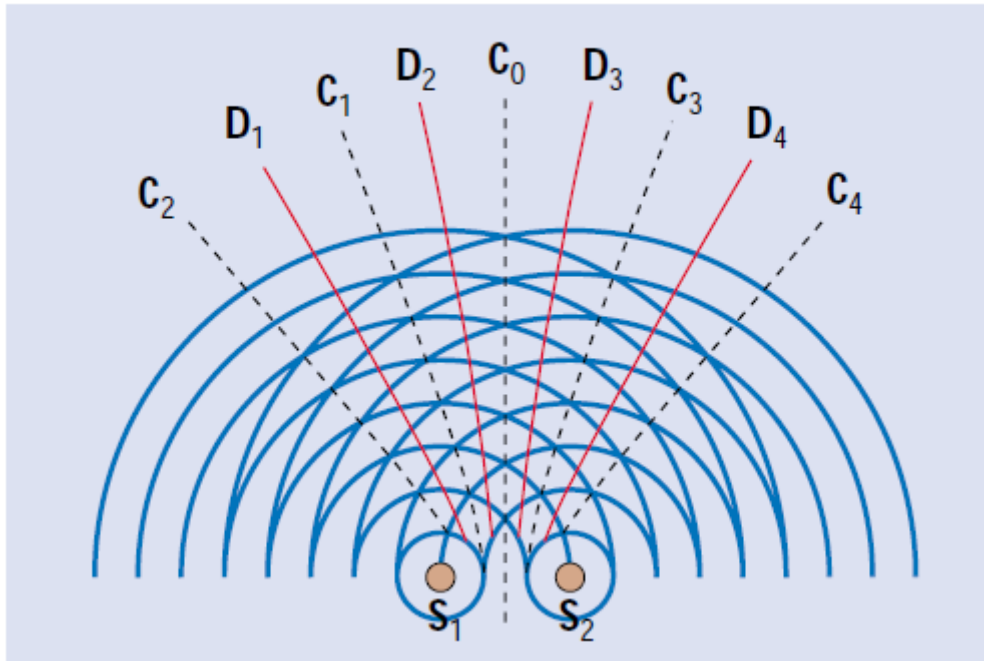
However, if the crests and troughs meet at the one point, destructive interference takes place and the waves cancel each other out.



**Def: Destructive interference is when two or more waves combine, resulting in a single wave of smaller amplitude than the source waves.**

# Interference Patterns from Two Point Sources

Fig 16.19



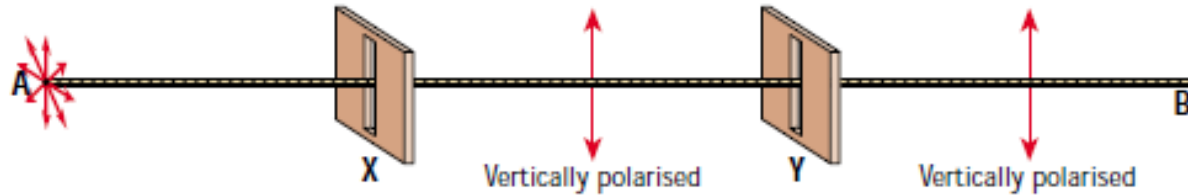
$C_0$  or  $C_1$ : Constructive interference occurs here. The crests and troughs of both sources always meet along these lines. Also called **antinodal** lines.

$D_1$  or  $D_2$ : Destructive interference occurs here. The crest of one source crosses path with the trough of another. These lines are called **nodal** lines.

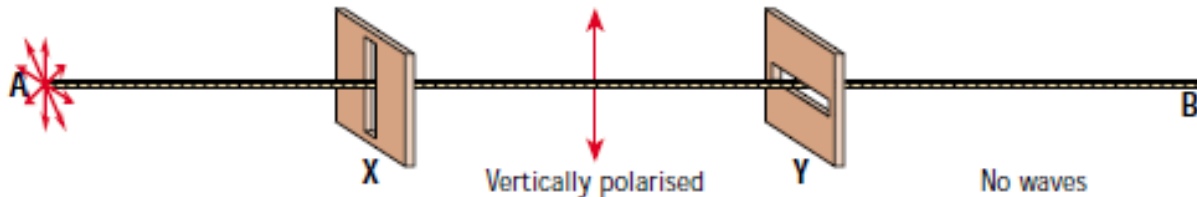
See fig 16.20. pg 182

## 5. Polarisation

Only transverse waves can be polarised. This is because the vibration is perpendicular to the direction of travel.



In this diagram, the rope at A is vibrating in all planes. However when it reaches the slit at X, it can only vibrate vertically. As it passes X, it is said to be vertically polarised. After it passes Y, it will continue to be vertically polarised.



