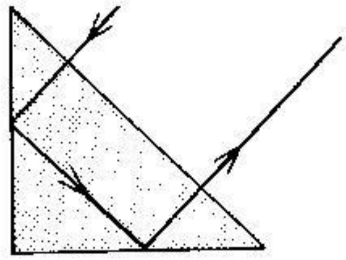
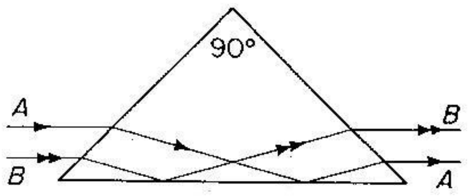
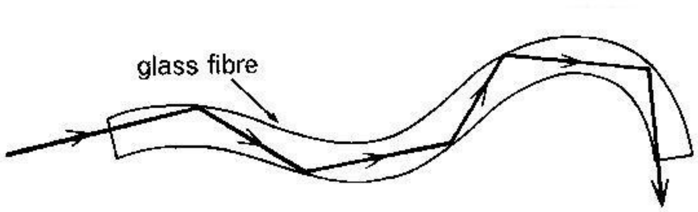
ii) Turning a ray through 180^0



iii) Turning a ray through 360^0



Optical light pipes



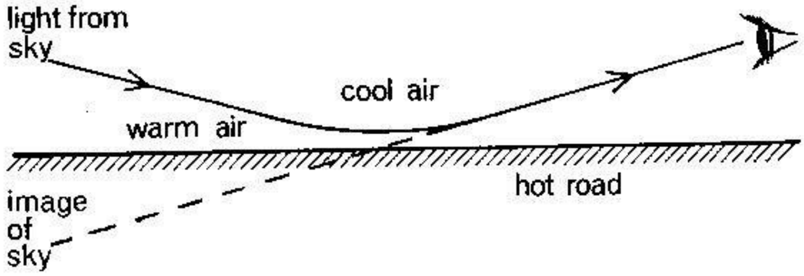
The inner surface has slightly higher refractive index than the outer surface making it slightly denser medium. Light can be trapped by total internal reflection inside a bent glass rod and piped along a curved path as shown above.

Optical fibres can be used by doctors and engineers to light up some awkward spot for inspection. Modern telephone cables are optical fibres using laser light.

EFFECTS OF TOTAL INTERNAL REFLECTION

The mirage

This can happen when the air nearer the surface of the ground is less dense than the above. Cool air is dense than warm air.

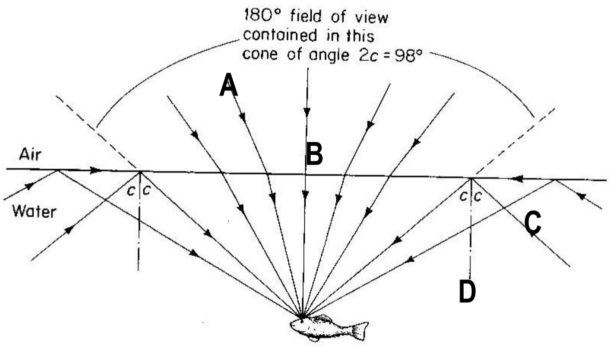


Light from the sky is gradually refracted away from the normal as it passes from denser layer of air to less dense layers

When light meets a layer at angles of incidences greater than the critical angle, it suffers total internal reflection.

The reflection of the sky forms an image which appears as a pool of water on the road.

Fish's eye view



- A fish in water can have a water field of view as it can see an object normally at A
- If angle i is less than the critical angle, it can see an object B by reflection.

It can also see an object as the bank C of lake if the angle of incidence is equal to the critical angle.

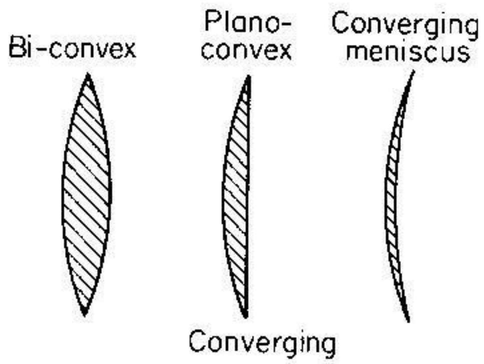
And if i is greater than the critical angle an object at D can be seen by total internal reflection.

LENSES (Refraction on circular surfaces)

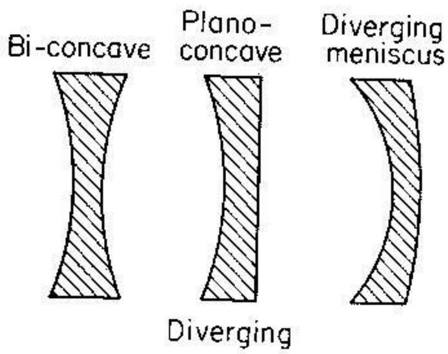
These are two types:

