Session Objectives

By the end of the session, participants should:

- define oscillations
- define waves.
- identify characteristics of oscillations and waves.
- identify properties of oscillating system and waves.
- use wave equation.
- identify properties of light.
- Apply light in everyday life.
- carry out practical work on concepts of oscillations and. waves using simple improvised materials.

Introduction

- The three concepts: oscillations, waves and light are closely related. These terms have also differences. Some teachers fail to give clear difference particularly for oscillations and waves. Characteristics and properties of these concepts can be effectively taught by using simple activities.

Activity 1: Demonstration a Pendulum

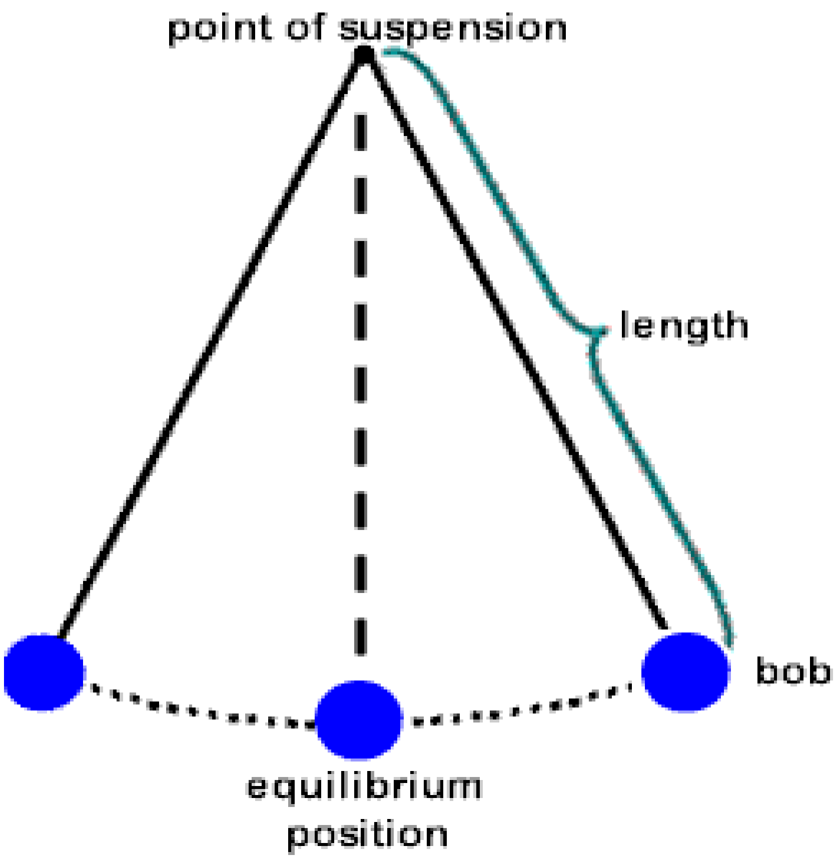
Materials

- A string
- A mass (a stone)
- A stand

Procedure

- Tie the mass to the string and hold it with your hand as shown below:

Pendulum



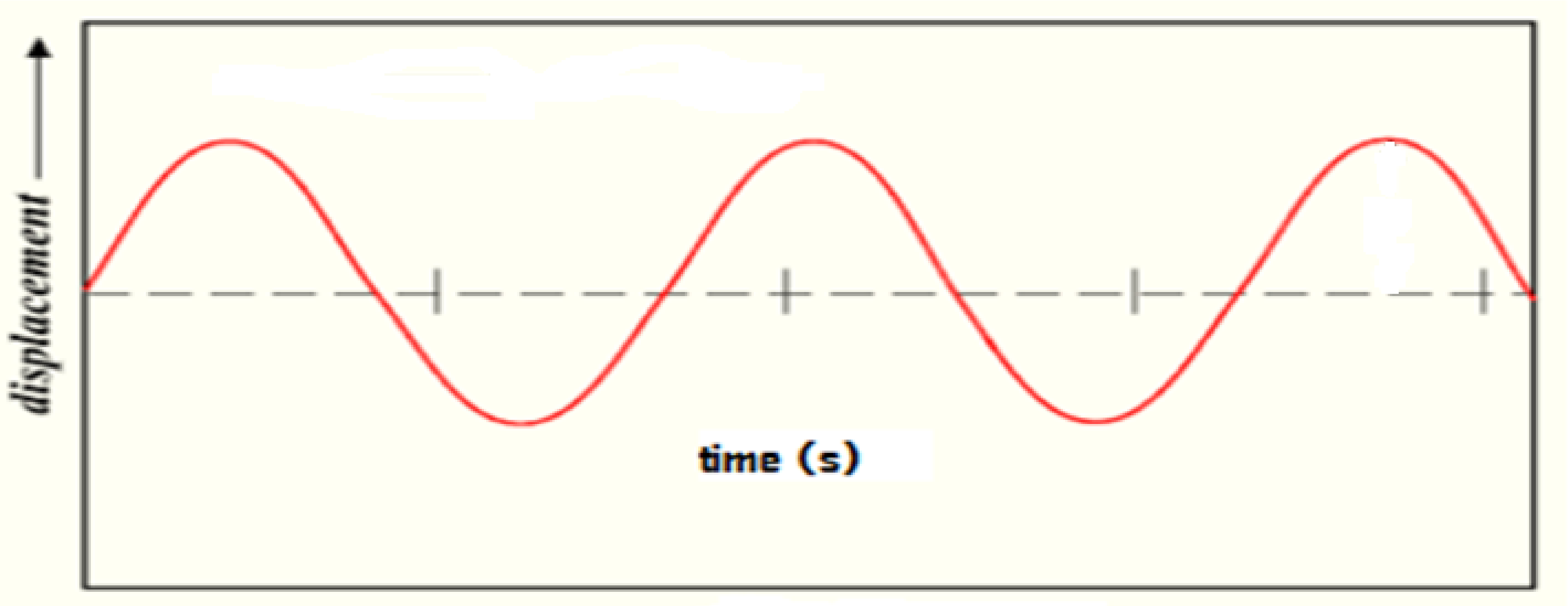
- Let it move several times and observe what happens.
- Use the pendulum as it moves to and fro to define oscillation, amplitude (A), frequency (f) and period (T).

Oscillation

Definition

- Oscillation can be defined as a to and fro, or an upward and downward movement of an object from its rest position or equilibrium position. Examples of oscillating systems are vibrating springs, pendulums, cantilevers etc.
- Each oscillating system is an example of the continuous interchange of potential energy (PE) and kinetic energy (KE). Graphs of oscillating systems take a sinusoidal shape.

Sinusoidal Shape of Oscillating Object

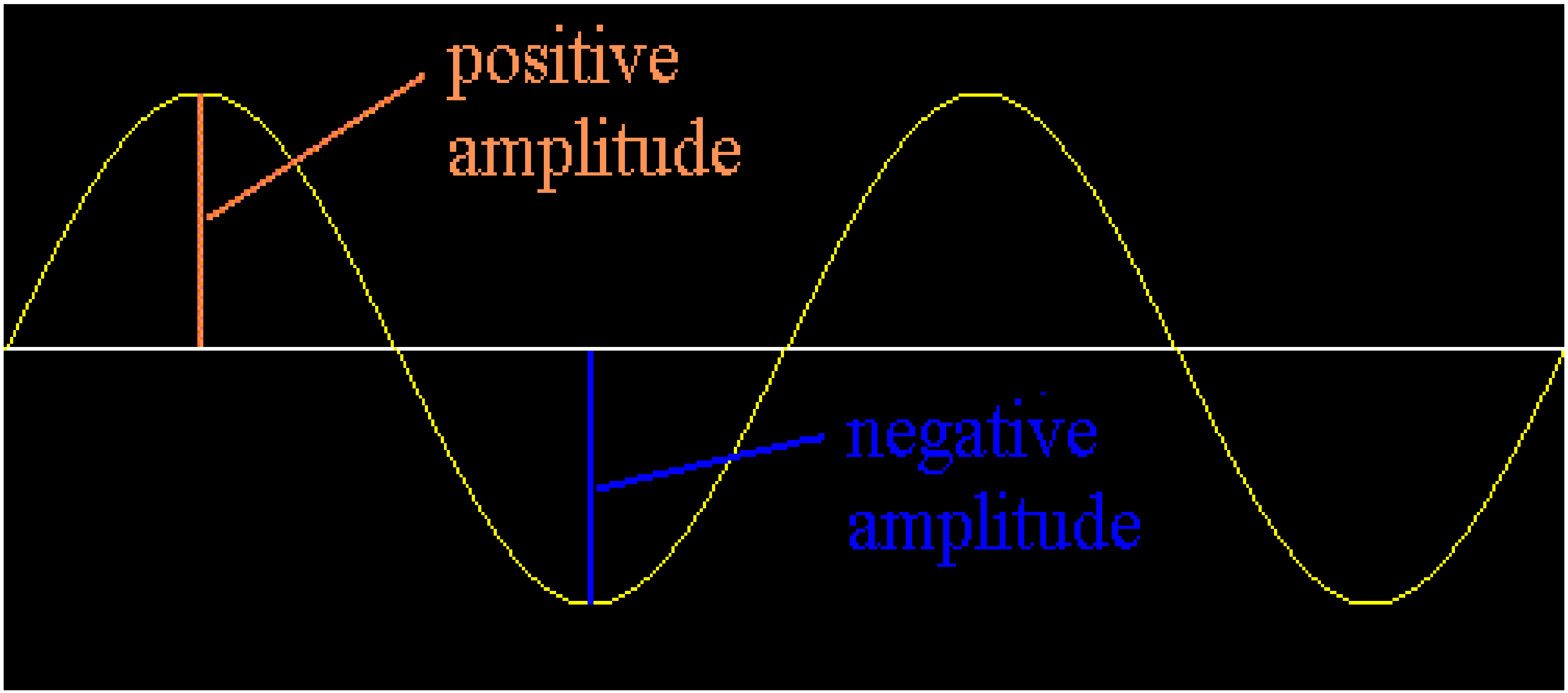


Characteristics of Oscillating System

Amplitude (A)

- This is the maximum displacement of an oscillating system from the equilibrium position. Amplitude is measured in mm, cm or m. This is the distance (A) as shown in the graph:

Amplitude (A) cont'd



Frequency (f)

- This is the number of cycles completed in one second by an oscillating system
- $$\text{Frequency (f)} = \frac{\text{Number of oscillations (n)}}{\text{Total time (t)}}$$
- The scientific unit of frequency is Hertz (Hz) and is equal to one cycle per second.

Period (T)

- This is the time taken for a system to perform one complete oscillation.

