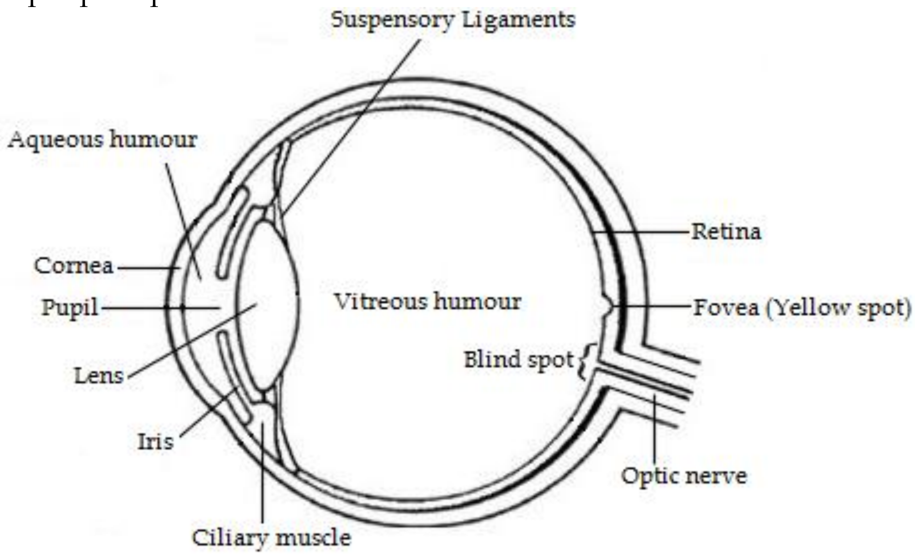
S3 PHYSICS CONTINUATION SET II

OPTICAL INSTRUMENTS

The human eye

The human eye is an organ that responds to light and allows light perception, color vision and depth perception.



Features of the human eye

1. The convex lens is used to focus light rays onto the retina.
2. The retina is a light sensitive area of cells at the back of the eye where real and inverted images are formed. The optic nerve conveys the signals of the eye to the brain for interpretation.
3. Ciliary muscles are attached to the eye lens they change the focal length of the lens by varying its thickness.
4. Yellow spot (fovea) is the most sensitive point on the retina. In good light the image is formed on the yellow spot to bring out its detail.
5. The iris is a coloured circle around the eye which controls the size of the pupil hence controlling the amount of light entering the eye
6. The pupil is a circular opening in the iris through which light enters the eye.
7. Cornea is a thick transparent protective covering in front of the eye which also helps in refracting light. The cornea and lens act together to form a real image on the light-sensitive retina.
8. Aqueous humor in front of the lens and vitreous humor behind are liquids in which the lens is suspended.
9. The blind spot is the area of the retina where the optic nerve leaves the eye. It doesn't have light sensitive cells hence images cannot be formed there.

Accommodation

Accommodation is the ability of the eye to view objects at different positions by adjusting the focal length of lens.

Accommodation is controlled by the Ciliary muscles which contract and relax to vary the thickness if the lens.

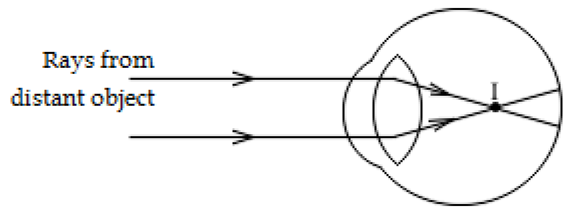
Defects of vision

Normal eye

A normal eye can focus clearly objects at a far point (infinity) and those at a near point about 25cm from the eye. The 25cm represent the least distance of distinct vision.

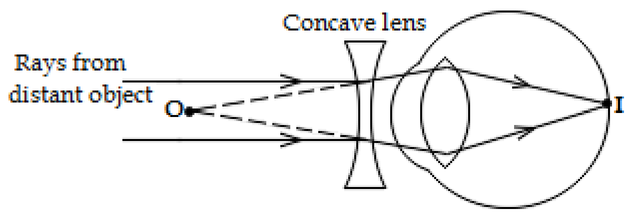
Short sight (Myopia)

A short sighted person can see clearly near objects but cannot focus clearly on far objects. The image of a distant object is formed in front of the retina because the eyeball is too long. The far point of a short sighted person is closer than infinity.



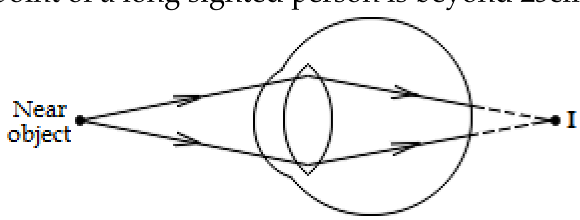
Correction of short sight

This is corrected by wearing glasses with a diverging (concave) lens. Rays from a distant point are diverged so that they appear to come from a new near point, O.



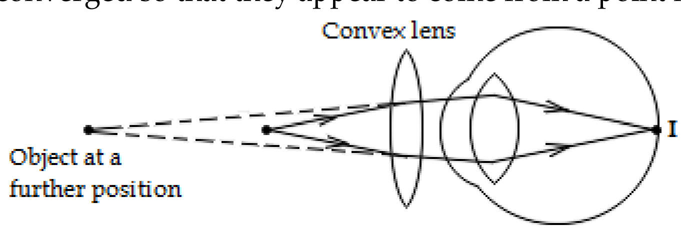
Long sight (hypermetropia)

A long sighted person can see clearly far objects but cannot focus clearly on near objects. The image of a near object is formed behind the retina because the eyeball is too short. The near point of a long sighted person is beyond 25cm.



Correction of long sight

This is corrected by wearing glasses with a converging (convex) lens. Rays from a near point are converged so that they appear to come from a point further than 25cm.



Loss of accommodation (Presbyopia)

This occurs when the ciliary muscles become weaker with old age. Full contraction of the ciliary muscles becomes difficult. This defect is similar to long sight when viewing a near point. It is corrected using a convex lens.

Astigmatism

This is a condition whereby each eye has a different defect. One eye may be short sighted while the other long sighted. This is corrected using a bifocal lens.

Colour blindness

This is when a person can't see other colours except black and white. Colour blindness is an effect of missing rods or cones in the retina that are responsible for colour formation.

Questions

1. (a) What is meant by the term accommodation as applied to the human eye?

 (b) Using relevant ray diagrams explain the following defects of vision and their correction

(i) Short sight

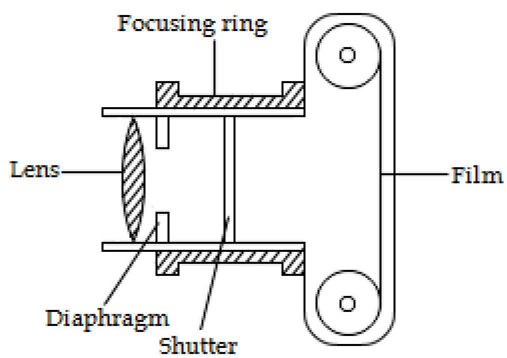
(ii) Long sight

2. A man holds a newspaper at arm's length in order to read it

(i) State the defect of vision that causes this

(ii) State the type of lens required to correct this defect.