(i) Convex/converging lenses
(ii) Concave/diverging lenses

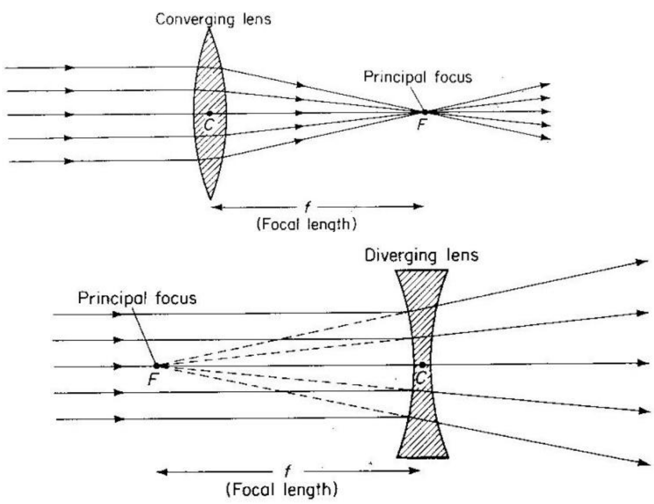
Convex lens



Concave lens



Terms used:

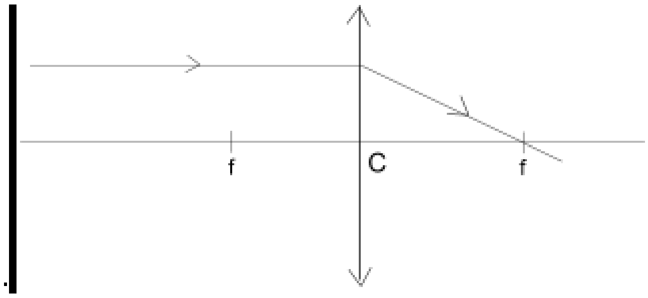


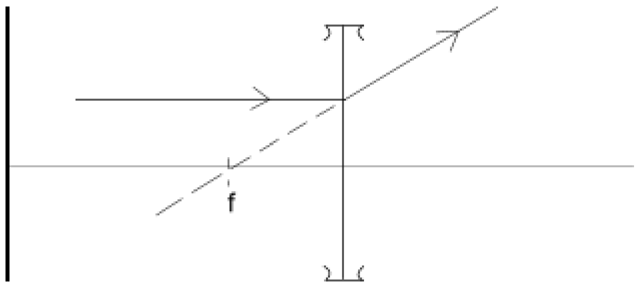
1. Principal axis is a line joining the principal focus and the optical Centre.
2. Principal focus of a convex lens is a point on the principal axis to which all rays originally parallel and close to the principal axis converge after refraction by the lens.
3. Principal focus of a concave lens: This is appoint on the principal axis to which all rays originally parallel and close to the principal axis appear to diverge after refraction.
4. Focal length: This is the distance between the principal focus and the optical centre.
5. Optical centre: this is the centre of the lens at which rays pass un deviated.

CONSTRUCTION OF RAY DIAGRAM

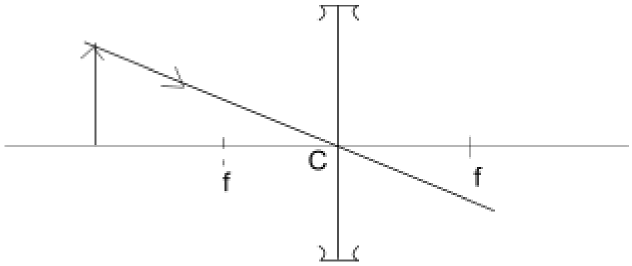
In constructing ray diagram, 2 of the 3 principal rules are used.

1. A ray parallel to the principal axis is refracted through the focal point.

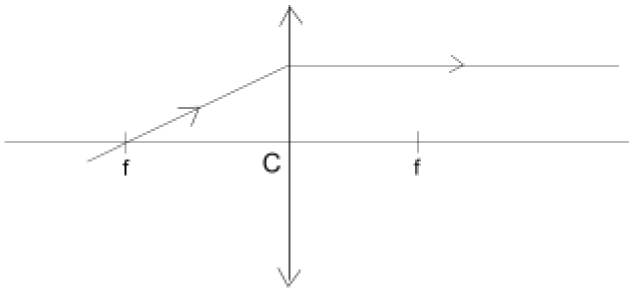




2. A ray through the optical centre passes un deviated i.e. is not refracted.



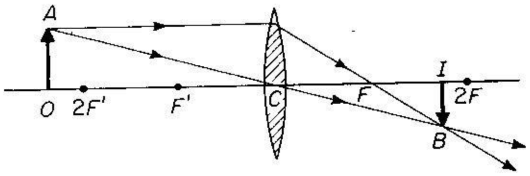
3. A ray through the principal focus emerge parallel to the principal axis after refraction.



Images formed by convex lenses:

The nature of the image formed in a convex lens depends on the position of the object from the lens.

(a) Object beyond 2f

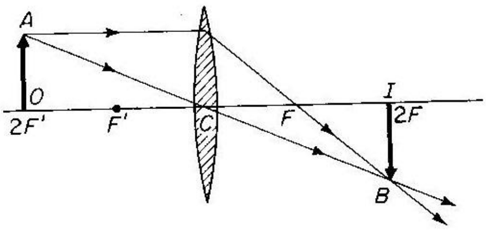


OBJECT BEYOND 2F'

the image is,

(1) Between F and 2F
(2) Real
(3) Inverted
(4) Smaller than object

(b) Object at 2f

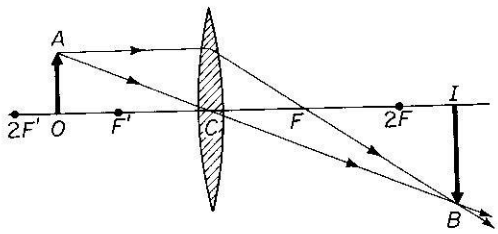


OBJECT AT 2F'

