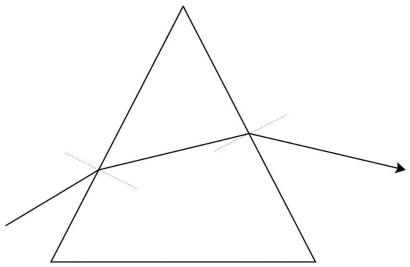
Chapter 3

THE WORLD OF COLOURS AND VISION

REFRACTION THROUGH A GLASS PRISM

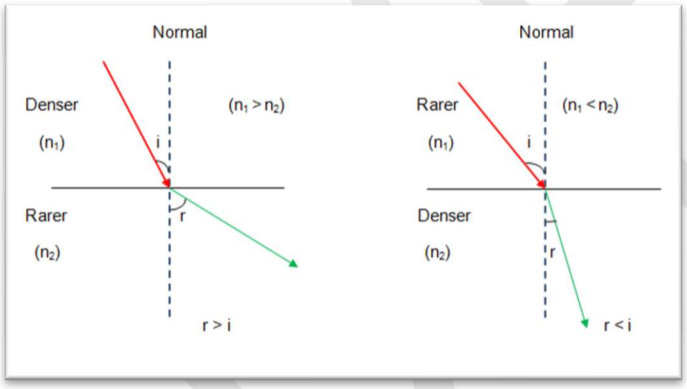
When light ray enters and leaves a prism, it deviates towards the base of the prism due to refraction.



WHAT ARE THE FACTORS ON WHICH THE DEVIATION OF A RAY OF LIGHT DEPEND?

- Refractive index of the medium
- Wavelength of the colour of light

DISPERSION OF LIGHT



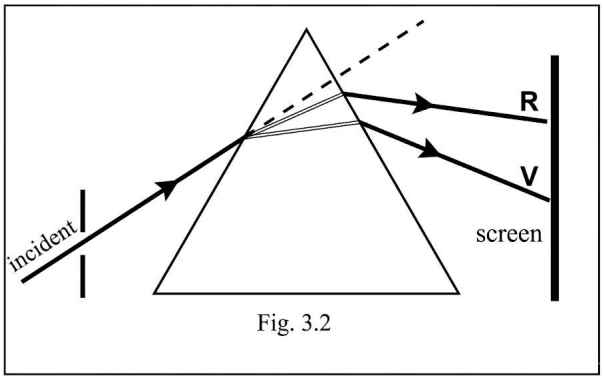


Fig. 3.2

The splitting of composite light into its component colours is called dispersion.

Light composed of different colours is a composite light.

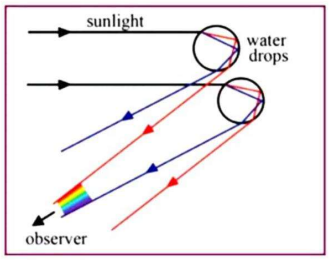
The band of the coloured components of a light beam is called its spectrum.

Different colours of light bend through different angles with respect to the incident ray, as they pass through a prism. The red light bends the least while the violet the most.

Red light bends the least because it has a longer wavelength.

Violet light bends the most because it has a shorter wavelength.

RAINBOW



A rainbow is a natural spectrum appearing in the sky after a rain shower.

It is caused by dispersion of sunlight by tiny water droplets, present in the atmosphere.

A rainbow is always formed in a direction opposite to that of the Sun.

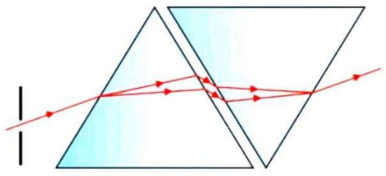
The water droplets act like small prisms. They refract and disperse the incident sunlight, then reflect it internally, and finally refract it again when it comes out of the raindrop.

Due to the dispersion of light and internal reflection, different colours reach the observer's eye.

A ray of sunlight passing through a water droplet undergoes refraction twice and internal reflection once.