The lens camera



A camera is a device that allows you to record images on film

A lens camera consists of a convex lens and a light sensitive film mounted in a light tight box painted black on the inside to avoid reflections. The distance between the lens and the film is adjusted using a focusing ring.

A diaphragm of variable aperture and a shutter of variable speed regulate the amount of light admitted through the lens.

The rays of light from the object are converged by the convex lens forming a real image on the film

The image is focused by adjusting the focusing ring depending on the position of the object.

(i) If the object is away from the lens, the image is focused by moving the lens closer to the film.

(ii) If the object is close to the lens, the image is focused by moving the lens away from the film.

Similarities between the human eye and the lens camera

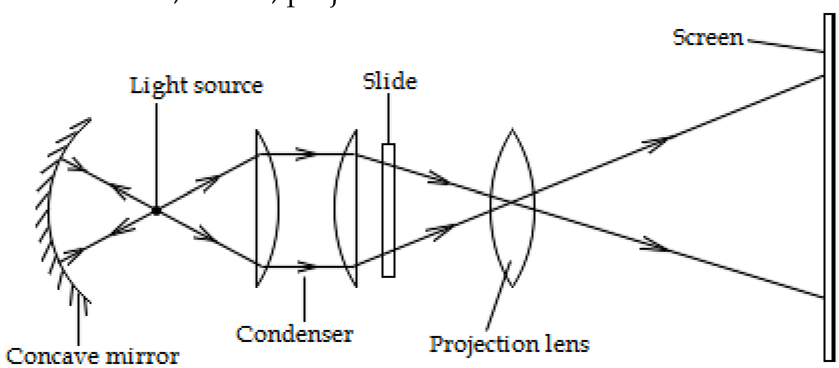
1. Both use a convex lens to focus light and create a real and inverted image.
2. Both form images on light sensitive parts, the camera has a film and the eye has a retina.

3. Both have a mechanism that controls the amount of light admitted. A camera has a diaphragm and shutter while the eye has a pupil at the center of the iris.

Differences between the human eye and the lens camera	
Human eye	**Lens camera**
1. The lens has a variable focal length.	The lens has a fixed focal length.
2. The image distance is constant.	The image distance is variable.
3. Focusing is by changing the focal length of the lens	Focusing is by moving the lens closer or away from the film
4. It is a biological organ	It is an artificial optical instrument
5. The lens, cornea, aqueous & vitreous humor all refract light.	Only the lens refracts light.

The slide projector

It has a concave mirror, a very powerful source of light, a condenser system made of two convex lenses, a slide, projection lens and a screen.



How a slide projector works.

- The light source is placed at the centre of curvature of a concave mirror.
- A concave mirror is used to reflect light back along the same paths to produce a brighter beam.
- The condenser is made up of two Plano-convex lenses that refract the light and beam it towards the slide so that all parts of the slide are strongly illuminated.
- The projection (convex) lens forms a real, larger and inverted image on the screen.
- The slide (object) must be placed between F and 2F in order to produce a real, larger, and inverted image.
- Because the image is inverted, the slide must be placed upside down and laterally inverted so we can see an upright image.

Dispersion of white light

Dispersion is the splitting of white light in to its seven component colours by a transparent medium like a glass prism.

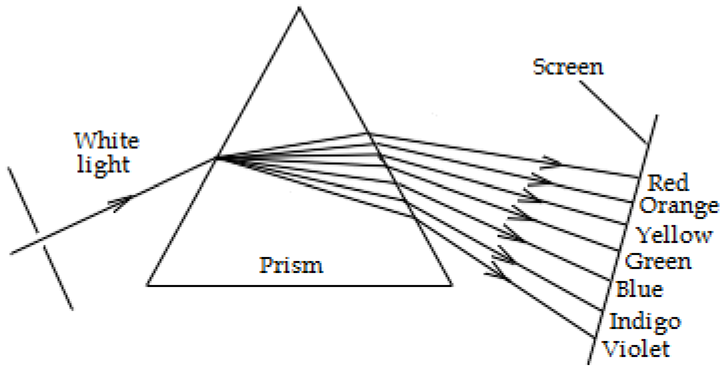
White light is a mixture of lights of seven colors: red, orange, yellow, green, blue, indigo and violet. A band of the seven colours is called a spectrum.

How dispersion occurs

The dispersion of light occurs because the refractive index of glass is different for different colours. When white light consisting of seven colors falls on a transparent medium (glass prism), each color in it is deviated by a different angle, hence the seven colors are spread out to form a spectrum.

The red color is the least deviated, so it forms the upper part of the spectrum. On the other hand, Violet color is the most deviated, so it appears at the bottom of the spectrum.

An impure spectrum

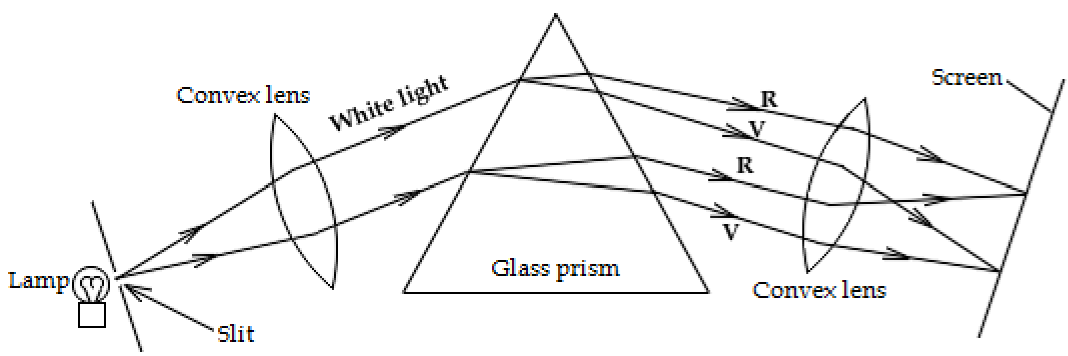


An impure spectrum is produced when white light is incident on a glass prism which splits it in seven colours which form a patch on a white screen. The seven colours overlap each other hence forming an impure spectrum

Production of pure spectrum

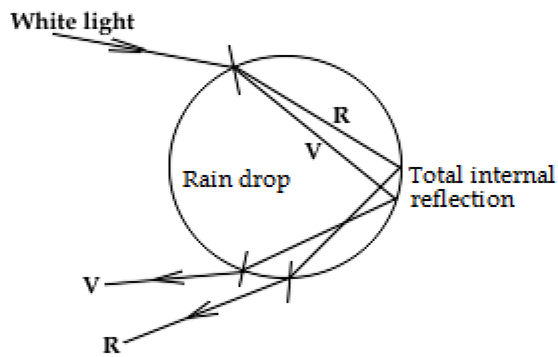
A pure spectrum is one in which the seven colours do not overlap.

An illuminated slit is placed at the principal focus of a convex lens so that a parallel beam of white light emerges and falls on the prism. Refraction by the prism splits white light into two separate parallel beams of colours of the spectrum these beams are focused by a second convex lens which brings each colour to its own focus on a screen placed at the principal focus of the second lens.



The rainbow

The rainbow is an arch of seven colors visible in the sky which is produced by reflection, refraction and dispersion of sunlight in water droplets within the atmosphere.