the image is,

(1) At 2F
(2) Real
(3) Inverted
(4) Same size as object

C) Object between f and 2f

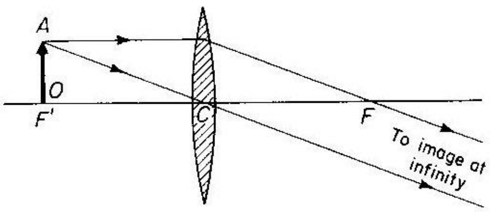


OBJECT BETWEEN F' and 2F'

the image is,

(1) Beyond 2F
(2) Real
(3) Inverted
(4) Larger than object

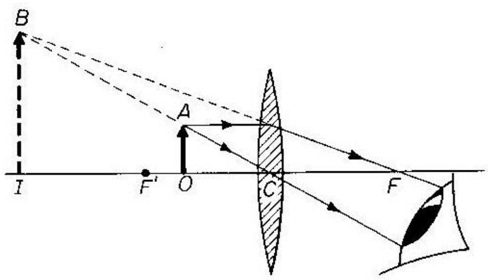
(c) Object at f



OBJECT AT F'

the image is at infinity

(d) Object between F and C



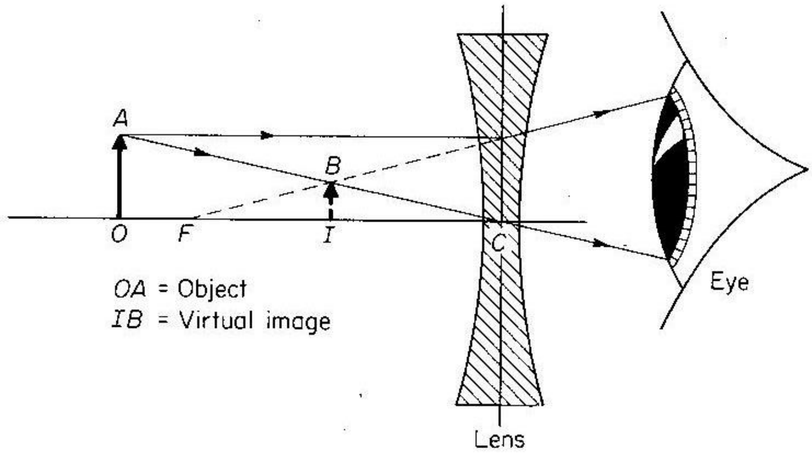
OBJECT BETWEEN LENS and F'

the image is,

(1) Behind the object
(2) Virtual
(3) Erect
(4) Larger than object

When the object is placed between f and c, the image is magnified and this is why the convex is known as a magnifying glass.

Image Formation in a Concave Lens



Power of a lens

It is defined as the reciprocal of focal length in metes

Power of lens = $\frac{1}{f}$ in meters where f – length.

S.I units of power of the lens is dioptres (D)

Example

1. Calculate the power of the focal length 10cm.

P = $\frac{1}{f}$ = $\frac{1}{0.01}$

= 10D

2. Find the power of the lens whose focal length is 20cm

P = $\frac{1}{f}$ = $\frac{1}{0.2}$

= 50

OR

F = 20cm = $\frac{50}{100}$ = 0.2m

Magnification of the lens

It is defined as the ratio of the image height to object height.

M = $\frac{hI}{ho}$

OR

It is the ratio of image distance to object distance from the lens

M = $\frac{v}{u}$ where –v – image distance

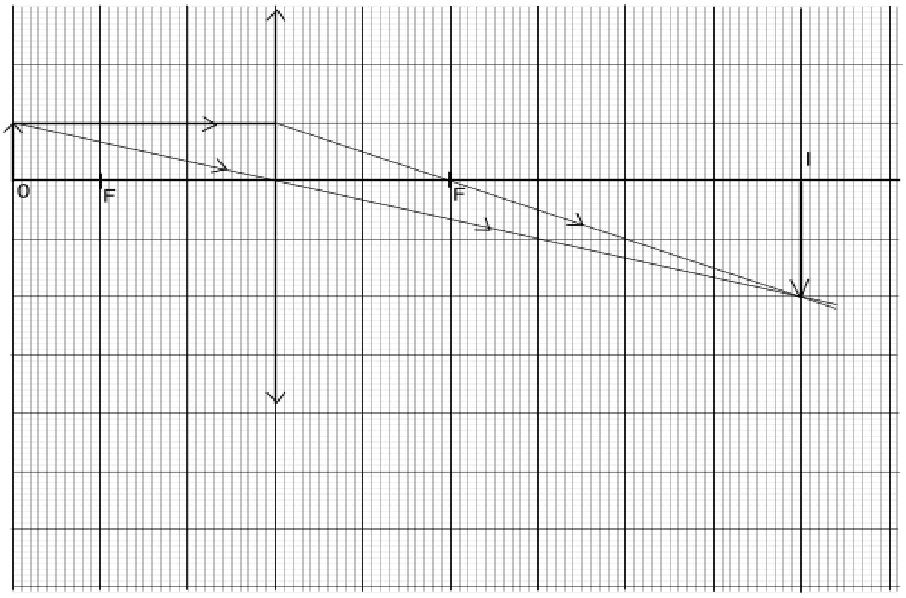
U – Object distance

Determination of image position by graphical method

Same rules are used.