- $$\text{Period (T)} = \frac{\text{Total time taken (t)}}{\text{Number of complete oscillations (n)}}$$

Relationship between f and T

- Note $T = t/n$ and

  $f = n/t$

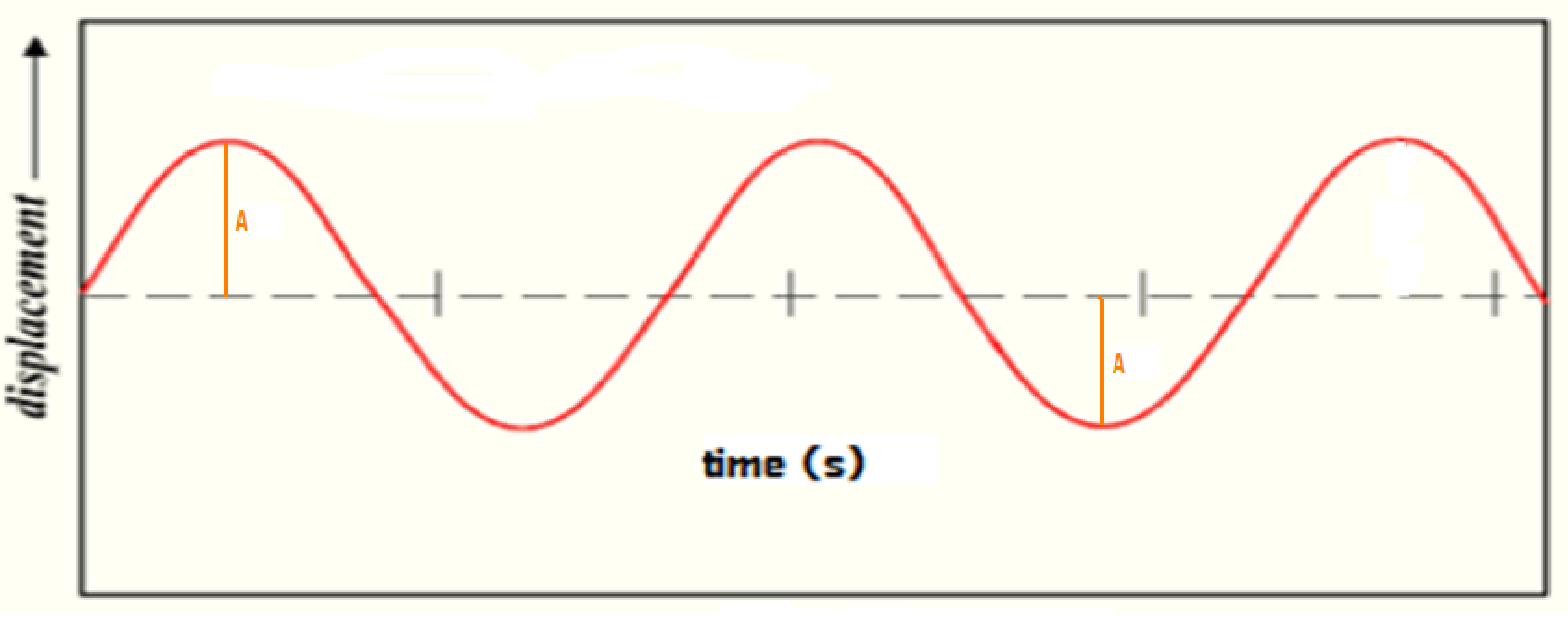
- Hence the relationship between Frequency (f) and Period (T) is:

$$f = 1/T \quad \text{or} \quad T = 1/f$$

Ideal Oscillations

- These are perfect oscillations where by both potential energy (PE) and kinetic energy (KE) are conserved. (No energy is lost). The amplitude (A) of the oscillation remains constant as in the figure below:

Shape of Ideal Oscillation



Ideal Oscillation

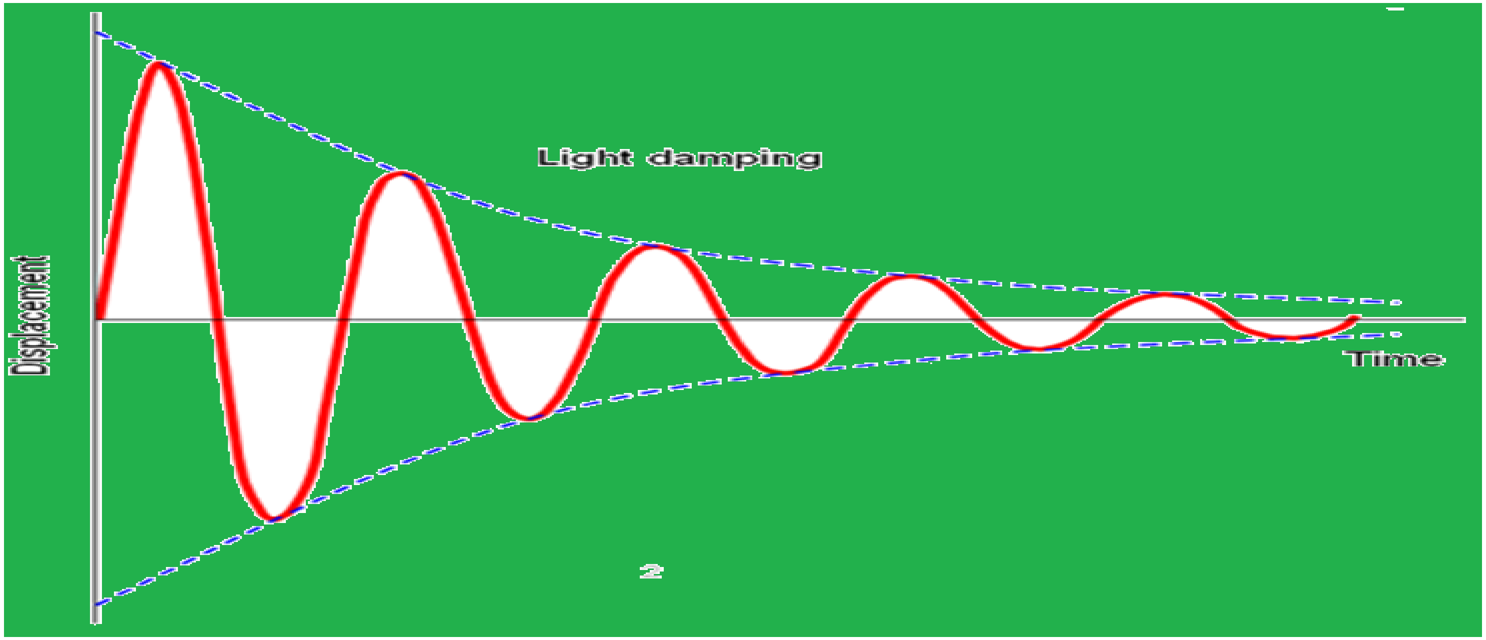
Ideal oscillations cannot be achieved due:

- Air resistance
- Friction at the pivot and where the bob is connected to the string

Damped/Real Oscillations

- These are oscillations where by both potential and kinetic energies are not conserved. There is energy loss due to friction. The amplitude (A) of the oscillating system decreases with time as shown in the figure below:

Graph of Damped Oscillation



ACTIVITY 2: What is the effect of length of pendulum on the frequency (f)?

- Design and conduct an investigation that will help you to answer the problem above. In your design, include the materials to be used and the steps to be followed in carrying out the investigation.

Effect of length on the frequency

- As the length increases, the height through which the bob moves decreases. Hence potential energy (PE) will decrease, so also kinetic energy (KE) decreases. Velocity therefore decreases. As velocity decreases, periodic time (time taken for one complete oscillation) will increase hence decreasing the frequency.
- As the length decreases, the height through which the bob moves increases. Hence potential energy (PE) will increase, so also kinetic energy (KE) increases. Velocity therefore increases. As velocity increases, periodic time (time taken for one complete oscillation) will decrease hence increasing the frequency.

Factors Affecting Frequency of Oscillating Systems

Oscillating system	Factors affecting frequency(f)
Spiral spring	• mass on the spring • force constant of the spring (material)
Pendulum	• length of pendulum • material of pendulum • considerable amplitude change
Cantilever	• mass on the end • length of cantilever • material of cantilever

Waves

Introduction

- Energy can be sent from one place to another by means of waves. In every case, the waves travel from a source to detector or receiver. Some examples of waves include sound, light, radio waves e.t.c. Sound can be received by ears or by microphones. Radio waves can be received by aerial attached to the radio receiver.

Definition of a Wave

- A wave can be defined as a disturbance which carries energy from one place to another without transferring of matter.

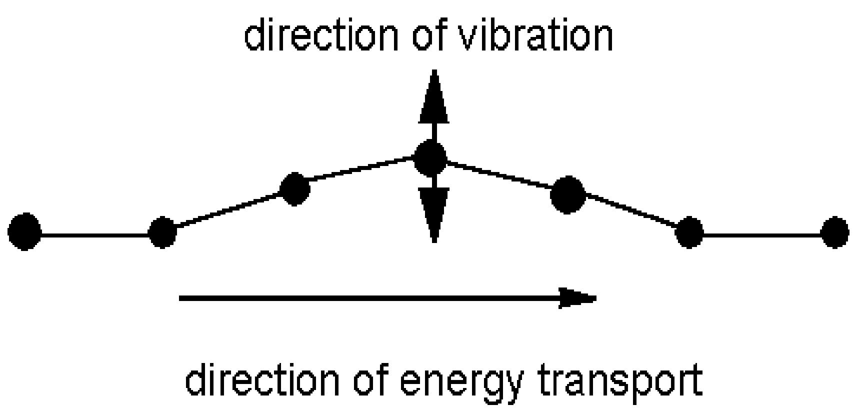
- A wave is a disturbance which travels through a medium, transporting energy from one location (its source) to another location without transporting matter. Each individual particle of the medium is temporarily displaced and then returns to its original equilibrium positioned.

- If a wave is travelling through a medium, the particles of the medium do not move along with it. They vibrate about their equilibrium position, and the energy is transmitted through the interaction of neighboring particles.

Types of Waves

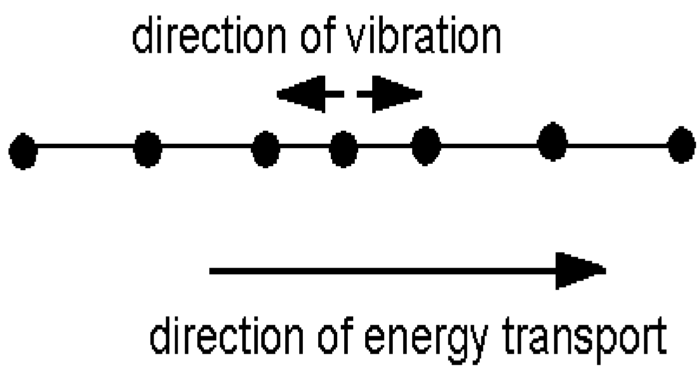
Transverse Wave

- Transverse wave is a wave in which particles vibrate perpendicular to the direction of the wave e.g. water wave



Longitudinal Wave:

- Longitudinal wave is a wave in which the particles vibrate along or parallel to direction of travel of the wave e.g. sound wave