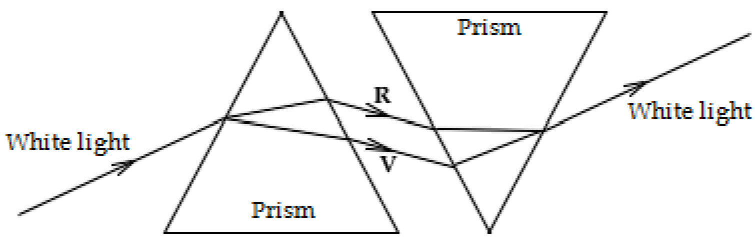
When Light from the sun strikes the raindrop, refraction and dispersion occur. White light splits into the seven component colours. Total internal reflection of the colours occurs at the back of the drop. Light is refracted again as it leaves the raindrop and the colours are further dispersed.

Methods of recombining a spectrum

When the colours of a spectrum are recombined, they form white light.

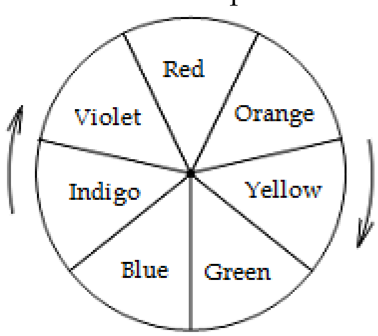
1. Using two prisms

When dispersion by a prism is reversed by a second inverted prism which deviates light in the opposite direction, hence the colours of the spectrum recombine.

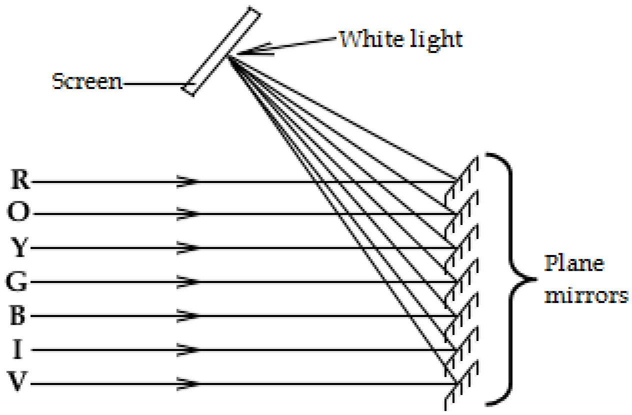


2. Using Newton's disc

This is a circular card painted with all the seven colours of the spectrum in order on equal sectors. The card is rotated a high speed. The card appears slightly grey instead of the expected white because the paints are not pure colours.

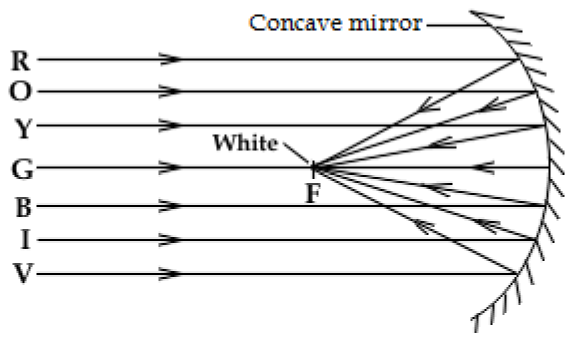


3. Using plane mirrors



A spectrum is allowed to fall on a row of seven small rectangular plane mirrors which are then adjusted so that they all reflect light to the same point on a screen. A white patch is formed at this point.

4. Using a concave mirror



A parallel beam of colours of a spectrum is incident on a concave mirror which reflects them to its principal focus where white light is formed.

Colour of an object

The colour of an object depends on;

(i) The colour of light falling on it

(ii) The colours reflected (transmitted) by the object

An object appears white in white light because it reflects all the colours.

A blue object appears blue in white light because it absorbs all colours and reflects only blue.

A blue object appears black in red light because no light is reflected. Black shows lack of colour.

In general an object appears black when it absorbs all colours and reflects none.

Mixing coloured lights

All colours can be made by mixing three basic colours in the desired proportions. The basic colours also known as primary colours are RED, GREEN and BLUE.

Primary colours cannot be obtained by mixing two or more colours.

Secondary colours are obtained by mixing any two primary colours.

Secondary colours are YELLOW, CYAN and MAGENTA

YELLOW = RED + GREEN

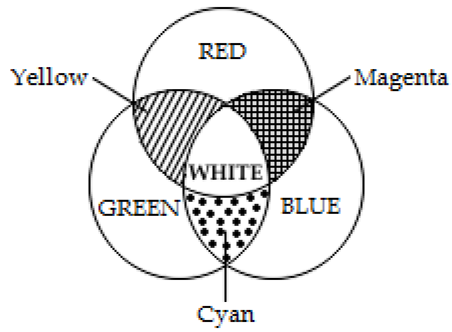
CYAN = GREEN + BLUE

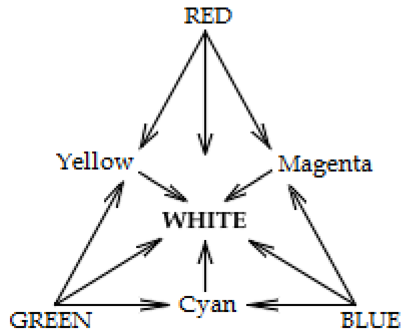
MAGENTA = RED + BLUE

When the three primary coloured lights are mixed you get white light.

Secondary colours also produce white light when mixed

The colour Venn-diagram and colour triangle





Complementary colours

These are two colours which combine to give white light. Examples are;

Magenta + Green = White

Yellow + Blue = White

Red + Cyan = White

Appearance of coloured objects in coloured lights

The colour of an object depends on the colour of light falling on it and the colour it reflects.

Examples

A yellow object appears yellow in yellow light and white light.

It appears red in red light

It appears green in green light

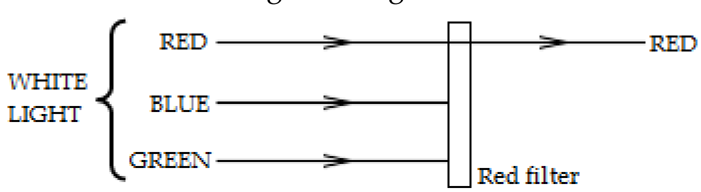
It appears black in blue light because yellow is a secondary colour made by mixing green and red lights hence no light is reflected.

Colour filters

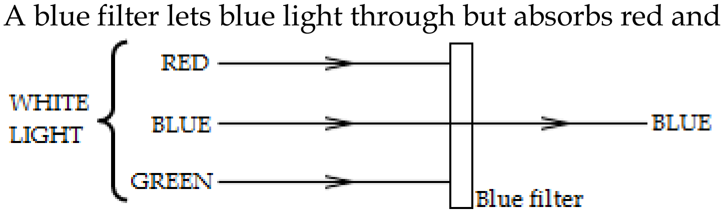
A colour filter is a coloured piece of transparent material which allows light of its own colour to pass through but absorbs all the others.