1. A lens is represented by a line on a graph paper. Scale must be used.

E.g. object 5cm tall is placed 15 cm away from a lens of focal length 10cm by construction.



Determine the position size and nature of the final image (use a scale 1:5cm)

Question

1. A simple magnifying glass of focal length 5cm forms an erect image of the object 25cm from the lens. By graphical method, find the distance between the object and image

   Calculate the magnification.
   Diag

2. An erect object 5cm high is placed at a point 25cm from a convex lens. A real image of the object is formed 25 cm high.

   Construct a ray diagram and use it to find the focal length of the lens

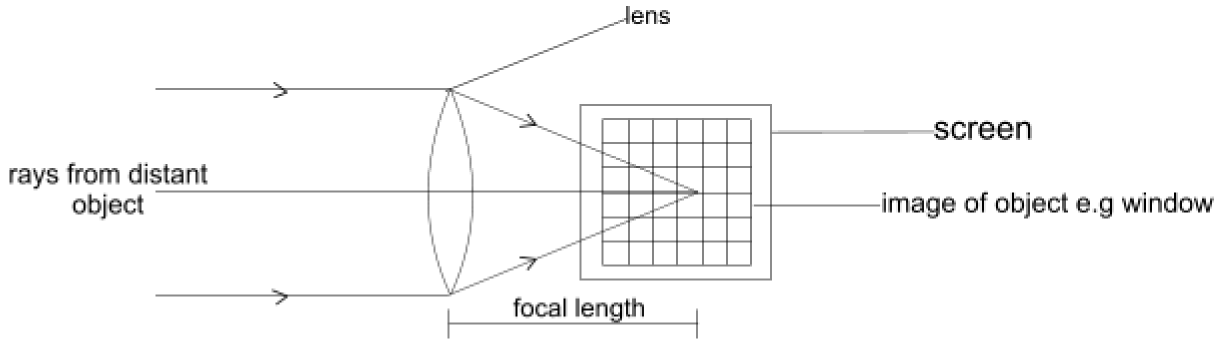
3. An object is placed at right angle to the principal axis of the thin covering lens of focal length 10cm. a real image of height 5cm is formed at 30cm on a lens . by construction, find the position and height of the object (use 1cm :5cm)

Determination of focal lens of a convex lens

a) **Method 1 rough method**

Procedure

A converging lens with a screen on one side is placed some distance from the distant object e.g. a window as shown.



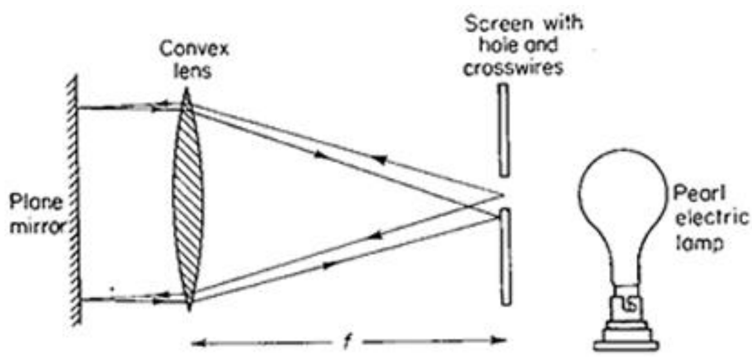
f – focal length

The screen is moved away or towards the lens until the sharp of the window is formed on the screen.

The distance between the lens and the screen is measured and this is its focal length f.

N.B – the value of f obtain by above method is …because rays of light from the window are assumed to be parallel may not be perfectly parallel.

b) **Determination of focal length using on illuminated object.**



Procedure

- A lens is set up in a suitable holder with a plane mirror behind it so that light passing through the lens is reflected back as shown above
- Across wire is used as the object in a hole of a white screen. It is illuminated by the bulb
- The position of the lens is adjusted until a sharp image of the object is formed on the screen along side the object.
- The distance between the lens and the screen is measured, this gives the focal length of the lens .

Application of lenses

Lenses are used in

- Lens camera
- Slide projectors
- Spectacles (used by people with eye defects)
- Microscopes and telescopes.

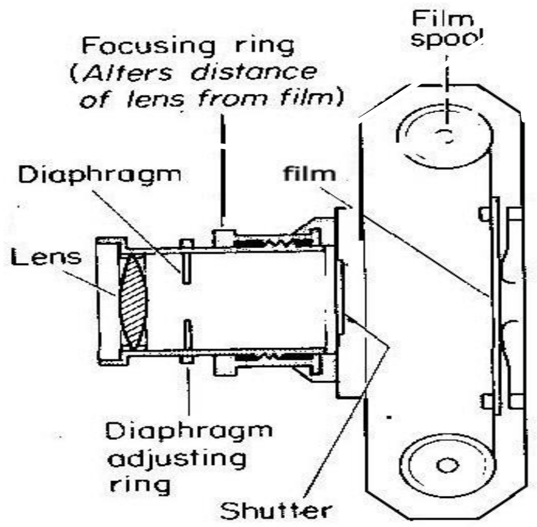
OPTICAL INSTRUMENTS

1. **The lens camera**

This is an optical instrument like the eye, light enters the camera through the convex lens which focuses light onto the film

The film contains a chemical that changes behavior on exposure light.