Characteristics of a Wave

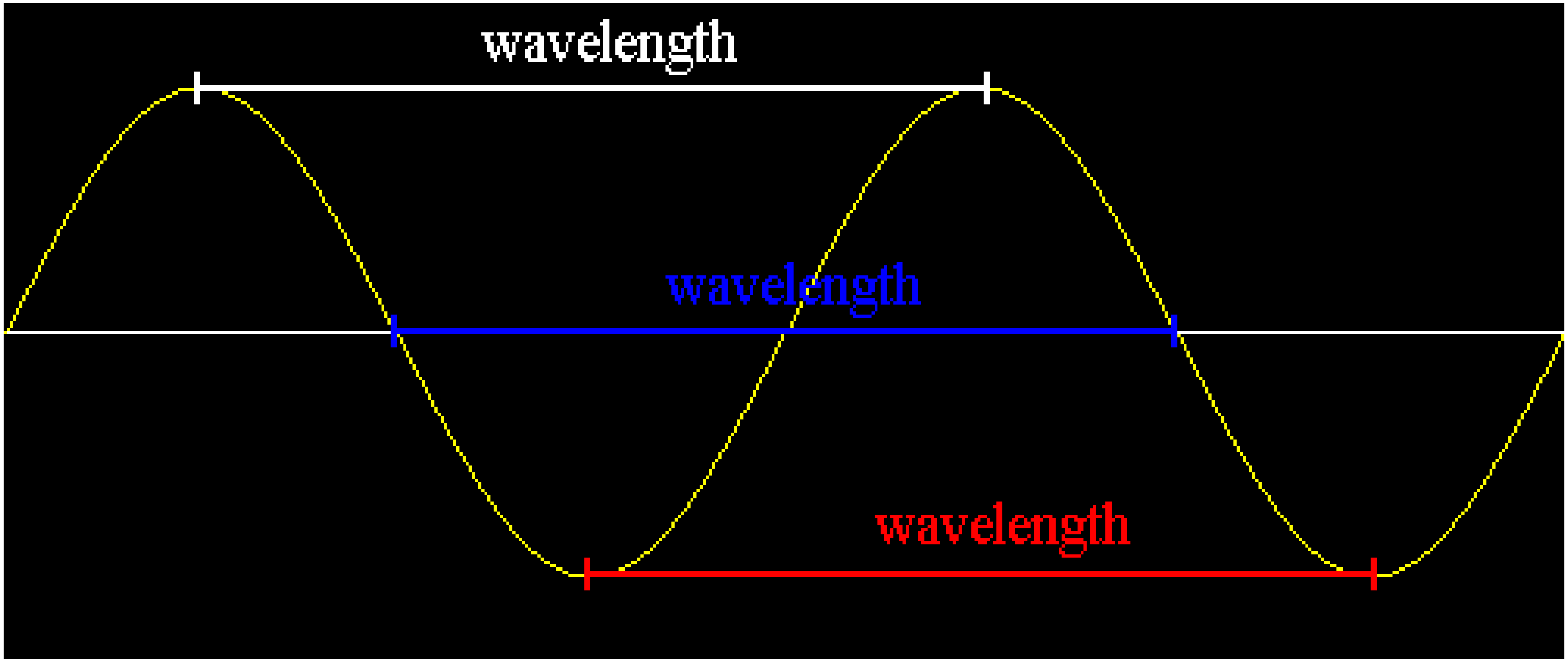
a) Frequency (f)

- This is the number of waves produced per second and it is measured in Hertz (Hz) or number of complete waves that pass a point per second

b) Wavelength (λ)

- Wavelength is the distance occupied by one complete wave or it is distance between two successive crests or troughs. It is measured in metres or centimetres.

Characteristics of a Wave cont'd



Characteristics of a Wave cont'd

c) Amplitude (A)

- This is the maximum displacement of a point from its rest position. Amplitude is measured in centimetres or metres.

d) Velocity

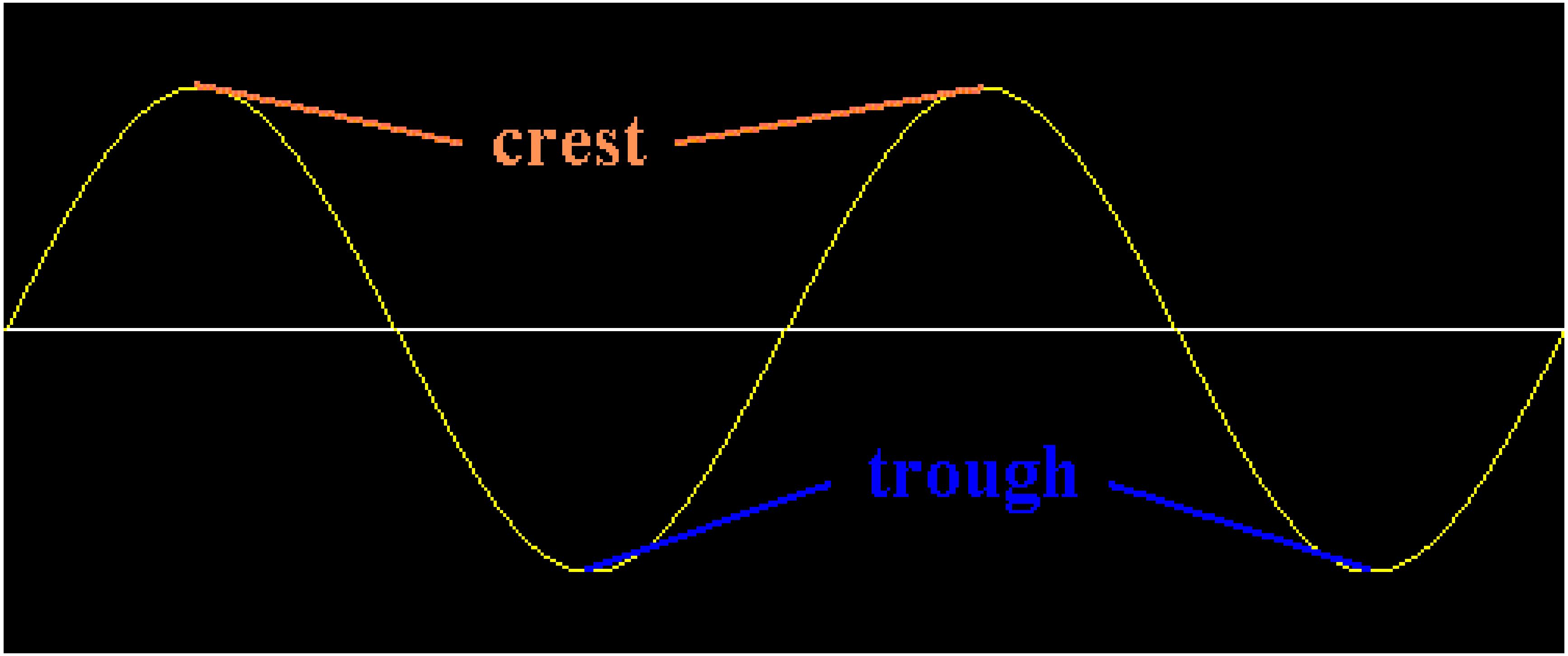
- Distance moved by a crest or any point on the wave in one second

NOTE:

Crest: This is the hill-like part of the wave

Trough: This is a hollow-like shape of the wave

Characteristics of a Wave cont'd

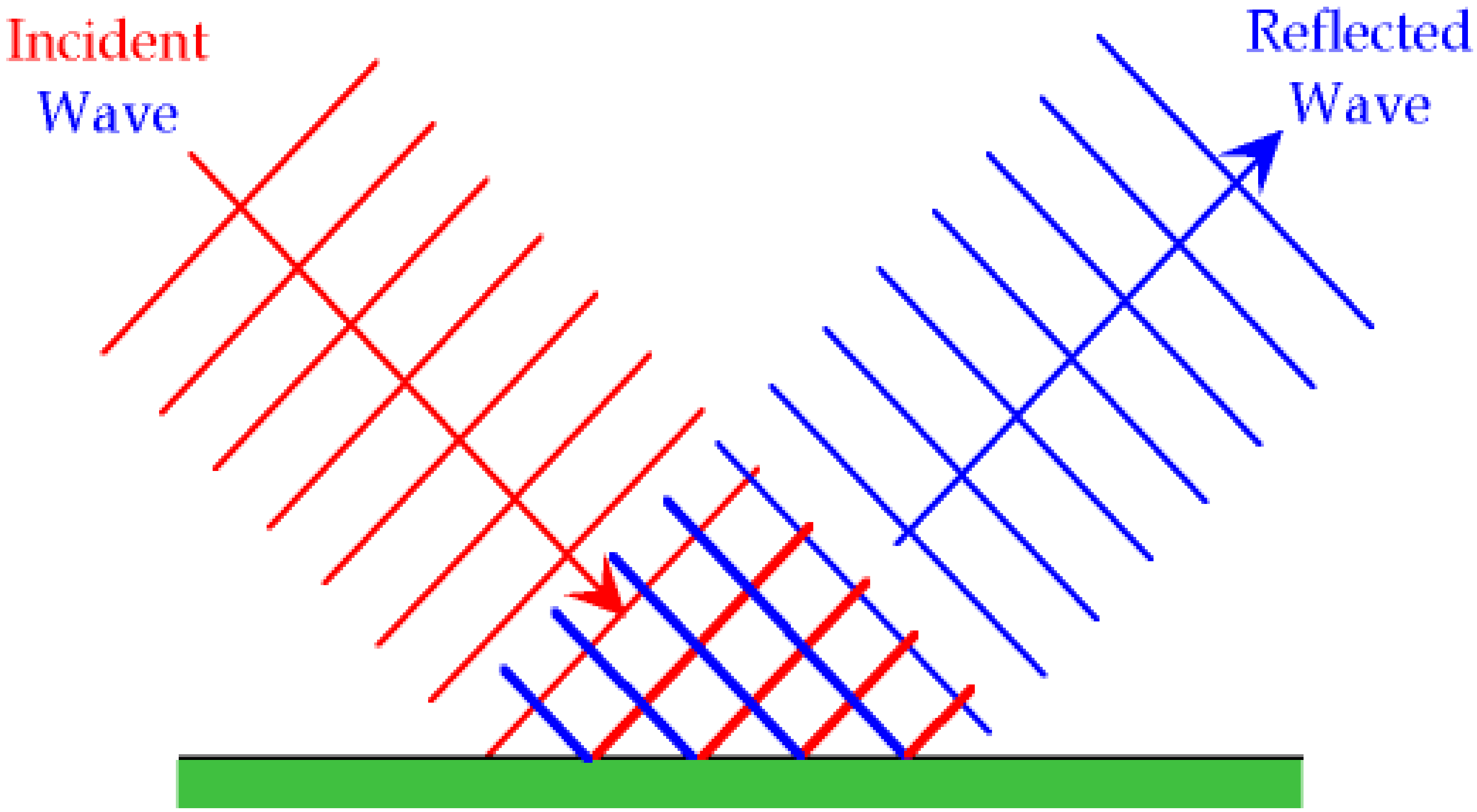


Properties of a Wave

Reflection of a Wave

- This is the sending back or bouncing back of a wave.
- Waves like those of water and light are reflected (sent back) when an obstacle is placed in front of their path.