RECOMBINATION OF COLOURS OF LIGHT

The rays of different colours from the first prism undergo a deviation in the opposite direction by the second prism. This results in the recombination of colours to produce white light on the wall.



SUNLIGHT

Sunlight consists of infrared, ultraviolet, and visible light.

Heat from Sunlight:

The infrared radiation is mainly responsible for the heat in sunlight.

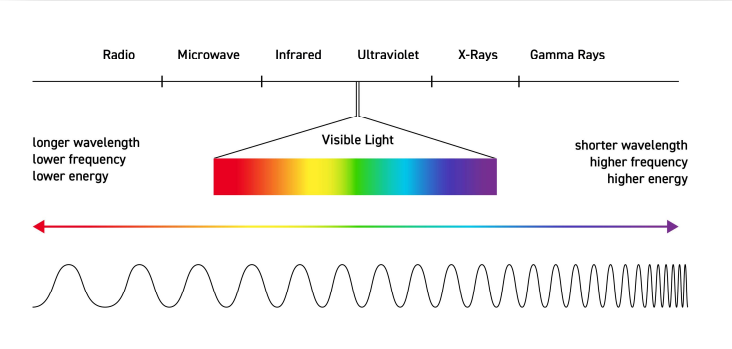
Ultraviolet Radiation Function:

Ultraviolet (UV) rays help the body produce vitamin D.

Light travel through vacuum at a speed of 300,000 kilometre per second (3 x 10^8 m/s).

ELECTROMAGNETIC SPECTRUM

The orderly distribution of electromagnetic radiations is known as the electromagnetic spectrum.



PRIMARY COLOURS AND SECONDARY COLOURS

Primary Colours

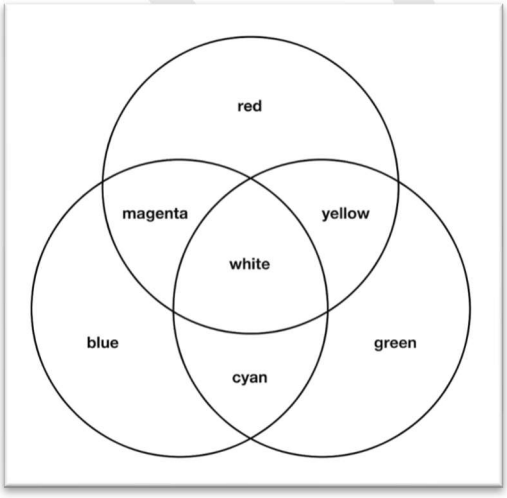
Not only white light, but all other coloured lights can also be created using red, green, and blue lights. Therefore, these colours are called the primary colours

red, green, and blue.

Secondary Colours

The coloured light formed by combining any two primary colours is a secondary colour of light.

Yellow, cyan, magenta.



Color Combination	Resulting Color
Red + Blue	Magenta
Red + Green	Yellow
Blue + Green	Cyan
Red + Blue + Green	White

COMPLEMENTARY COLOURS

When a secondary colour is combined with a primary colour, we get white light. Such pairs of colours are called complementary colours.

Complementary colours are two colours that combine to form white light:

- Red + Cyan = White
- Green + Magenta = White
- Blue + Yellow = White

PERSISTENCE OF VISION

When we quickly remove an object from our field of vision the visual experience of that object persists for about 1/16 of a second. This phenomenon is the persistence of vision.

Eg: Movies (Cinema), Animated Flipbooks, Television Screens, Spinning Wheel with Colours (Newton's Disc).

NEWTON'S COLOUR DISC

When Newton's colour disc is rotated very fast, before the visual experience of any one colour vanishes from the eye, the rays from the succeeding colours reach the eyes in quick succession. Due to the phenomenon of persistence of vision, the combined effect of all the colours persists in our eyes and appears almost white.

COLOUR OF TRANSPARENT OBJECTS

The colour of a transparent object is the colour of the light it transmits.

A transparent object allows light to pass through it.

But it may absorb some wavelengths (colours) and transmit others.