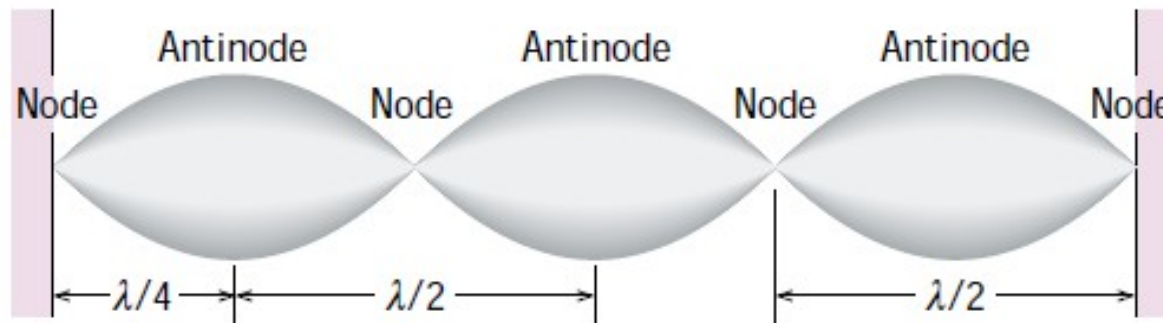
However in this diagram, the Y has been rotated. So, as the vertically polarised wave reaches Y, it cannot pass through.

## Stationary Waves.

**Def: Stationary waves occur when two periodic waves of equal frequency and amplitude moving in opposite directions meet and interfere with each other.**

Also called standing waves. These waves do not travel but remain in the same position.

If a rope is tied to a door and the other end shaken up and down at a certain frequency, it appears that the wave remains on the same place on the rope.



The frequency of all moving parts are the same. The nodes are at rest.

The frequency of the stationary wave is the same as the frequency of the travelling wave producing it.

The distance between 2 consecutive nodes or antinodes is  $\lambda/2$

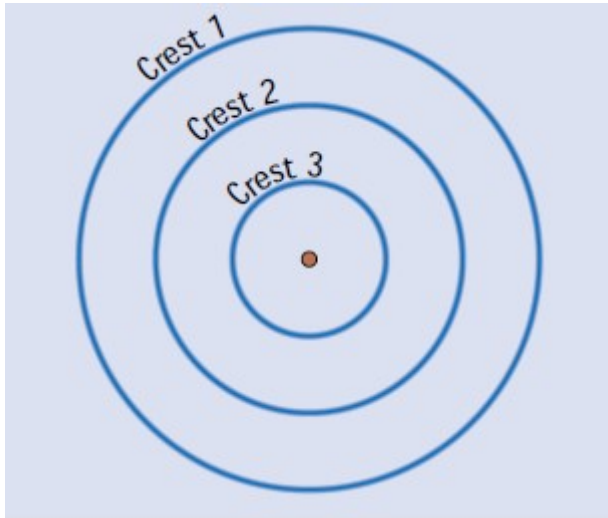
The distance between a node and an antinode is  $\lambda/4$

Example:

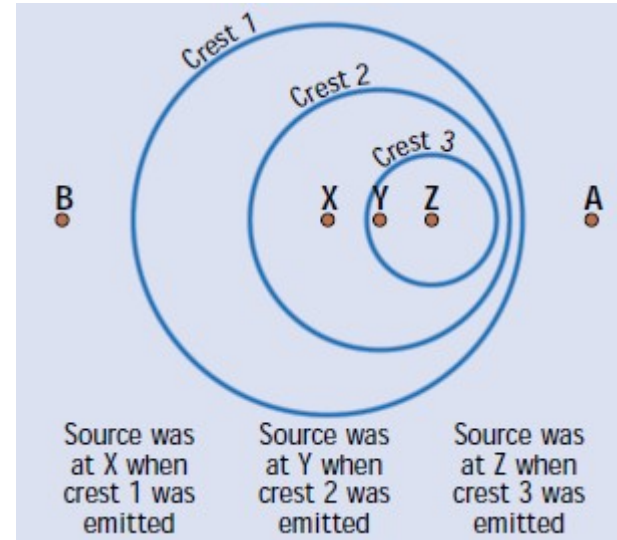
Waves on a rope travel at a speed of 5 m/s. The distance between the node and nearest antinode is 80 cm. What is the frequency of the wave?

## The Doppler Effect

Def: The Doppler Effect is the apparent change in the frequency of waves due to the relative motion between a wave source and observer.



Source is not moving so no matter where you stand, the waves are the same.



Source is moving towards A. At A, the frequency is greater than at B. Also the wavelength at A is less than the wavelength at B.

## Formula: Frequency of Waves of Moving Objects

Moving towards the observer:  $f' = \frac{fc}{c - u}$

Moving away from the observer:  $f' = \frac{fc}{c + u}$

### Example:

An ambulance siren emits a note of 770 Hz. When it is travelling towards an observer standing on the roadside, the note appears to be at 840 Hz. Given that the speed of sound in air is 340 m/s, calculate the speed of the car.