Red, green and blue filters are called primary filters

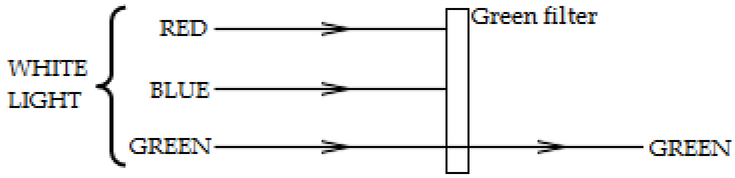
A red filter lets red light through but absorbs blue and green light.



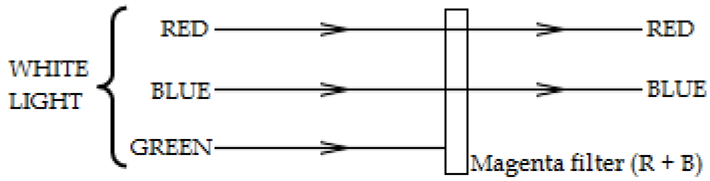
A blue filter lets blue light through but absorbs red and green light.



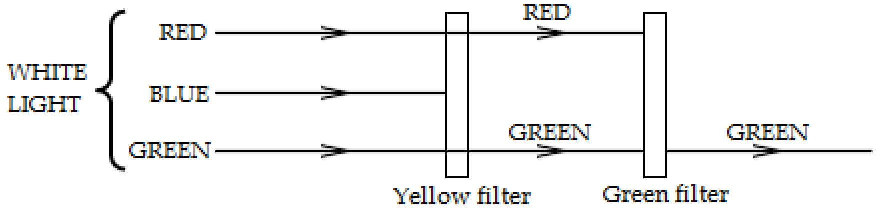
A green filter lets green light through but absorbs blue and red light.

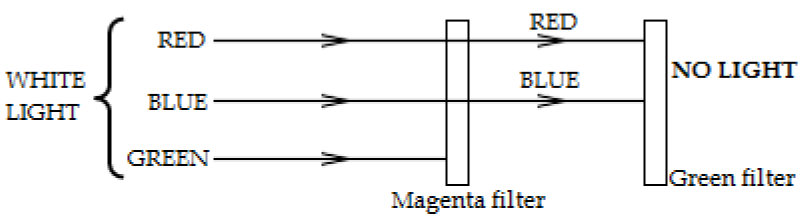


We can use complementary colour filters in which case about two thirds of the spectrum will pass through. A magenta filter allows blue and red light to pass through but absorbs green light. A magenta filter is also called a minus green filter.



Double filters

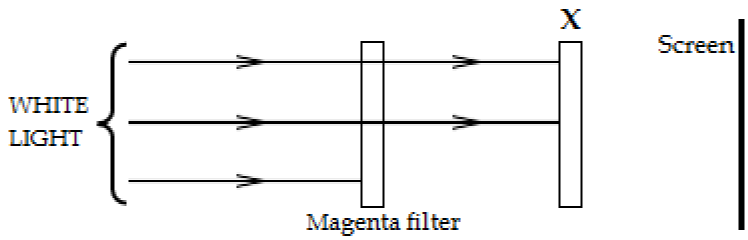




Revision questions

1. White flowers with green leaves are kept in a blue flower pot. Describe hoe the arrangement will look like in (i) red light (ii) yellow light.
2. A house is painted green and blue. What colour will it appear when viewed through a magenta filter?
3. A student holding a white paper with green printing on it. If he enters a room with red light, what will he see?
4. A translucent white bottle has a red printing on it. An electric lamp with blue glass is suspended inside the bottle and switched on in a darkened room. What will be the appearance of the green printing on the bottle?
5. An object looks blue in white light. The white light is passed through a clear plastic blue filter onto the object in front of the screen. What colour will the object appear to be?
6. An object looks yellow in white light. The white light is passed through a clear plastic blue filter onto the object in front of the screen. What colour will the object appear to be?
7. Describe the appearance of a blue shirt with red dots in yellow light.

8. A girl wearing a red dress with white stripes passes under green light. Describe the appearance of her dress.
9. Describe the appearance of a girl a girl dressed in a red cap, yellow blouse and a green skirt in (i) Red light (ii) yellow light (iii) Blue light (iv) Green light
10. The diagram below shows white light incident on a magenta colour filter. What colour filter should X be so that red is seen on the screen?



ELECTROSTATICS

Electrostatics is the study of electric charges at rest.
It is also the study of static electricity.

Illustrations that show the existence of static electricity

A glass rod rubbed with dry silk attracts small pieces of paper.
A plastic pen rubbed with dry hair attracts small pieces of paper.
When a dry piece of cloth is used to clean a glass window, dust particles are attracted to the glass.
When ebonite is rubbed on fur it attracts small pieces of paper.
All these show the existence of static electricity

Evidence for the charges

All objects are made up of atoms, and all atoms are made up of protons, neutrons and electrons each with their own properties.
Protons have a Positive (+) charge.
Electrons have a Negative (-) charge.
Neutrons are Neutral (no charge).
The positive charge and negative charge are equal in magnitude.
Since atoms contain the same number of protons and electrons. So the positive and negative charges are cancelled out making the atom electrically neutral.
The protons and neutrons are held very tightly in the nucleus.
Electrons are located outside the nucleus within circular orbits (shells).

The law of electrostatics

It states that; unlike charges attract while like charges repel.
Each type of charge attracts the opposite type but repels the same type.

Conductors and insulators of electricity

Conductors

A conductor is a material which has some electrons that can move freely from atom to atom.
The free electrons conduct electricity from one part of a conductor to another. Most metals are

good conductors. Electrolytes and graphite are also conductors. Conductors are not charged by rubbing because our bodies would conduct the charges to the earth.

Insulators

An insulator is a material which has all its electrons bound firmly to their atoms. Examples of insulators are Plastics, cloth, glass, dry wood, paper and dry air. An insulator can be charged by rubbing because the charge produced cannot move from where the rubbing occurs.

Precautions when conducting electrostatic experiments

(i) Avoid unnecessary touching og materials in use

(ii) Materials used must be dry

(iii) Experiments must be conducted in dry conditions

Charging an insulator by friction

When two insulators are rubbed together, electrons are transferred from one insulator to another. Rubbing causes friction between the two surfaces increasing the surface contact and allowing more electrons to be transferred.

The object which looses electrons becomes positively charged and the one that gains the electrons becomes negatively charged.

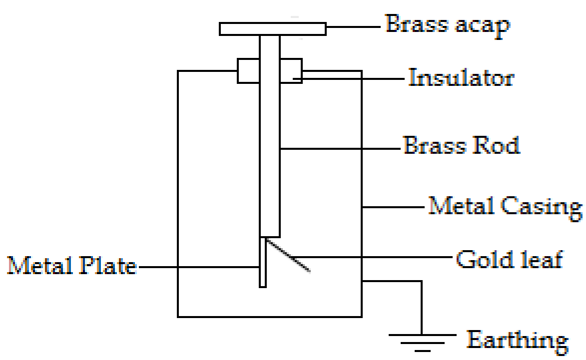
Examples

1. When a glass rod is rubbed with a piece of silk cloth, glass loses electrons which attach themselves on silk as a result glass becomes positively charged and silk negatively charged.
2. When a polythene strip is rubbed on wool, electrons are transferred from wool to the polythene strip. Hence polythene becomes negatively charged and wool is positively charged.
3. When ebonite is rubbed with fur, electrons are transferred from fur to ebonite. Hence ebonite becomes negatively charged and fur is positively charged.