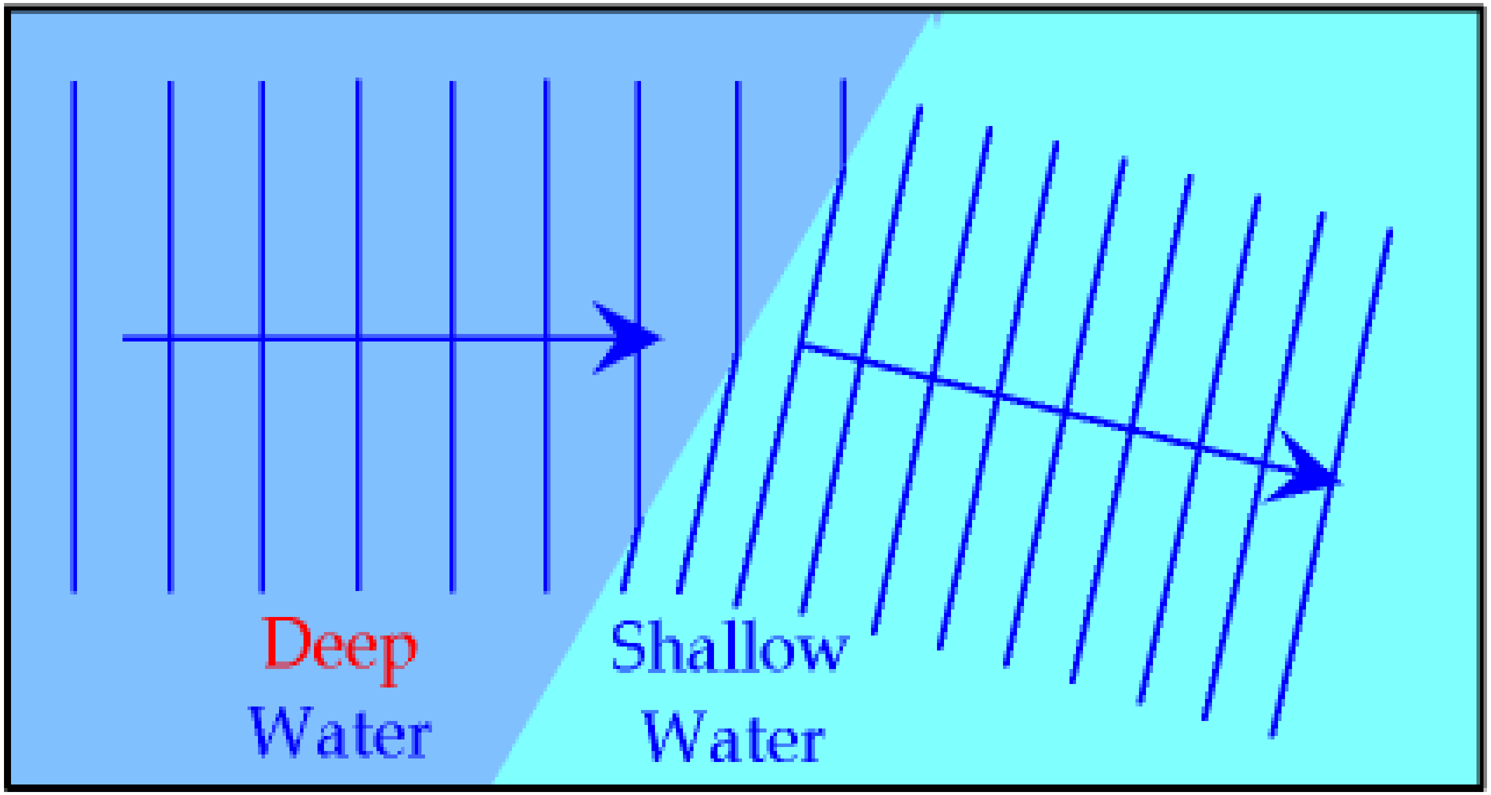
Reflection of a Wave



Refraction of a Wave

- This is the sudden change of direction of a wave.
- The change of direction of propagation of any wave phenomenon which occurs when the wave velocity changes.

Refraction of a Wave cont'd

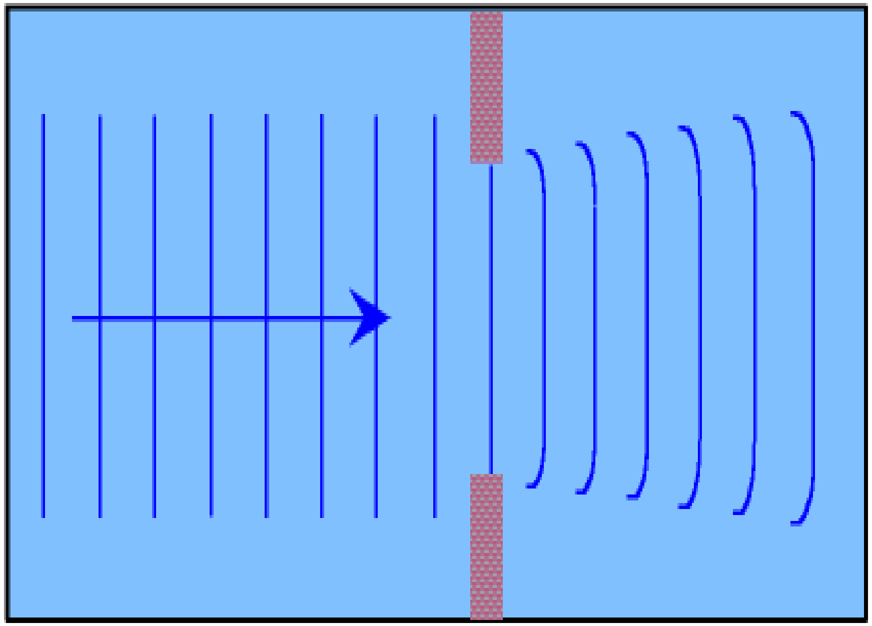


Diffraction of a Wave

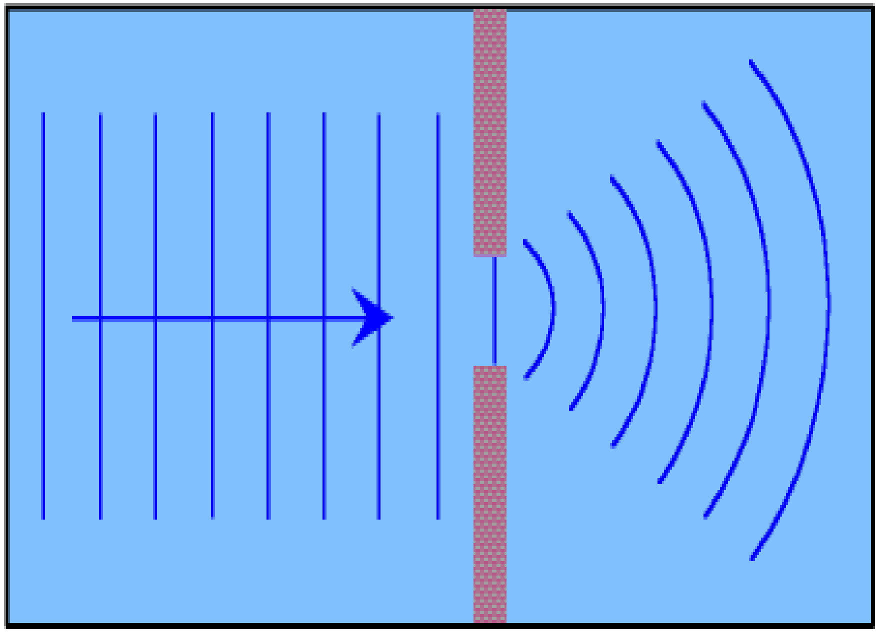
- Diffraction is the bending of waves as they pass through a gap. Waves passing through the gap spread out in all direction

Diffraction of a Wave cont'd

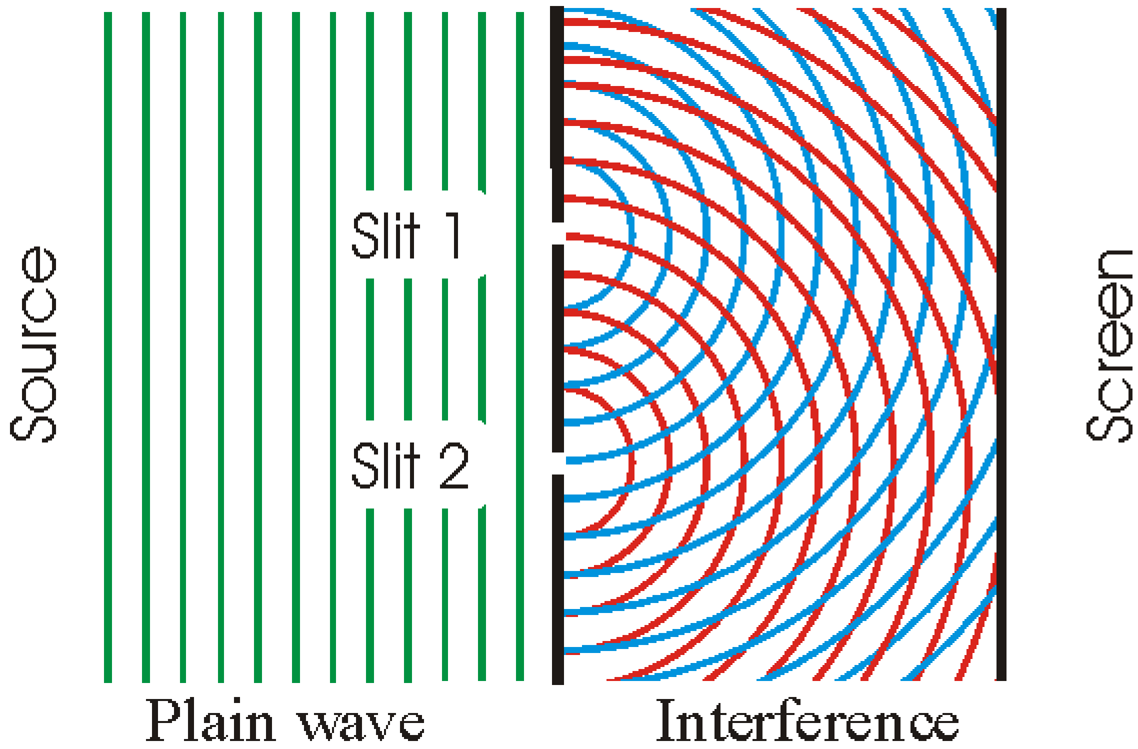
Wider Gap



Small Gap



Interference of Waves cont'd



Activity 3: Demonstration of Interference of sound waves

Materials:

- 3 empty glass bottle i.e. fanta or coke.
- Water.

Procedure:

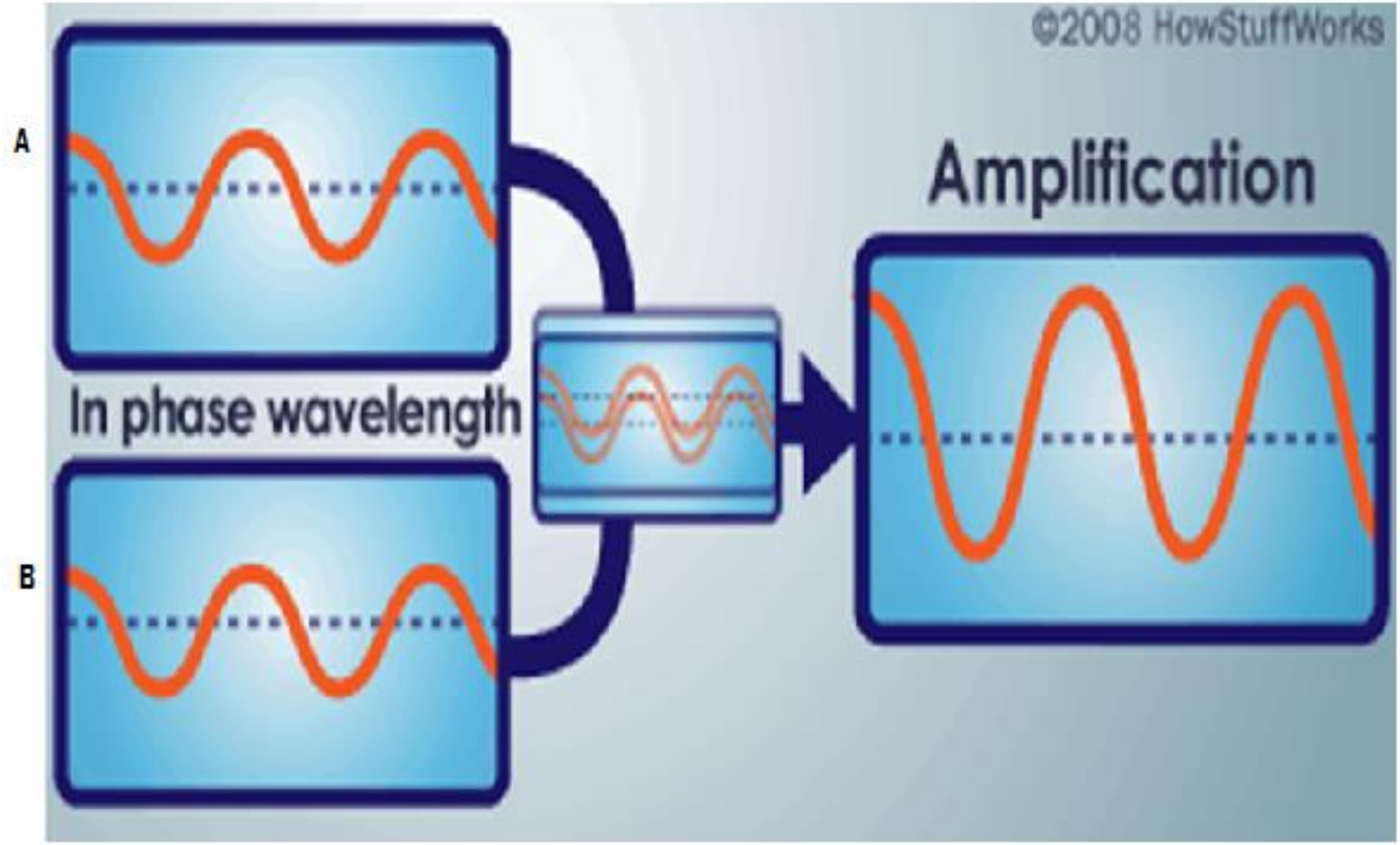
- Pour a little amount of water into the bottles.
- Let one participant blow one bottle and note the sound.
- Let three participants blow the three bottles at the same time.
- Discuss the difference in the quality of sound.

Types of Interferences

Constructive Interference

- When the crest of one wave passes through, or is superpositioned upon, the crest of another wave, we say that the waves constructively interfere.
- Constructive interference also occurs when the trough of one wave is superpositioned upon the trough of another wave. In the diagram below two waves, A and B, reinforce each other.

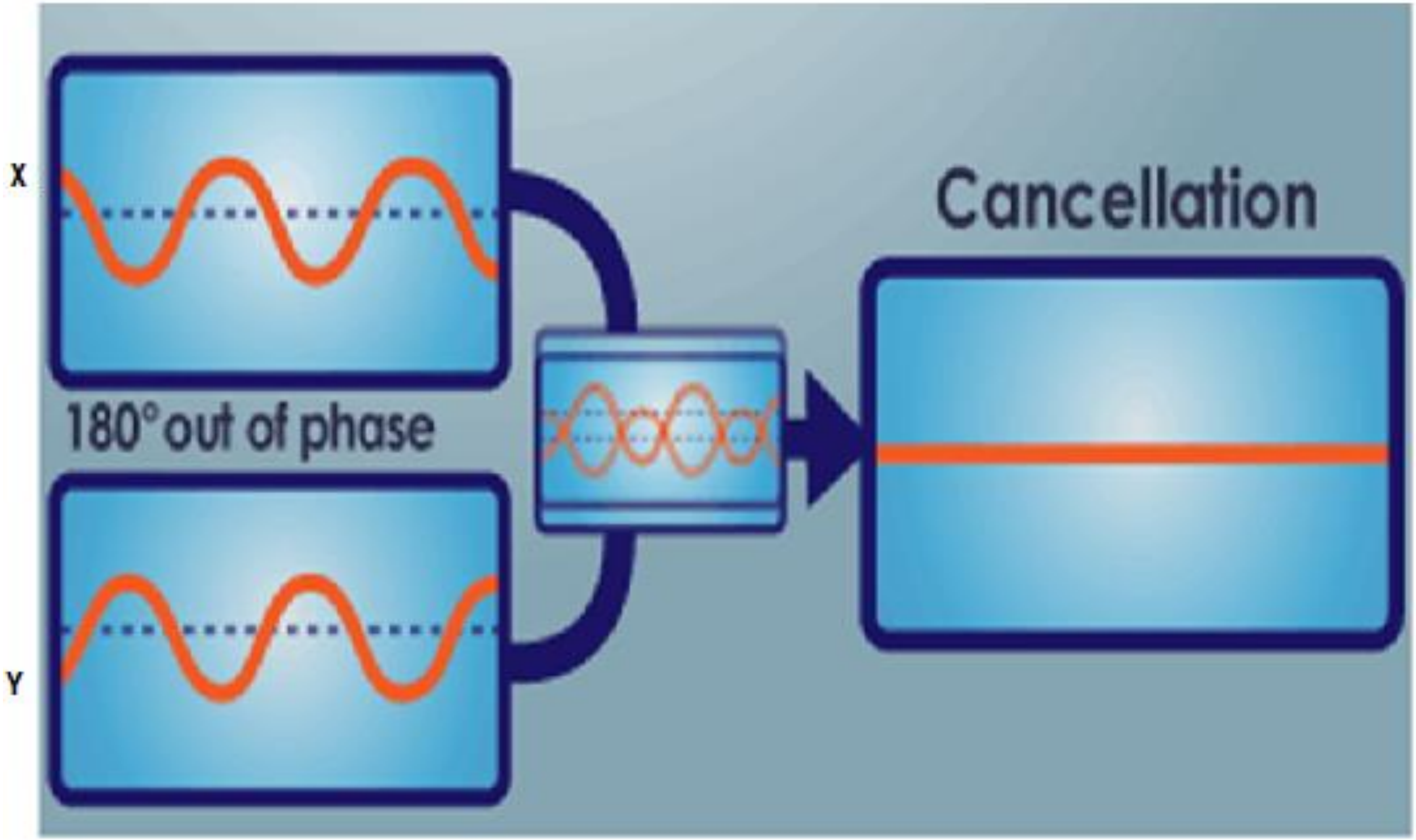
Constructive Interference



Destructive Interference

- When the crest of one wave passes through, or is superpositioned upon, the trough of another wave, we say that the waves destructively interfere.
- In the diagram below two waves, X and Y, destructively interfere and result in total cancellation.

Destructive Interference cont'd



Electromagnetic versus Mechanical Waves

- Another way to categorize waves is on the basis of their ability or inability to transmit energy through a vacuum (i.e., empty space).

Electromagnetic Waves

- An **electromagnetic wave** is a wave which is capable of transmitting its energy through a vacuum (i.e., empty space). Electromagnetic waves are produced by the vibration of charged particles.
- Light waves, microwave, x-rays and TV and Radio transmissions are all examples of electromagnetic waves (light waves from the sun travel through the vacuum to reach the earth).

Mechanical Waves

- A **mechanical wave** is a wave which is capable of transmitting its energy through a medium only. Mechanical waves require a medium in order to transport their energy from one location to another. E.g. sound waves, water waves etc

Wave Equation

- This equation shows the relationship of wave speed (v), frequency (f) and wavelength (λ). It states that: Wavespeed (v) = frequency (f) $\times$ Wavelength (λ),

$$v = f\,\lambda$$

NOTE: distance (d) = speed (v) $\times$ time (t)

$$d = v \times t$$

But $\quad d = \lambda$

Therefore $\lambda = v \times t$

Since $t = 1/f$

Then $\lambda = v/f$

Hence $v = f \times \lambda$

Light

Definition

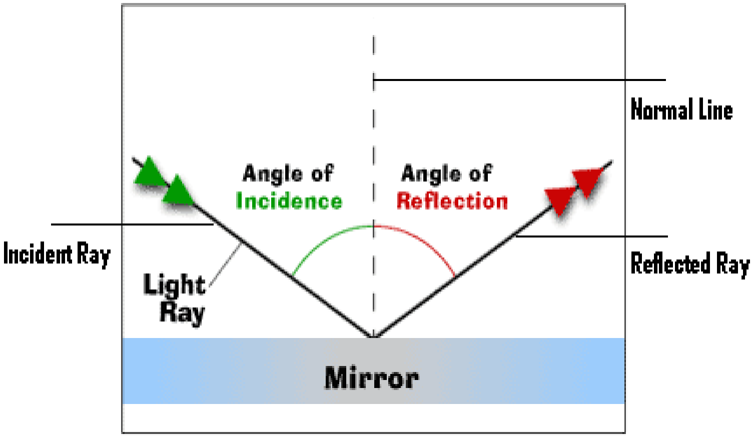
- A form of energy

Properties of Light

Reflection of Light

- Sending back of light.
- This is done when a ray of light strikes a plane surface. The light is reflected back at the same angle as the incident ray.

Reflection of Light

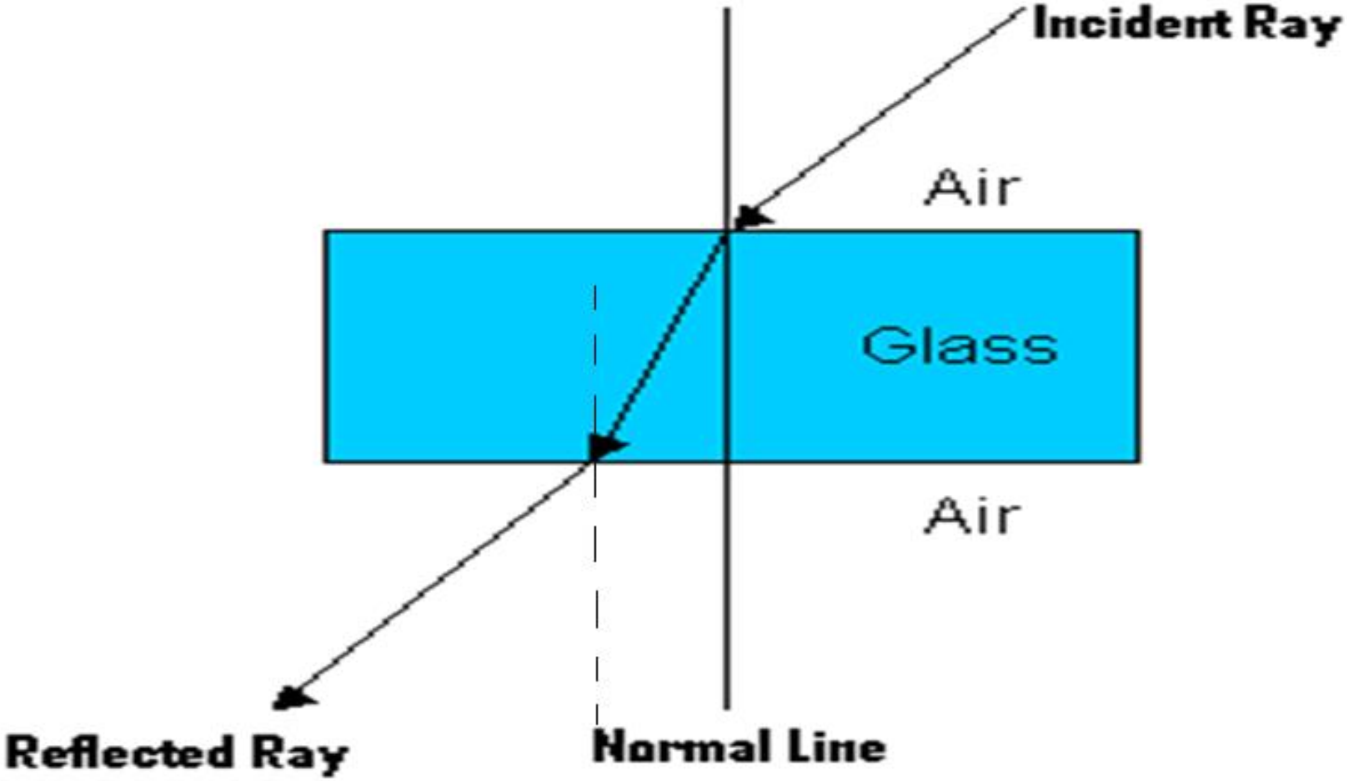


- **Incident Ray**: This is the incoming ray
- **Reflected Ray**: This is the outgoing ray
- **Normal Line**: This is the imaginary line that is perpendicular to the front surface of the mirror.
- **Angle of Incidence, (i)**: The angle made between the incident ray and the normal line
- **Angle of Reflection, (r)**: The angle made between the reflected ray and the normal line

Refraction of Light

- Sudden change of direction of light when it passes from one medium to another e.g. from air to water.
- The ray refracts towards the normal line when entering a denser medium and away from normal line when going into a less dense medium.