The colour we see is the colour of the light that passes through.

A filter of secondary colour transmits light of its own colour and its component colours.

Transparent Object	Light Falling	Colour Seen (Light Transmitted)
Red glass	White light	Red (Red light)
Green plastic sheet	White light	Green (Green light)
Blue filter	White light	Blue (Blue light)

NOW LET US PASS EACH OF THE PRIMARY COLOURS AND WHITE LIGHT THROUGH A YELLOW FILTER. WHAT DO YOU OBSERVE?

A yellow filter only allows red and green light to pass through because yellow is made by combining red and green. It absorbs blue light.

Light falling on the filter	Colour of light passing through the yellow filter	Explanation
White light	Yellow (red + green)	The filter transmits red and green components and absorbs blue.
Red light	Red	Red passes through, as yellow filter allows red.
Green light	Green	Green passes through, as yellow filter allows green.
Blue light	No light (appears dark)	Blue is absorbed completely by the yellow filter.

Filters transmit only the colour of the filter and its component colours from the white light, and block the other colours.

Colour of opaque objects

The colour of an opaque object is the colour of the light it reflects.

Opaque objects do not allow light to pass through.

They absorb some wavelengths (colours) and reflect others.

The colour we see is the colour of the reflected light.

Colour of opaque object = Colour of reflected light

An opaque object of a secondary colour can reflect light of its colour and its component colours.

Transparent -> transmitted colour

Opaque -> reflected colour

WHITE AND DARK

A surface that reflects all colours will appear white in white light. We know that a surface that absorbs all colours appears dark.

SCATTERING OF LIGHT

Scattering is the irregular and partial directional deviation of light when it encounters particles in a medium.

Scattering depends on:

- Size of particles
- Wavelength of light

Examples:

- The blue colour of the sky
- Colour of water in deep sea
- The reddening of the sun at sunrise and sunset

SCATTERING OF LIGHT AND PARTICLE SIZE

Reaction: When sodium thiosulphate reacts with hydrochloric acid, colloidal sulphur is formed.

Particle Growth: The size of sulphur particles gradually increases during the reaction.

Wavelength and Scattering:

- Shorter wavelengths (violet, indigo, blue) are scattered more.
- Longer wavelengths (like red) are scattered less and travel farther.

Effect of Particle Size:

- Small particles -> More scattering of shorter wavelengths.
- As particles become larger -> Scattering increases overall.
- When particle size becomes larger than light's wavelength -> All colours scatter equally (no colour is scattered more).

TYNDALL EFFECT

Tyndall Effect: The scattering of light by colloidal particles or suspensions, making the path of light visible.

Activity:

- Mix chalk powder in water in a beaker.
- Shine a torch light through it.
- You can see the light beam clearly due to scattering.

Why does this happen?

Chalk powder in water forms a suspension. Light scatters when it hits the tiny particles. This scattered light makes the path of the beam visible.

Daily Life Example:

In winter, light rays passing through tree branches appear clearly due to scattering.

Important Note:

The intensity of scattering increases as the size of the particles increases. Larger particles cause more intense scattering. Hence, the visibility of the light path increases with particle size.

BLUE COLOUR OF THE SKY

Sunlight is made up of different colours (VIBGYOR). When sunlight passes through the atmosphere, it undergoes scattering.

Shorter wavelengths like violet, indigo, and blue are scattered the most. Out of these, blue is scattered more and is also more visible to the human eye.

This scattered blue light reaches our eyes from all directions. Hence, the sky appears blue.

COLOUR OF SETTING AND RISING SUN

During sunrise and sunset, the sun's rays travel a longer distance through the atmosphere to reach us.

As the distance increases, shorter wavelengths (like blue, violet, indigo) undergo more scattering and are scattered away.

Longer wavelengths (like red, orange, yellow) undergo less scattering, so they remain in the light that reaches our eyes. Therefore, the red, yellow, and orange colours become prominent, making the sun appear reddish or orange.