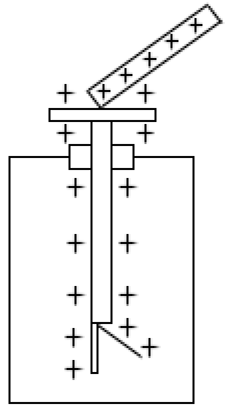
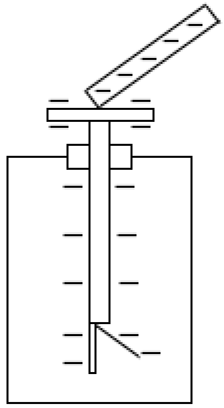
The gold leaf electroscope

This is a sensitive instrument used in electrostatics in various ways.

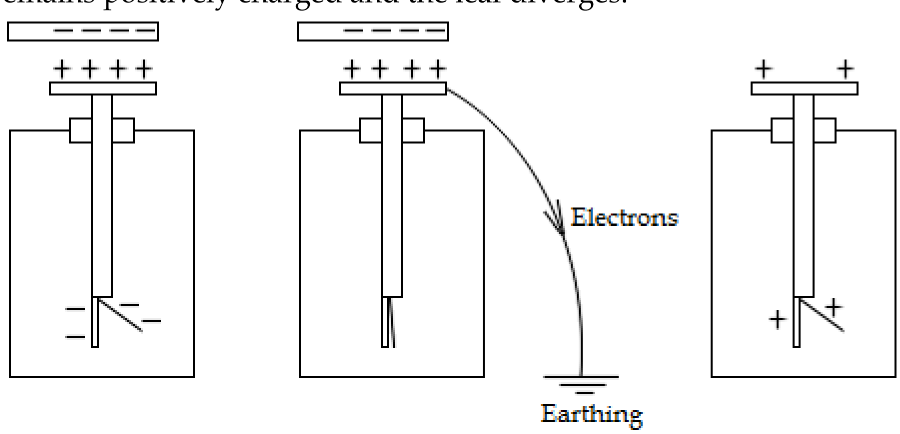
It consists of a brass cap on a metal rod (copper or brass) which has a metal plate at the bottom to which a leaf of gold foil is attached. The rod is held by an insulating plastic plug in a case with glass sides for viewing the leaf. The case protects the leaf from draughts.



Charging a gold leaf electroscope

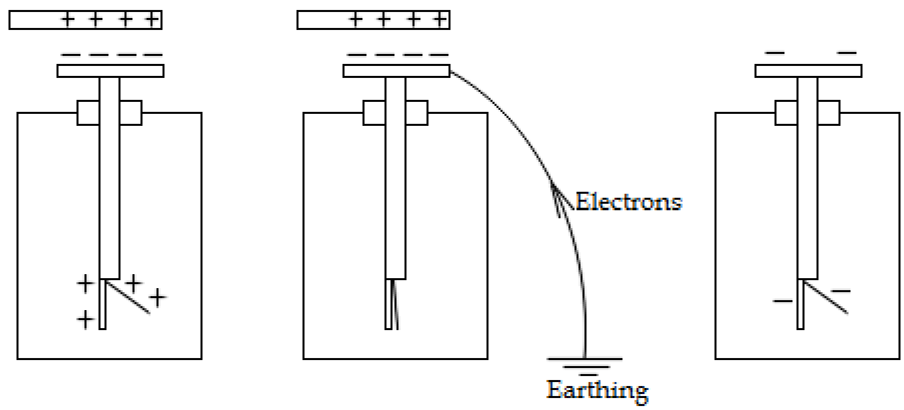
Charging positively by contact 	A positively charged polythene rod is pressed on the cap and dragged across the edge of the cap. The leaf remains diverged when the rod is removed if it doesn't the process is repeated. Positive charges are transferred from the rod to the electroscope making it positively charged.
Charging negatively by contact 	A negatively charged polythene rod is pressed on the cap and dragged across the edge of the cap. The leaf remains diverged when the rod is removed if it doesn't the process is repeated. Negative charges are transferred from the rod to the electroscope making it negatively charged.

Charging positively by induction
A negatively charged inducing rod is brought near the cap of the electroscope. The negative charge on the rod repels the negative charges down to the metal plate and leaf which diverges. The cap is momentarily earthed by touching in presence of the inducing charge so that negative charges flow to the earth, the leaf falls. On removing the inducing charge, the electroscope remains positively charged and the leaf diverges.



Charging negatively by induction

When a positively charged inducing rod is brought near the cap of the electroscope, it attracts electrons from the metal plate and the leaf which move upwards to the brass cap. The brass plate and the leaf are left with a positive charge and the leaf diverges.
The cap is momentarily earthed by touching in presence of the inducing charge so that negative charges flow from the earth to the cap and neutralise the positive charge. The leaf falls. On removing the inducing charge, the electroscope remains negatively charged and the leaf diverges



Uses of the gold leaf electroscope
1. Testing for presence of charge on a body
The material under test is brought near the cap of an uncharged gold leaf electroscope. If the leaf diverges, the material is charged. If the leaf remains in the same position, then the body is not charged.
2. Testing for the nature of charge on a body
The charge under test is brought near the cap of a gold leaf electroscope of a known charge. An increase in divergence occurs when the charges are of the same kind. If the charges are different, then the leaf will reduce in divergence.

Charge on electroscope	**Charge under test**	**Leaf divergence**
Negative (-)	Negative (-)	Increases
Positive (+)	Positive (+)	Increases
Positive (+)	Negative (-)	Decreases
Negative (-)	Positive (+)	Decreases

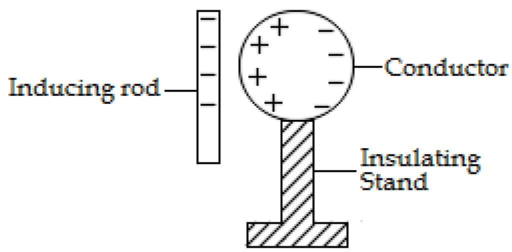
3. Comparing the magnitude of charge on two bodies carrying the same charge
The two charged bodies are brought in turn near the cap of a gold leaf electroscope carrying a similar charge. The increase in divergence is observed. A bigger angle of divergence shows a higher magnitude of charge on that body.
4. Testing whether a body is a conductor or an insulator
The material under test is held with a bare hand and brought in contact with the cap of a charged gold leaf electroscope.
If the leaf falls immediately, then the material is a good conductor.
If the leaf remains diverged, then the material is a good insulator.
If the leaf falls slowly, then the material is a poor conductor or a poor insulator.

Electrostatic induction

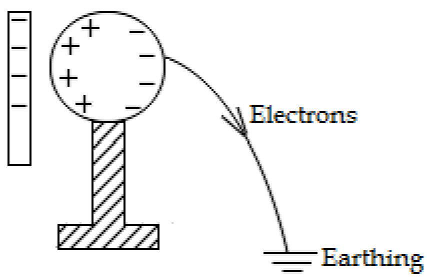
This is the process of making a conductor acquire a charge by the presence of a nearby inducing charge.