Refraction of Light cont'd



Activity 4: Sticks in water

Materials:

- Small sticks, transparent container or tins and water.

Procedure:

- Pour water into the tin or container
- Dip in the stick at an angle and observe shape of the stick.

Observation:

- The stick will appear to be bent although it is straight.

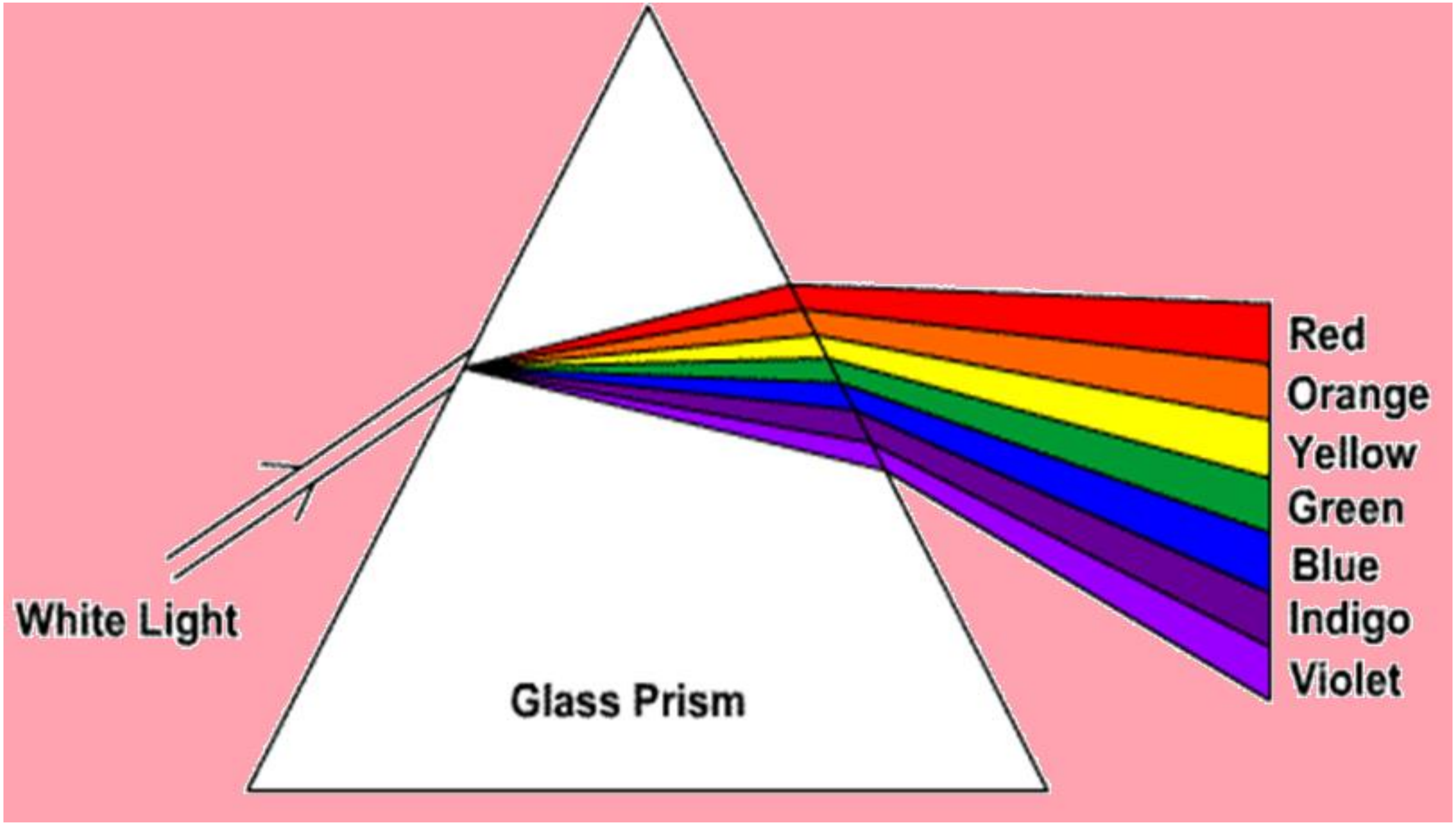
Explanation:

- Light is being refracted since it is changing the medium of travel.

Dispersion of Light

- Splitting up of white light into different colours of the spectrum after passing through a prism.

Dispersion of Light cont'd



Activity 5: Splitting light into different colours

Materials:

- Ball pen stems, surf, water, container

Procedure:

- Dissolve the surf in water
- Suck the solution in the pen stem and blow to make bubbles.
- Observe the colours of the spectrum on the surfaces of the bubbles

Observation:

- There is a spectrum formed on the bubbles

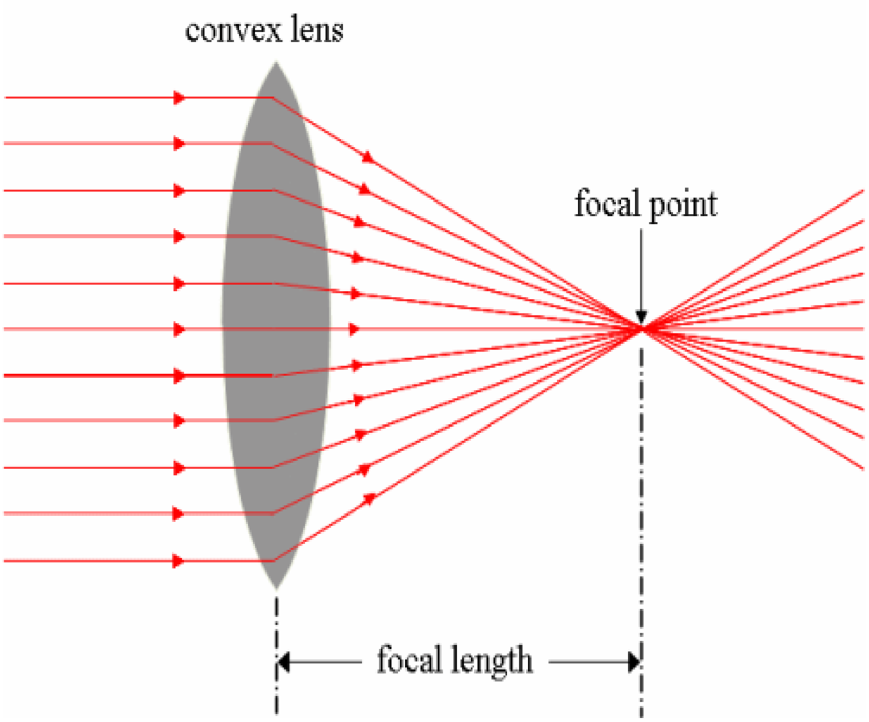
Explanation:

- The shape of the bubbles is slightly similar to the shape of a prism and this disperses the white light.

Lenses

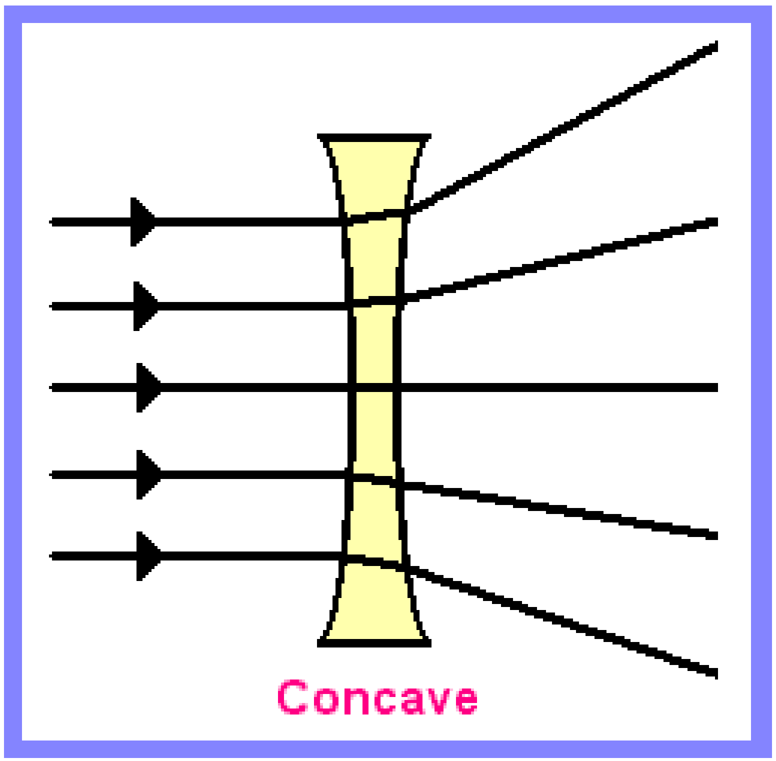
- A lens is a transparent material that can converge or diverge light, such as a glass, and has either one curved surface and one flat surface or two curved surfaces.
- A Lens allow light to pass through it.
- Lenses are either convex or concave

Convex Lenses (Converging Lens)



- When parallel light rays pass through these lenses they are refracted. The rays are refracted through a point on the other side of lens. The point is called the focal point.

Concave Lenses (Diverging Lens)



- In concave lenses the rays are refracted away from each other and only pass through a focal point on the same side when the refracted rays are produced backwards.

Terminologies used in Optics

PRINCIPAL AXIS (P.A)

- An imaginary line that passes through centre of lens and at right angles to it.