It is developed to give a negative from which a photograph is made by printing.

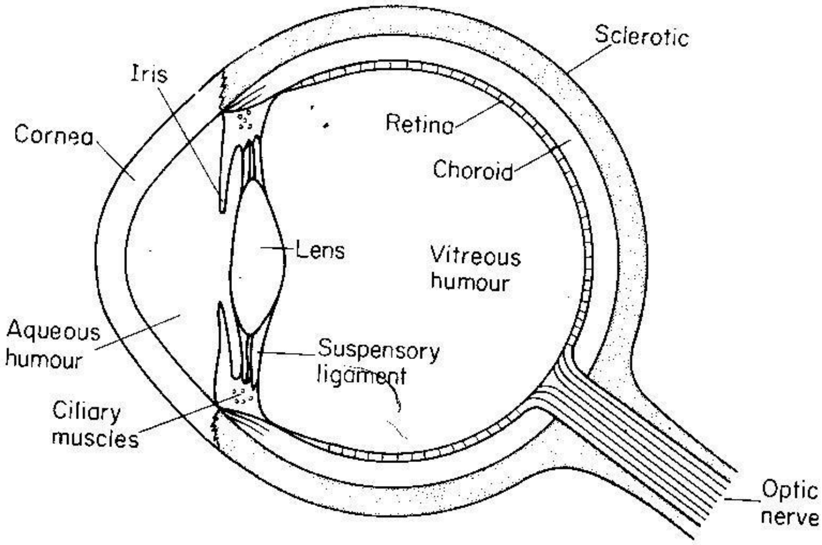


The camera is focused by varying the distance between the lens and the film. The lens is mounted on a screw thread so that, it can be moved in and out for near objects, the lens is moved away from the film.

The amount of light entering the camera is controlled by the

1) shutter, which opens for a certain length of the time to expose the film to the light
2. Aperture (hole) through which light enters the camera by varying its size
3. Diaphragm, this changes the size of the aperture. a stope is made of a sense of metal plates which can be moved to increase the aperture size

THE EYE



Functions of the parts of the eye .

1. **Lens**

   The lens inside the eye is convex . it's sharp , it changes in order to focus light.

2. **Ciliary muscle**

   These alter the focal length of lens by changing its shape so that the eye can focus on image on the retina.

3. **The iris**

   This is the coloured position of the eye. It controls the amount of light entering the eye by regulating the size of the pupil

4. **The retina**

   This is a light sensitive layer at the back of the eye where the image is formed.

5. **The optic nerve**

   It is the nerve that transmits the image on the retina to the brain for interpretation.

6. **The cornea**

   It is the protective layer and it also partly focuses light entering the eye

Accommodation

This is the process by which the human eye changes its size so as to focus the image on the retina. This process makes the eye to see both near and far objects.

EYE DEFECTS AND THEIR CORRECTIONS

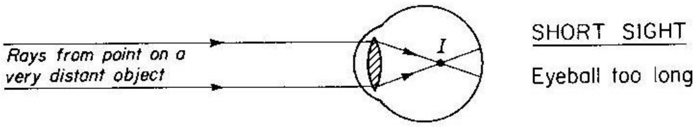
The normal eye can see objects clearly placed at infinity (far point) to see objects in greater details the eye sees it at the near point i.e 25cm

TYPES OF EYE DEFECTS

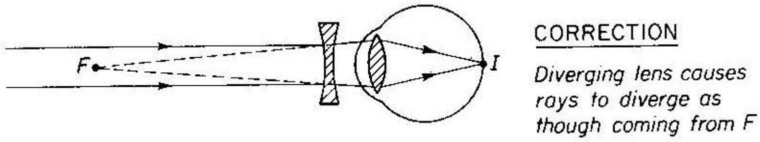
a) Short sightedness
b) Long sightedness

SHORT SIGHTEDNESS

A person with short sightedness can see near objects clearly but distant objects are blurred. The furthest point at which one can see the objects clearly is the far point. An object which is further than the far point is focused in front of the retina.



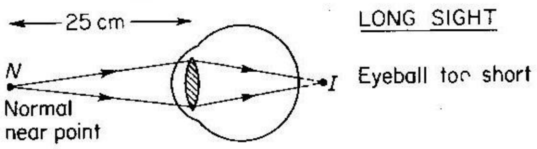
Correction of shortsightedness



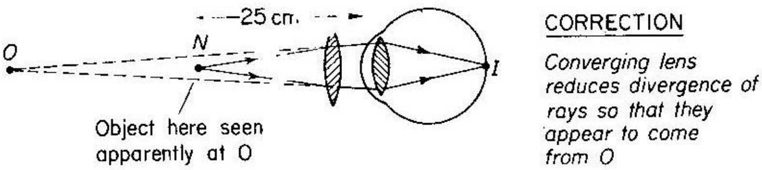
A concave lens is placed in front of the eye to make the light diverge so that it appears to come from the near point when its actually coming far away as shown above.

LONGSIGHTEDNESS

A long sighted person can see distant objects clearly but those that are near are blurred. The nearest point at which the person can see an object clearly is called near point . an object placed near than the near point is focused behind the retina as shown below.



Correction of long sightedness



A convex lens is placed in front of the eye to make the light parallel, so that it appears to come from a distant object as shown above.