Charging a conductor positively by induction

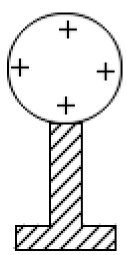
A negatively charged inducing rod is brought near the conductor placed on an insulating stand. The end of conductor near the charging rod is induced with a positive charge and the far end with a negative charge.



In the presence of the inducing charge the conductor is momentarily earthed so that electrons flow to the earth.

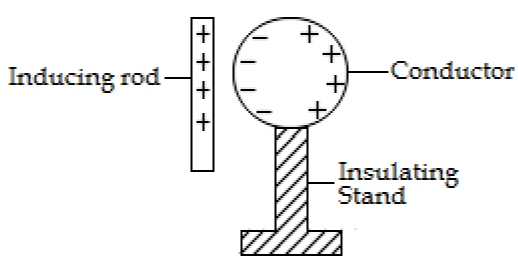


On removing the inducing charge, the conductor remains positively charged.

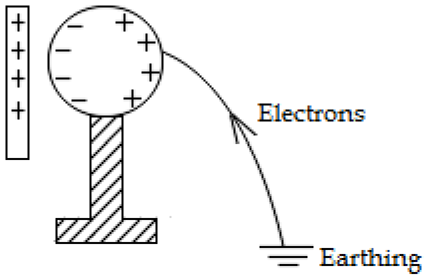


Charging a conductor negatively by induction

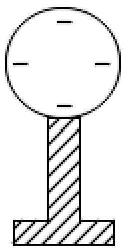
A positively charged inducing rod is brought near the conductor placed on an insulating stand. The end of conductor near the charging rod is induced with a negative charge and the far end with a positive charge.



In the presence of the inducing charge the conductor is momentarily earthed so that electrons flow from the earth to neutralise positive charges on the extreme end of the conductor.

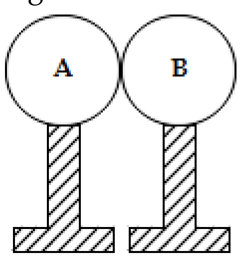


On removing the inducing charge, the conductor remains negatively charged.

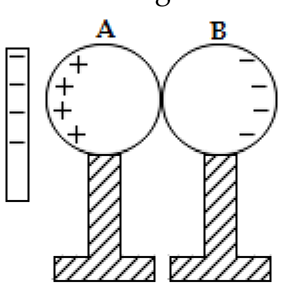


Charging two conductors oppositely at once by induction

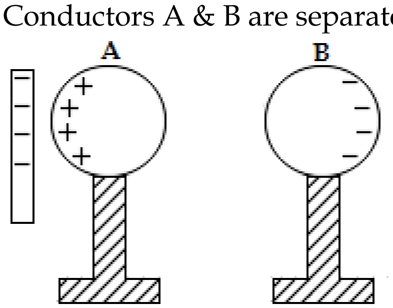
Two uncharged conductors A & B placed on insulating stands are brought in contact to form a single conductor.



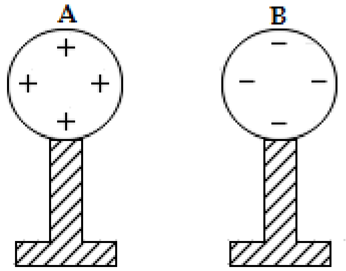
A negatively charged inducing rod is brought near conductor A. Positive charges are induced on A and negative charges are induced on B.



Conductors A & B are separated in presence of the inducing charge.

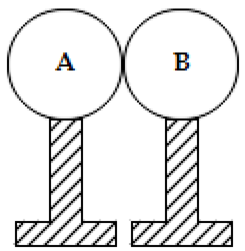


On removing the inducing charge, A is positively charged and B is negatively charged.

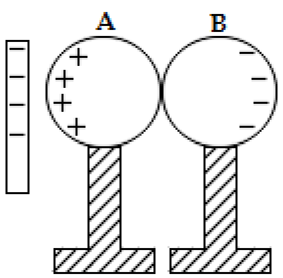


Charging two conductors positively at once by induction

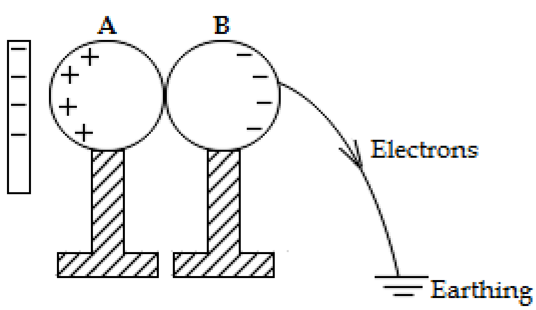
Two uncharged conductors A & B placed on insulating stands are brought in contact to form a single conductor.



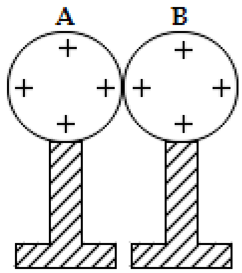
A negatively charged inducing rod is brought near conductor A. Positive charges are induced on A and negative charges are induced on B.



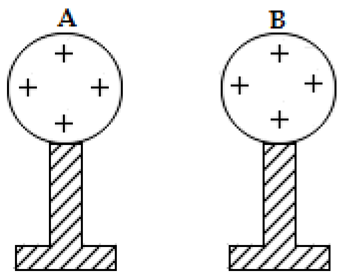
In the presence of the inducing charge the conductor is momentarily earthed so that electrons flow to the earth.



The earthling and inducing rod are removed and the conductors are kept in contact for some time.

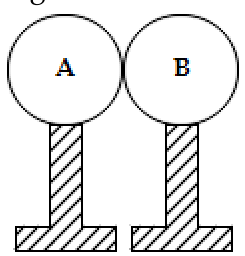


On separating the conductors A & B, each will have a positive charge.

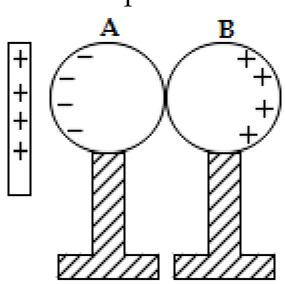


Charging two conductors negatively at once by induction

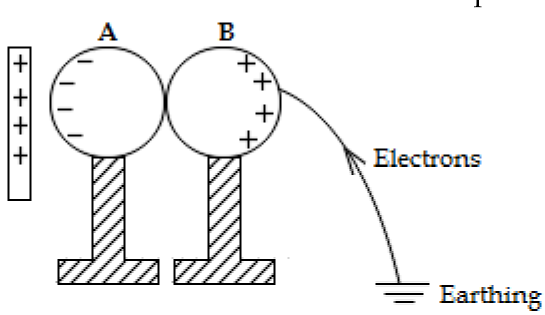
Two uncharged conductors A & B placed on insulating stands are brought in contact to form a single conductor.



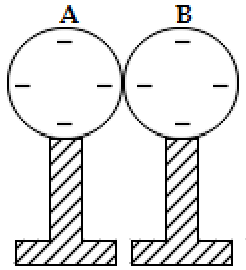
A positively charged inducing rod is brought near conductor A. Negative charges are induced on A and positive charges are induced on B.