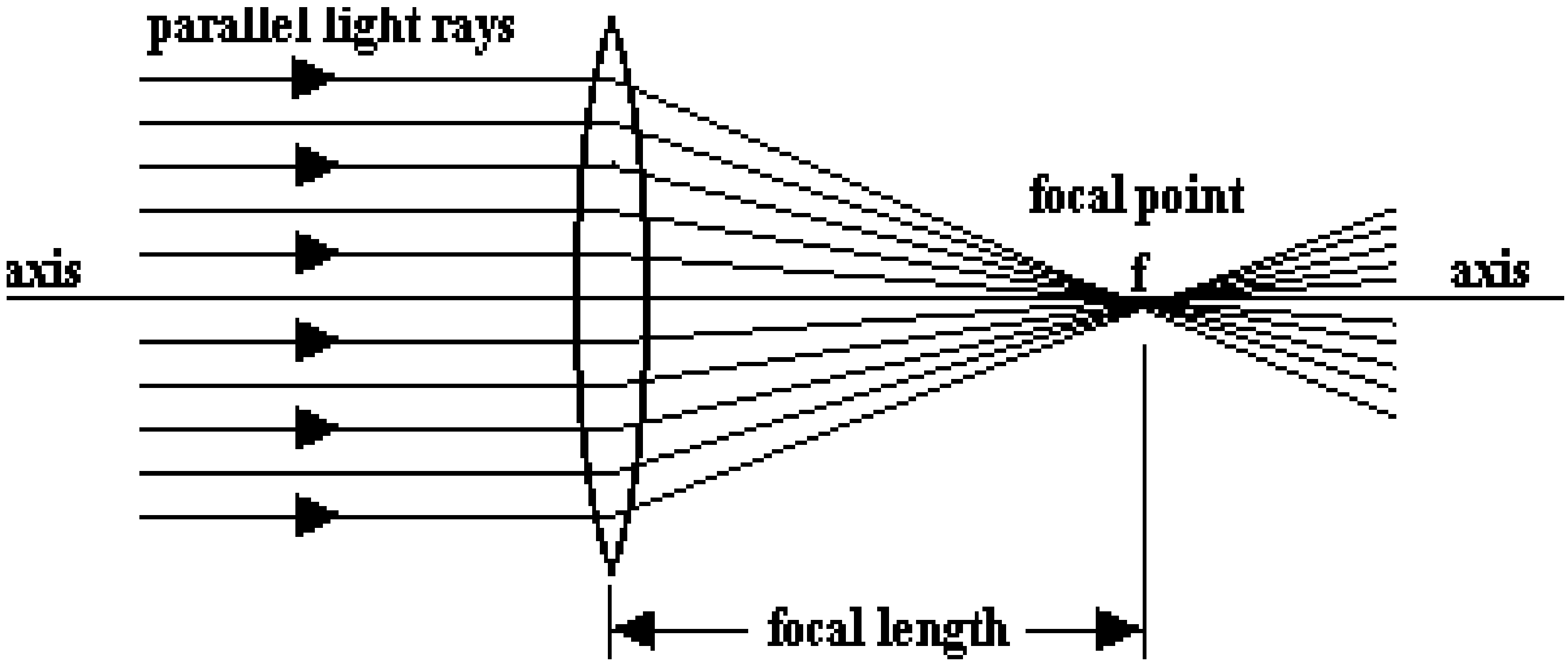
FOCAL POINT (PRINCIPAL FOCUS)

- The focal point of a convex lens is the point where light rays parallel to the axis are brought to a point.

FOCAL LENGTH (f)

- Distance between centres of the lens and focal point

Terminologies used in Optics cont'd



Terminologies used in Optics cont'd

FOCAL PLANE

- A plane passing through the focal point where an image is produced.

IMAGE DISTANCE (v)

- Distance between mid plane of lens and image.

OBJECT DISTANCE (u)

- Distance between mid plane of lens and object

Image Formation (Ray Diagrams)

Construction rays used for image formation in a Ray Diagram;

- **Principal Ray:** A ray parallel to the PA refracted through F on the other side of converging lens.
- **Central Ray:** A ray passing through the centre of lens and is not refracted.
- **Focal Ray:** A ray passing through F and is refracted parallel to the principal axis on the other side of the lens.

Image Formation(Ray Diagrams) cont'd

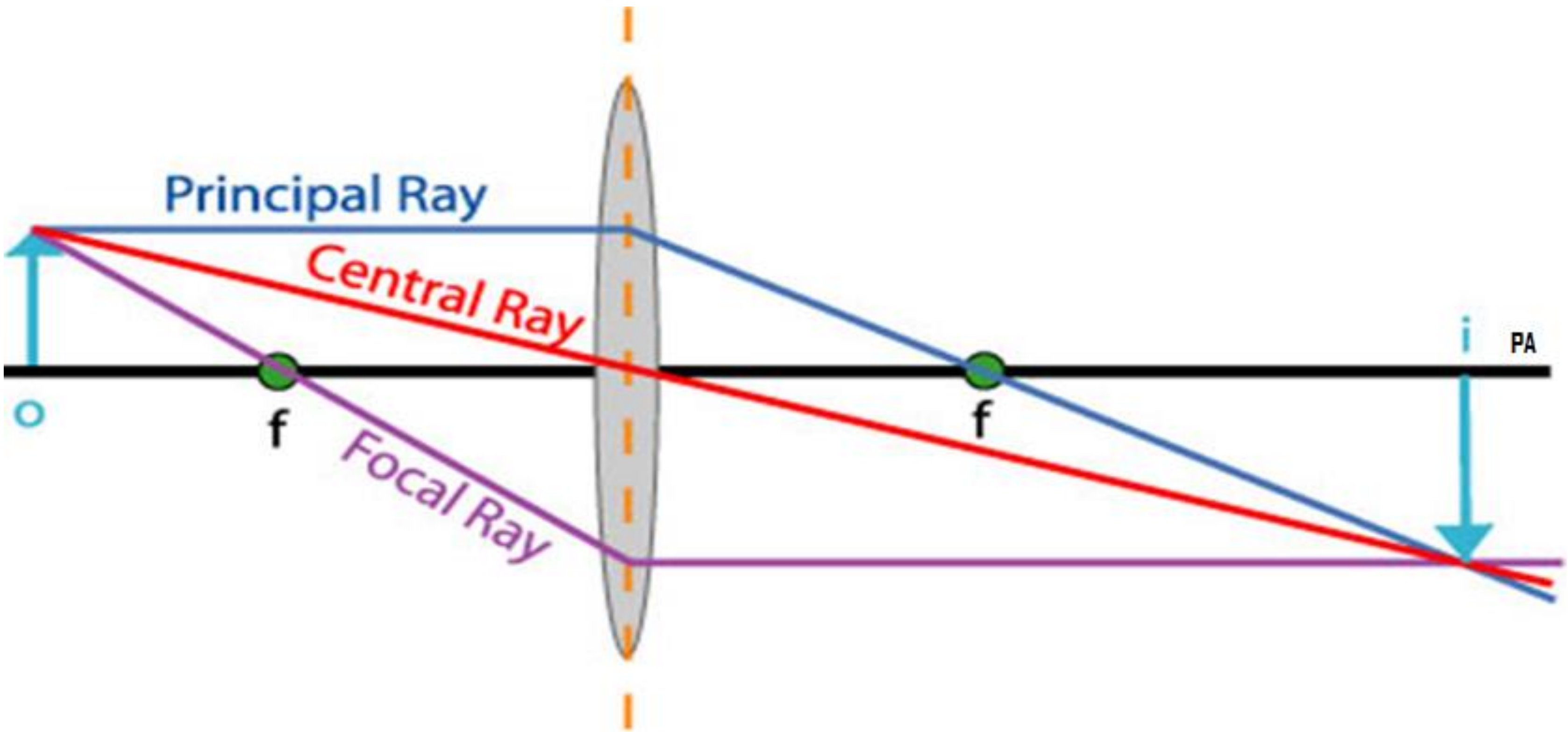


Image Formation(Ray Diagrams) cont'd

- All rays always start from the same point

- A combination of any 2 of the three will give us position of image.

Image Formation(Ray Diagrams) cont'd

The images formed from objects which are placed at different object distances have different characteristics. The following 3 characteristics show the nature of the image produced depending on the object distance.

- Upright or upside down
- Real or virtual
- Magnified or diminished

Activity 6: To locate position of Image

Materials

- Chart paper, markers, 1 metre rule

Procedure

- In groups participants draw ray diagram of focal length 15cm to locate position and nature of image. The object distance will be different in the different groups. i.e. at 10cm, 15cm,25cm,30cm and 40cm. Object height should be 7cm.

Lens Formula

- Another way of determining u, v and f is by using the Lens formula. This formula helps in solving problems without drawing ray diagrams.

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

Where u = Object distance

v = Image distance

f = focal length

Magnification

- This is the comparison of the image formed to the object and can be calculated using the following relationship.

- **Magnification, m, =** $\dfrac{\text{Image distance}(v)}{\text{Object distance}(u)}$

- The table summarises the relationship between object distance, image distance and nature of the image formed

Magnification cont'd

OBJECT DISTANCE(u)	IMAGE DISTANCE(v)	NATURE OF IMAGE
1. Infinity	F	Real, Upside down, Diminished
2. After 2F	Between F and 2F	Real, Upside down, Diminished
3. At 2F	At 2F	Real, Upside down, same size as the object
4. Between F and 2F	After 2F	Real, Upside down, magnified
5. At F	Infinity	Real, Upside down, Magnified
6. Within F	On same side of lens	Virtual, Upright, Magnified

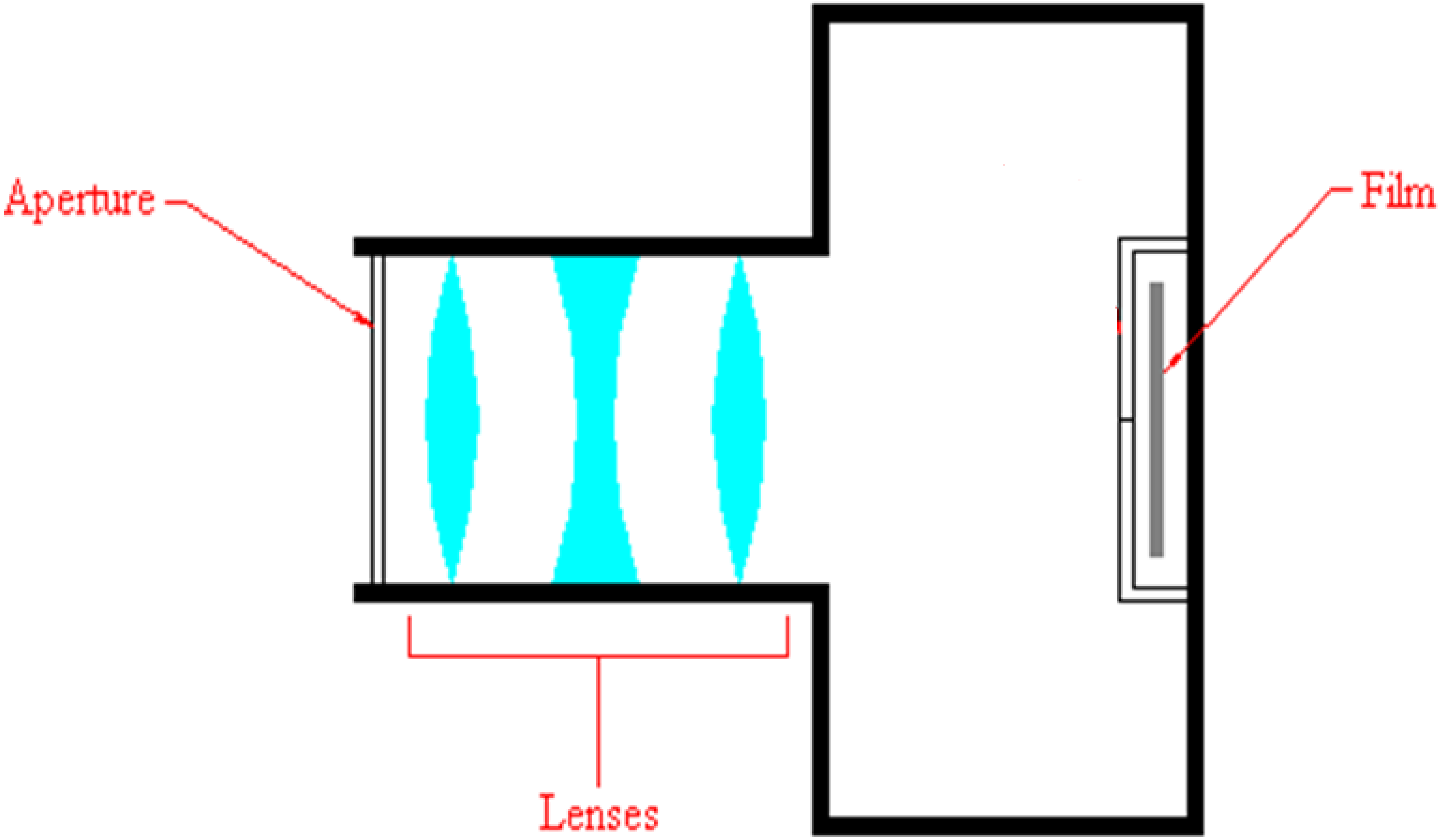
Example

- Find the focal length of a lens that will have an image produced at 12cm when the object distance is 6cm.