Similarities and differences between the eye and camera

Similarities

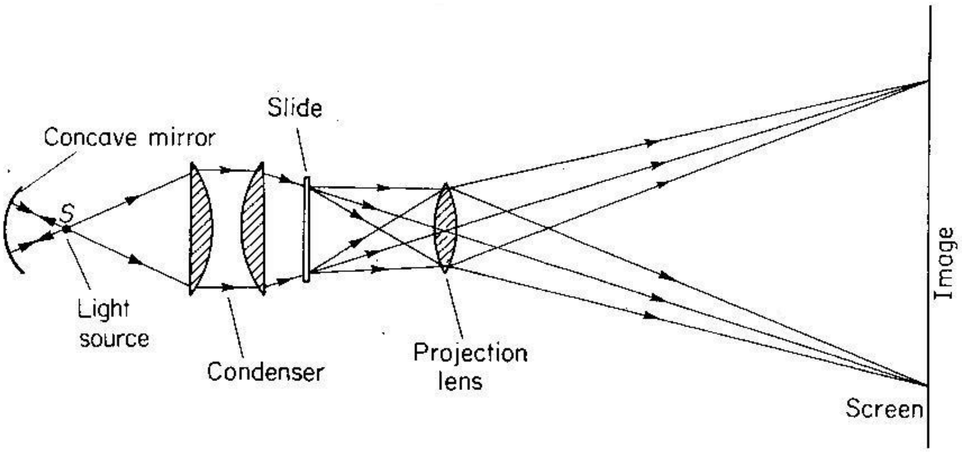
- The camera consists of the (a) light proof box painted blck inside the eye it is fitted with a black pigment in to it to prevent stray reflection of light
- Both have converging lens that focus light from the external objects
- Both have light sensitive parts, the camera has a film while the eye has a retina.
- Both have a system that controls the amount of light entering them

- In the eye, iris is responsible and diaphragm does the same function in the camera.

Differences

- The eye lens is a biological organ while that of a camera is made out of glass.
- The distance between the eye lens and the retina is fixed while that between the camera lens and the film can be varied.
- The eye focuses image by changing the shape of the lens , in a camera the image is focused by changing the distance between the lens and the film.

THE SLIDE PROJECTOR

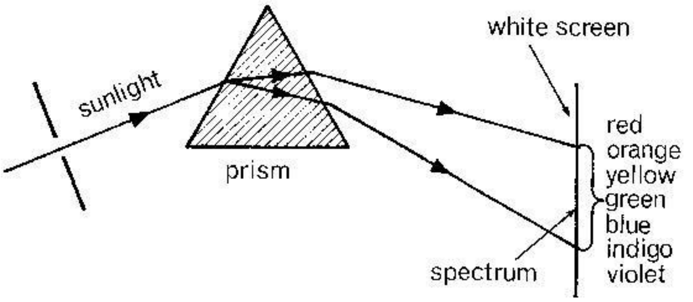


Functions of the parts of the slide projection

1. Lamp – it gives small but very high intensity source of light. It is suitable at the center of curvature of a convex mirror.
2. Concave mirror- it is placed behind the light source. It reflects all lights forward.
3. Condenser lens – it converges light through the slide on to the projector lens
4. Convex projector lens – it focuses the image of the slide on the screen
5. The fan- cools the light source once a lot of heat is produced
6. Heat shield – it shield the slide from heat produced by the light source
7. The slide – this is where the object is placed
8. Screen – this is where the object is formed . the size of the image on the screen increases as the projector is moved back from it. Th image is focused by altering the distance between the slide and the lens . the projector lens is mounted on the screw thread so that it can be moved in and out to focus the image.

DISPERSION OF LIGHT

This is the separation of white light into various colours listed in order. The colours are red, orange, yellow, green, blue, indigo, and violet. The bundle of colour formed is called a spectrum. Visible light spectrum can be made by passing a beam of white light through a glass prism.

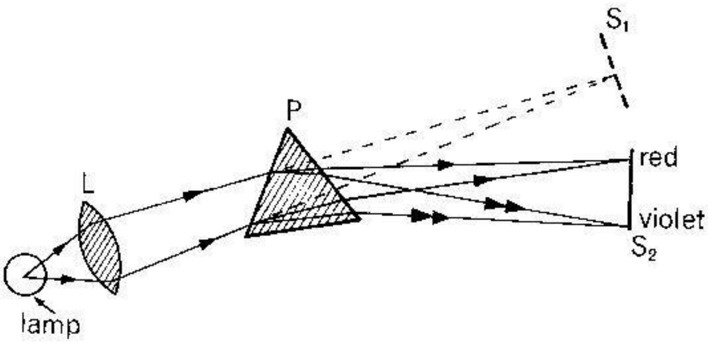


Dispersion occurs because each colour is refracted in glass by different amount i.e. each colour has different refractive index. So red is refracted least and violet is refracted most.

HOW TO OBTAIN A PURE SPECTRUM

The spectrum obtained above is impure i.e. the colours of the spectrum overlap one another.

Apure spectrum is one in which light of one colour only forms each part of the image on the screen without overlap. This can be achieved by playing a convex lens in front of the prism to increase on the deviation of the colours as they pass through the prism.



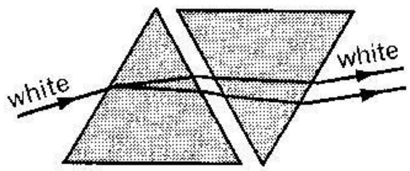
Lens L produces parallel beam of white light. The light is then dispersed and deviated at the prism sprinting up into various colours.