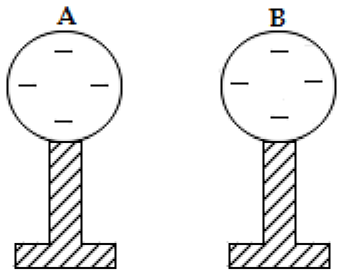
In the presence of the inducing charge the conductor is momentarily earthed so that electrons flow from the earth to neutralise the positive charge.



The earthling and inducing rod are removed and the conductors are kept in contact for some time.



On separating the conductors A & B, each will have a negative charge.

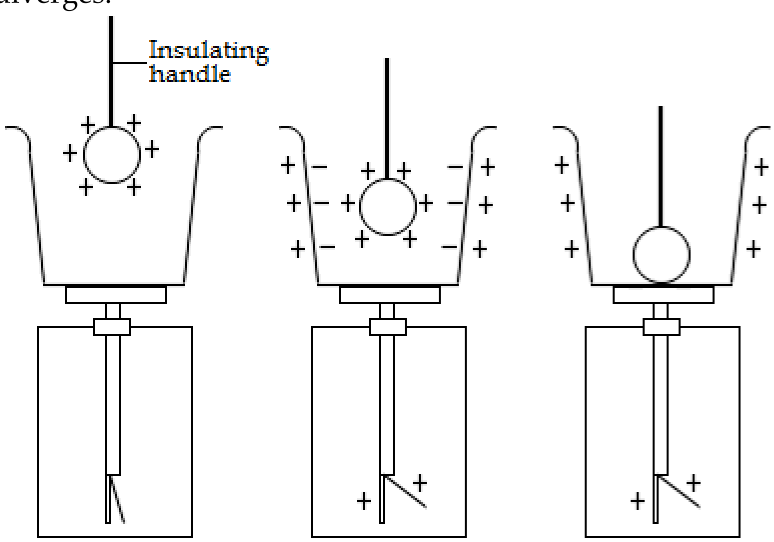


Advantages of charging by induction

1. There is a continuous supply of charge which cannot be exhausted because the original charge is not carried away.
2. The quantity of charge on the inducing rod can be transferred to the conductor being charged

Faraday's ice pail experiment

In this experiment a positively charged metallic ball is carefully lowered into a metallic pail placed on top of the cap of an electroscope. The ball does not touch pail. Negative charges are induced on the inside of the pail and positive charges are induced on the outside. The leaf diverges.



When the ball is moved inside the pail without touching the inner surface there is no change in the divergence of the leaf.

When the ball is allowed to touch the inner surface of the pail, the gold leaf remains diverged but on testing the ball on another electroscope it is found that it has no charge.

Explanation

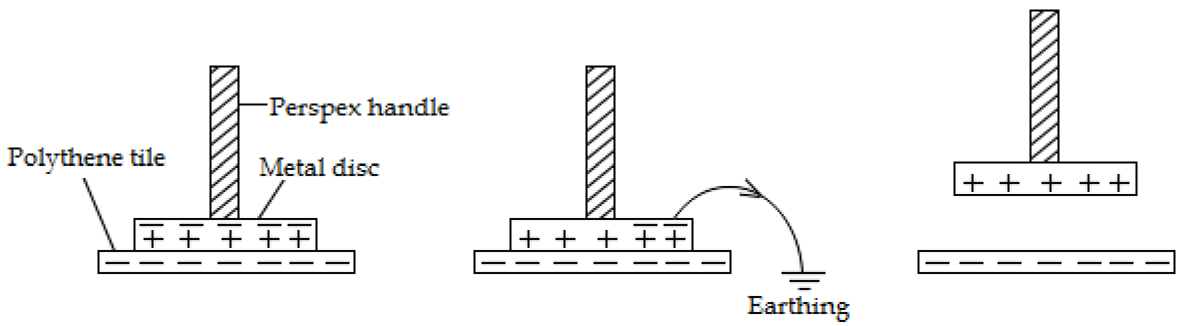
The positively charged ball induces equal negative charges inside the pail and positive charges outside the pail.
When the ball touches the inner surface of the pail, negative charges neutralise the positive charge on the ball and positive charges remain on the outside hence the leaf remains diverged.

Conclusion

When a charged body is lowered into a metal conductor, it induces on the inside of the conductor an equal but opposite charge to its own and on the outside an equal and similar charge to its own.
At all times, the total charge inside the pail is zero. I.e. no charge resides inside a charged hollow conductor.

Electrophorus

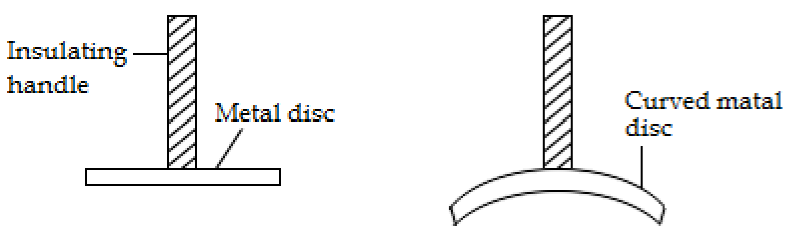
This is a device used to produce any number of positive charges from one negative charge source by electrostatic induction.



A polythene tile is negatively charged by rubbing and then a metal disc with insulated handle is placed on it. Positive charge is induced on its lower surface and negative charge on its upper surface. If the disc is earthed it becomes positively charged.

Distribution of charges on the surface of conductors

A proof plane is used to determine the distribution of charges on a conductor. It is a metal disc with an insulated handle. It is used in conjunction with a gold leaf electroscope. Proof planes with discs of varying curvature are used to fit onto various shapes of conductors.



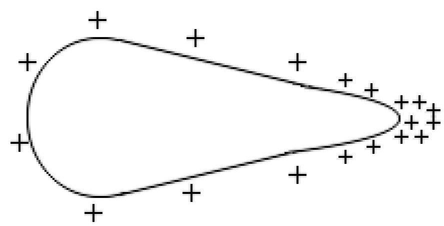
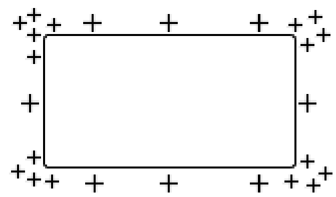
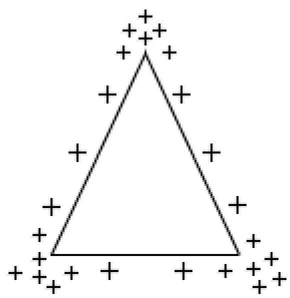
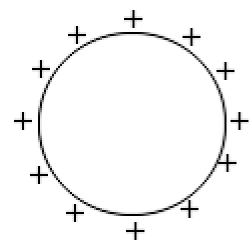
Surface density

This is the quantity of charge per unit area of the surface of the conductor.

$$\text{Surface density} = \frac{\text{Total charge}}{\text{Total surface area}}$$

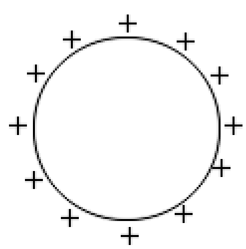
Most charges on a conductor are concentrated at the most curved part of the surface ie at the sharpest points.