POWER OF ACCOMMODATION OF THE EYE

The ability of the eye to change the curvature of the lens and adjust the focal length so that the image of the object always falls on the retina, regardless of the position of the object, is the power of accommodation of the eye.

LEAST DISTANCE OF DISTINCT VISION

The nearest point at which an object can be seen clearly is the near point. For healthy eyes, the minimum distance for clear vision is 25 cm.

FAR POINT

The farthest point at which an object can be seen clearly is the far point. This distance is considered to be infinity.

EYE DEFECTS

- 1. Short sightedness / Myopia
- 2. Long sightedness / Hypermetropia
- 3. Presbyopia

SHORT SIGHTEDNESS / MYOPIA

Some people can see nearby objects clearly but cannot see distant objects. This defect of the eye is short sightedness.

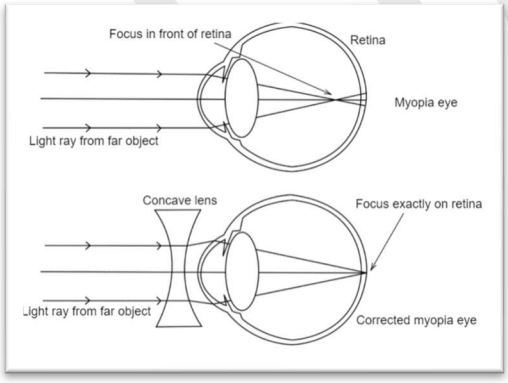
For people with this defect, the far point will not be at infinity. It will be at a certain distance from the eye.

Reason:

Either the eyeball is too long or the lens is too curved (more powerful). As a result, the light rays converge too early, forming the image before it reaches the retina.

The size of the eyeball is: larger
The power of the lens is: more

CORRECTION:



Myopia is corrected using a concave lens, which helps the light rays to diverge slightly so that the image forms on the retina.

LONG SIGHTEDNESS / HYPERMETROPIA

Some people can see distant objects clearly but cannot see nearby objects clearly. This defect of the eye is long-sightedness.

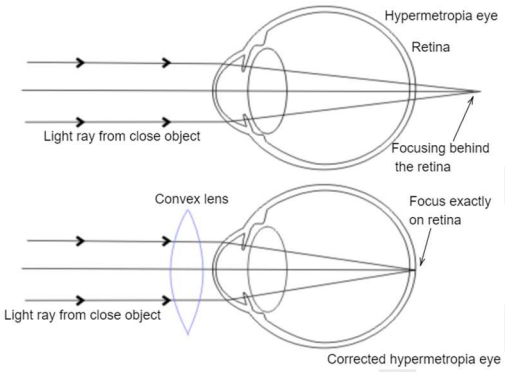
The near point of a person with long sightedness will be more than 25 cm.

Reason:

The eyeball is too short, or the lens is not curved enough (low power). As a result, the light rays from nearby objects do not converge enough and form the image behind the retina.

The size of the eyeball is: smaller
The power of the lens is: less

CORRECTION:



Long sightedness can be rectified using a convex lens with suitable power.

The convex lens converges the rays before they enter the eye, so the image is formed on the retina.

PRESBYOPIA

For older people, the distance to the near point may be more than 25 cm. This is because the efficiency of the ciliary muscles decreases. Such people have less power of accommodation. This is presbyopia.

Correction:

Bifocal lenses are used. These lenses allow elderly people to see both near and far objects clearly with the same pair of spectacles.

- The upper part helps in seeing distant objects.
- The lower part helps in seeing nearby objects.

LIGHT POLLUTION

Light pollution refers to the creation of artificial light in excessive amounts and intensity. Artificial light adversely affects the reproduction and predation of many nocturnal animals.

Excess of artificial light adversely affects the natural activities, mental and physical health of humans.

Consequences Of Light Pollution:

- Causes difficulty during night drive
- Makes astronomical observations difficult by obstructing the night sky
- The light from multi-storeyed flats misleads migratory birds
- Disturbs ecosystems and animals
- Wastes energy