Lens B collects the different coloured lines so that the parallel beam of each separate colour is focused on the screen.

RECOMBINATION OF THE SPECTRUM:

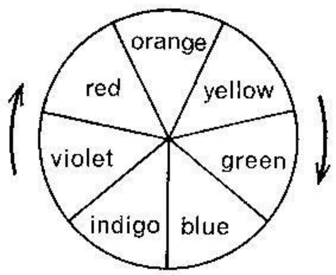
The colours of the spectrum can be recombined by;

(i) Arranging a second prism so that the light is deviated in the opposite direction/****/.



(a)

(ii) Using an electric motor to rotate at high speed, a disc with spectral colours from its sectors as shown below.



The whiteness is slightly grey because paints are not pure colours.

Colours of objectives:

The colour of an object depends on;

(i) The colour of light falling on it.
(ii) The colour it transmits or reflects eg an object appears blue because it reflects blue light into the eyes and absorbs the other colours of the spectrum. Similarly, an object appears red because it reflects light into the eyes and reflects all other colours.
(iii) A white object reflects all the colours of the spectrum into the eyes and absorbs none.

A body appears white because it absorbs all colours and reflects none.

Types of colours:

a) **Primary colours**

These are colours that can't be obtained by adding two different colours of light. they include red , blue and green

b) Secondary colour

These are colours which are obtained by adding 2 primary colours together. They include yellow, peacock blue and magenta.

NB :- peacock blue is times called cyan or tachois.

c) Complementally colours

There are two different colours which when added produce white light. One of them is a secondary colour and the other must be a primary colour. The pairs are

Red + peacock blue → white light

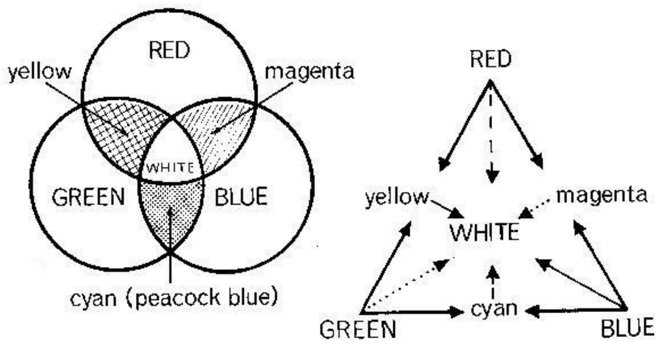
Green + magenta → white light

Blue + yellow → white light

Complementally colours

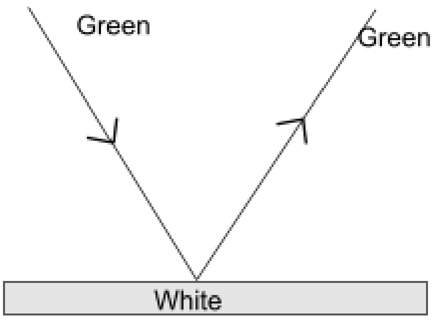
From the complementally colours it is noted that when the three primary colours are joined, they produce white light.

SUMMARY OF COLOURED LIGHTS

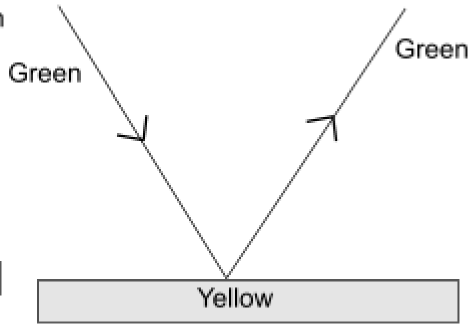


Coloured objects in white light

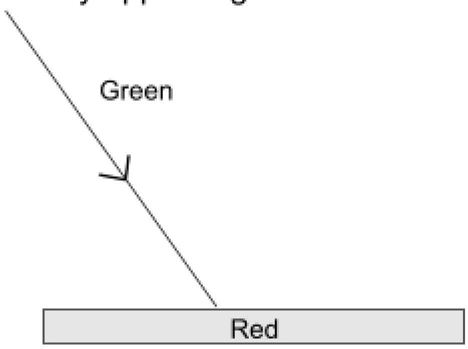
A coloured object reflects and transmits its own colour and absorbs other colour incident on it. Examples:



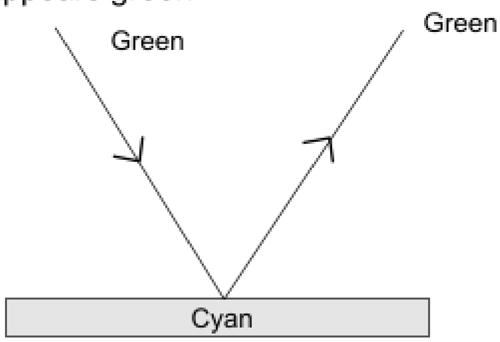
Body appears green



Body appears green



None is reflected, body appears black



Body appears green

N.B:- primary colour +primary colour = black
Primary colour + secondary colour = primary
Secondary colour + secondary colour = common primary colour.