Optical Instruments

- Optical instruments are those that use light in their operations.

Simple Camera



Parts and Functions a Camera

Film:

- Where an image is produced

Lens:

- To converge the light rays to the film

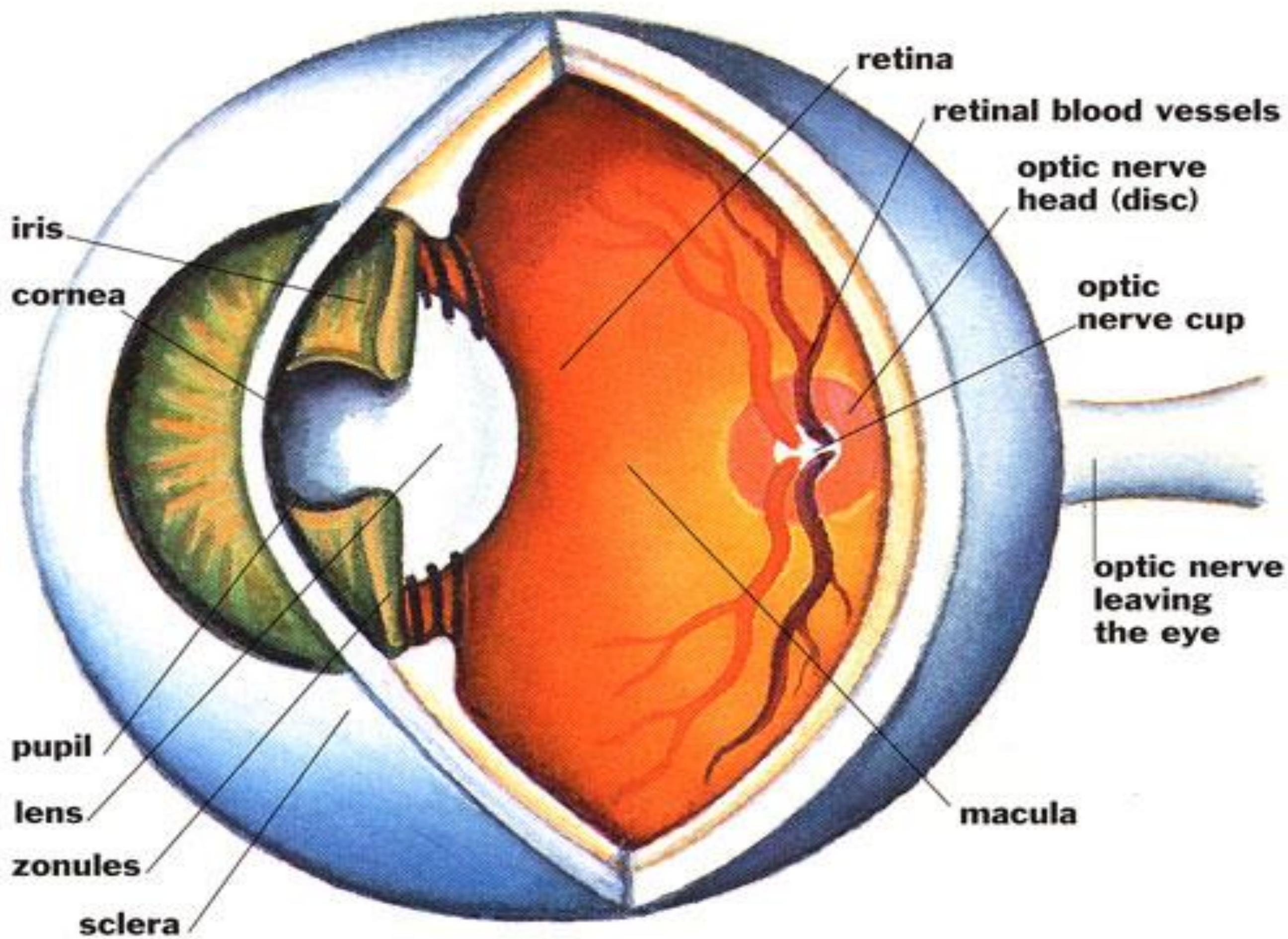
Diaphragm:

- To control the amount of light entering the camera.

Aperture:

- To allow light enter the camera

The Eye


retina
retinal blood vessels
optic nerve
head (disc)
iris
cornea
optic
nerve cup
optic nerve
leaving
the eye
pupil
lens
zonules
sclera
macula

Parts and Functions of an Eye

Retina:

- Where an image is produced.

Lens:

- To converge the light rays onto the retina.

Iris:

- To control the amount of light entering the eye.

Pupil:

- To allow light enter the eye

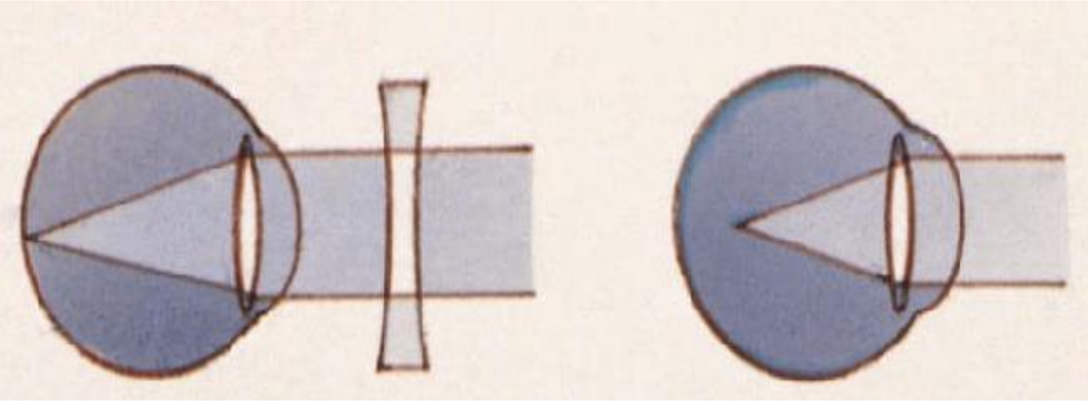
Accommodation

- This is the ability of the eye to focus near and distant objects onto the retina. The lens in the eye changes its shape depending on the object distance in order to have a clear sharp image produced on the retina. Sometimes the eye fails to focus clear images. When this happens, the defect must be corrected.

Defects of the Eye

SHORT SIGHT (MYOPIA)

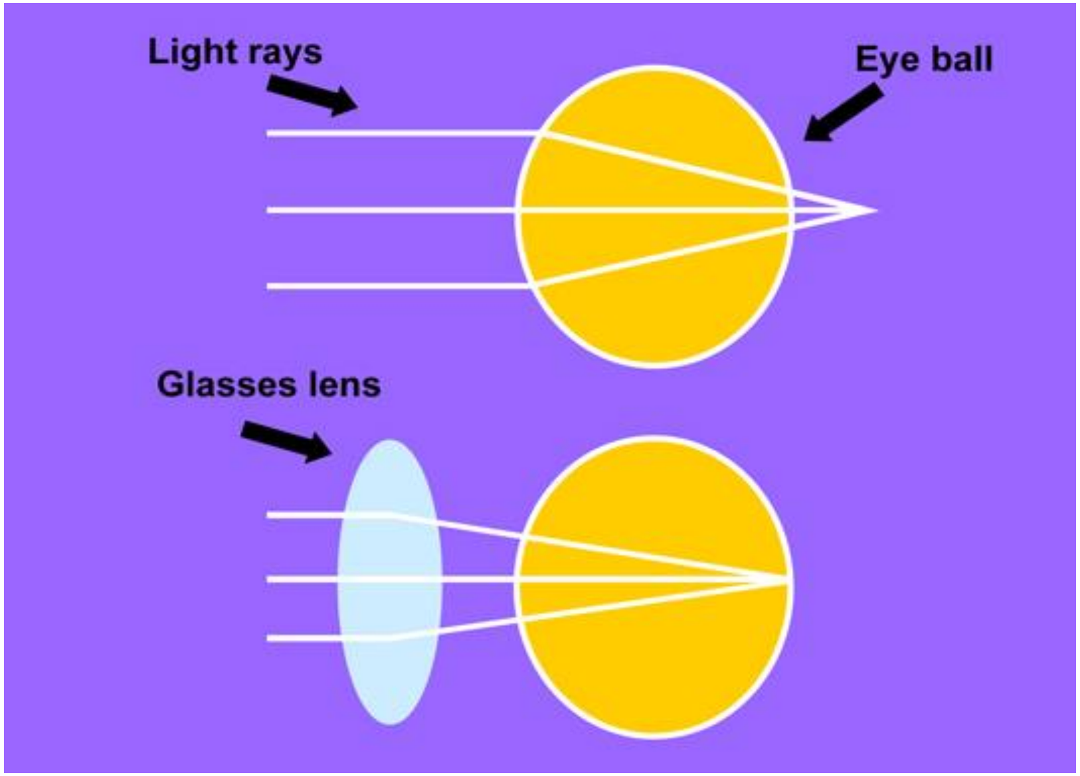
- A short-sighted person sees near objects clearly but cannot see distant objects clearly. The image of a distant object is formed in front of the retina because the lens cannot be made thin enough. This defect can be corrected by using a CONCAVE lens which diverges the light before it enters the eye. The lens in the eye then converges the rays onto the retina.



Defects of the Eye cont'd

LONG SIGHT (HYPERMETROPIA)

- A long sighted person sees distant objects clearly but does not see near objects clearly. The image of a near object is focussed behind the retina because the eyeball is too short or because the lens cannot be made thick enough. This defect can be corrected by using a CONVEX lens which converges the rays before entering the eye. The lens in the eye then converges the rays further onto the retina



Activity 7: Designing Activity Sheet

- In groups, select any concept from the just covered topic (oscillations and waves). From the selected concept, formulate a problem and design activity sheet that the learners may use to solve the problem. The activity sheet should be formulated in a way that it can enhance scientific skills in the learners.

Conclusion

- The topic on oscillation and waves has quite a lot of concepts, some of which have been discussed in this paper. Characteristics of waves and oscillations as well as Light have been well explained and there is all the hope that participants have grasped what this write-up was meant to address. More activities on this topic can be developed by participants when they get back to their schools. Participants are discouraged to use this for teaching rather to be used as a guide.