Question

Describe and explain the appearance of a red tie with blue spots when observed in .

a) Red light
b) Green light – **<u>the whole tie appears because both colours are primary colours and non is reflected black</u>**
c) Red light – **<u>in the red light the tie appears red and blue spots blacks.</u>**
<u>This is because the red reflects the red colour and observes blue colour.</u>

Question2

A plant with green leaves and red flowers is placed in

a) green
b) blue
c) Yellow

what colour will the leaves and flowers appear in each case . Assume all colours are pure

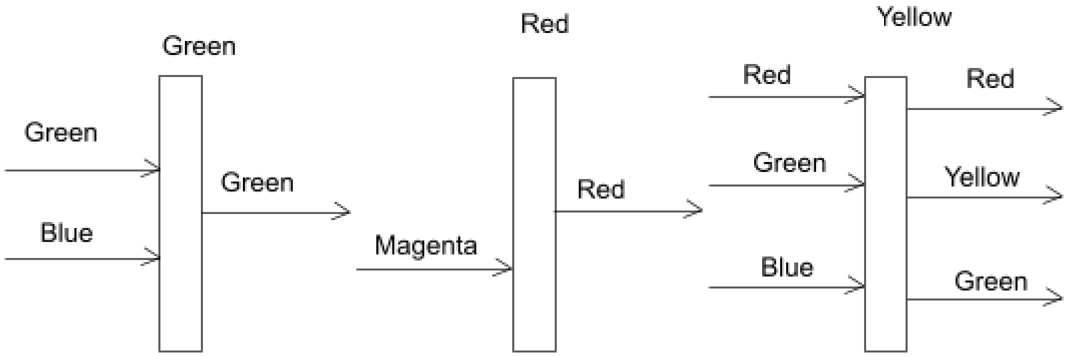
a) green -: <u>the leaves remain green but the flower black</u>

b) blue -: <u>the leaves will appear black and flowers black</u>

c) Yellow <u>-: the leaves appear green and flowers appear red.</u>

FILTERS (COLOUR)

A filter is a coloured sheet of plastic or glass material which allows light of its own type to pass through it and absorbs the rest of the coloured lights i.e. a green filter transmits only green, a blue transmits only blue , a yellow filter transmits red , green and yellow lights.



MIXING OF COLOURED PIGMENTS

A pigment is a substance which gives its colour to another substance .A pigment absorbs all the colours except its own which it reflects . When pigments are mixed the colour reflected is the common to all e.g. blue + yellow → green

Yellow + orange →black

Green + indigo → blue

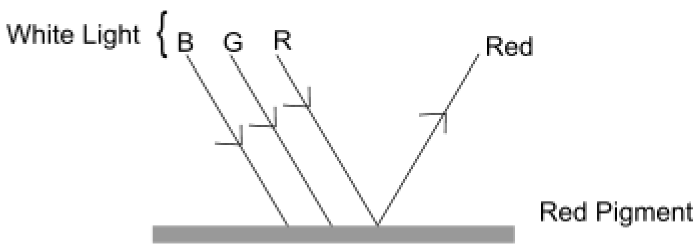
The blue reflects indigo and green its neighbour in the spectrum as well as blue

Yellow reflects green, yellow and orange only green is reflected by both

Mixing coloured pigment is called colour mixing by subtraction

Pigments appears black because non of the colours are reflected.

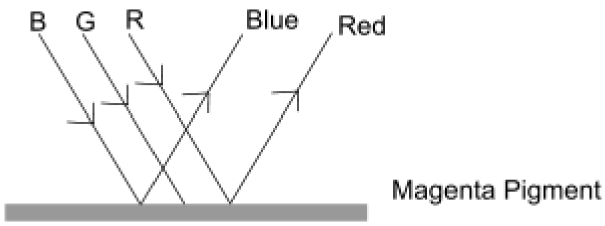
APPEARANCE OF COLOUR PIGMENT IN THE WHITE LIGHT .



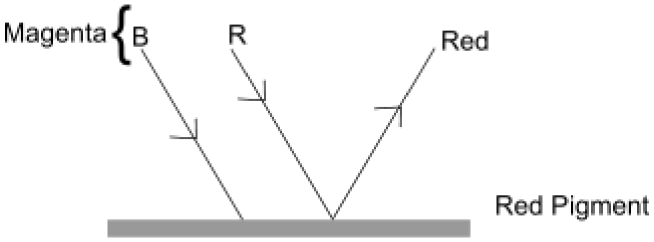
A colour pigments reflects only one colour .

APPEARANCE A COLOUR PIGMENT IN COLOURED LIGHT

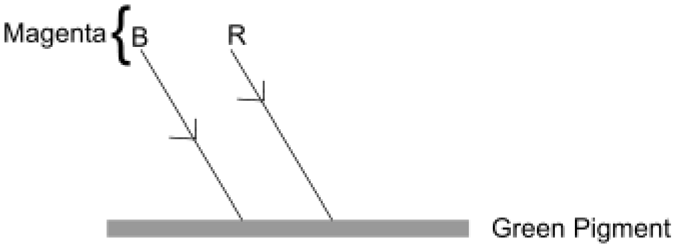
(a.) Magenta pigment reflects two colours of light i.e. blue and red when white light is incident on it



(b.) Red pigment reflects only the red colour when magenta light is incident on it.



(c.) The pigment appears black because none of the colours in the magenta light is reflected.



- Used in pointers to prevent errors due to parallax.
- Used in optical lever instruments to magnify angle of rotation.
- Used in kaleidoscope.
- Used in small shops and supermarkets, take away and saloons to give a false magnification as a result of multiple reflections.