Distribution of charges on conductors of different shapes

Pear shape	Cylindrical shape
	
Triangular	Spherical shape
	

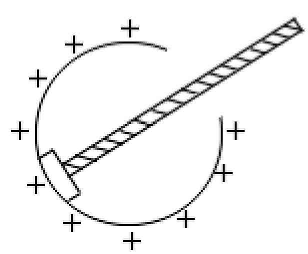
Distribution of charges on a hollow spherical conductor

Outside the sphere



Outside a positively charged sphere, the charges are uniformly distributed. This is determined by using a proof plane in conjunction with the gold leaf electroscope.

Inside the sphere



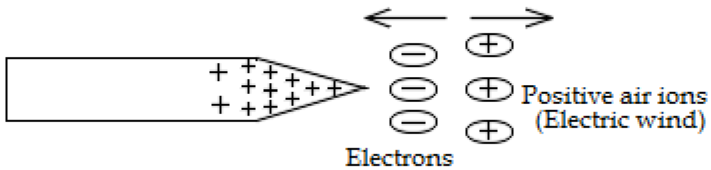
If a proof plane is put inside the sphere and transferred to the gold leaf electroscope there is no increase in divergence of the gold leaf.

This observation means that inside the sphere there are no charges

Action of sharp Points

Charge concentrates at the sharp point of a conductor and the force it exerts on air molecules removes electrons from them and they become positive ions.

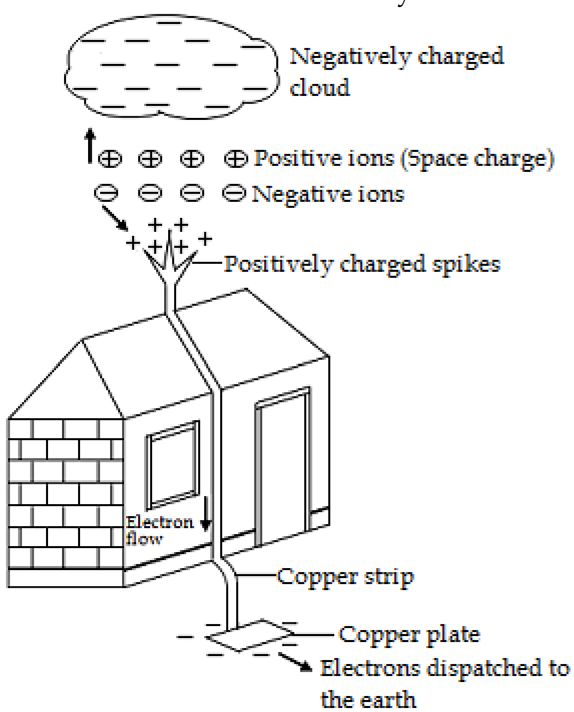
If the sharp conductor is positively charged, it attracts the negative electrons and repels the positive ions stream away as an **electric wind.** The attracted electrons momentarily neutralise the sharp point. This is known as point discharge.



The lightning conductor

A lightning conductor uses action of sharp points to protect tall buildings from lightning. It is made up of a thick copper strip which connects a set of sharp spikes that extend beyond the highest part of a building to a large metal plate buried in the ground.

The lightning conductor provides a low resistance path that accepts any discharge which may occur and conducts it harmlessly to the earth without damaging the building.



How it works

When a negatively charged cloud passes over head, it induces positive charges on the spikes and repels negative charges to the earth through the copper strip attached to a buried copper plate.

The positive charges on the spikes repel the positive ions in the atmosphere towards the cloud which neutralise some of its charges reducing its dangerous effect.

The negative ions are attracted to the spikes and become discharged by giving up their electrons which pass through the copper strip down to the earth. This prevents a buildup of charge on the highest part of the building.

Thunder and lightning

A cloud moving through air becomes charged by friction between air and the cloud.

Since air between the ground and the cloud is an insulator, it prevents the cloud charges from reaching the ground and a nearby cloud with opposite charges.
As the cloud moves, the electrical potential difference becomes too great and the air insulation fails.
A stream of charged particles manages to pass between the clouds and the ground and nearby oppositely charged clouds. When the two opposite charges meet a flash of lightning is produced.
A large amount of electrical energy heats up the air to temperatures hotter than the sun which Causes air to expand explosively producing the sound we hear as thunder.

Electric fields

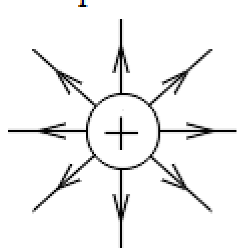
An electric field is the space around an electric charge where it exerts a force on another charge.
An electric field is represented by electric field lines with arrows showing the direction of the field.
The direction of an electric field at any point is the direction of the force on a small positive charge placed at that point.

Properties of electric field lines (lines of force)

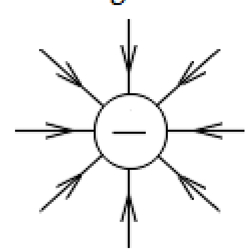
1. They start from positive charges and end at negative charges.
2. Two field lines can never intersect each other.
3. They repel each other sideways.
4. They are perpendicular to the surface of a charged conductor.
5. They do not pass though the conductor.

Nature of the lines of force in the following cases:

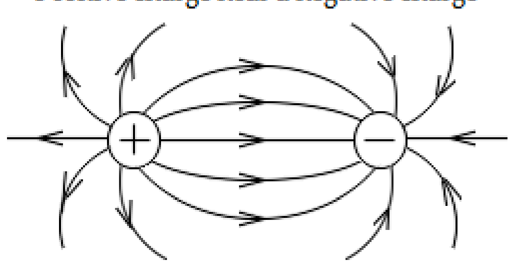
Isolated positive charge



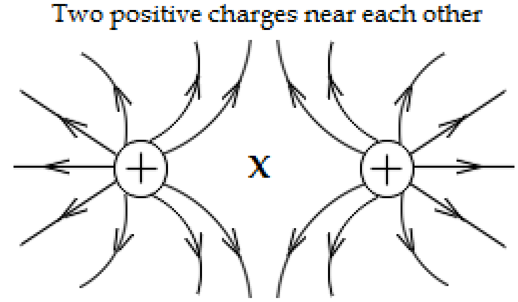
Isolated negative charge



Positive charge near a negative charge

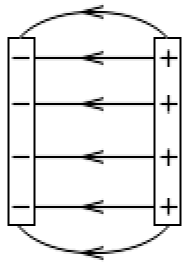


Two positive charges near each other

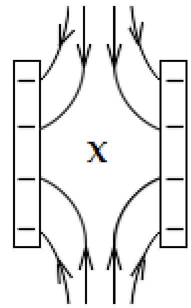


X - Neutral point

Oppositely charged parallel plates

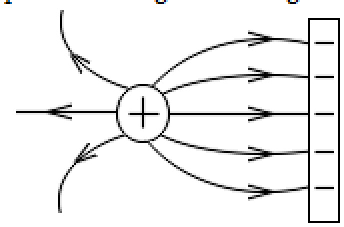


Negatively charged parallel plates

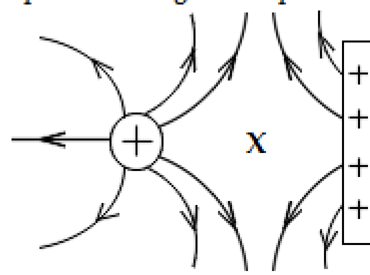


X - Neutral point

A positive charge and a negative plate

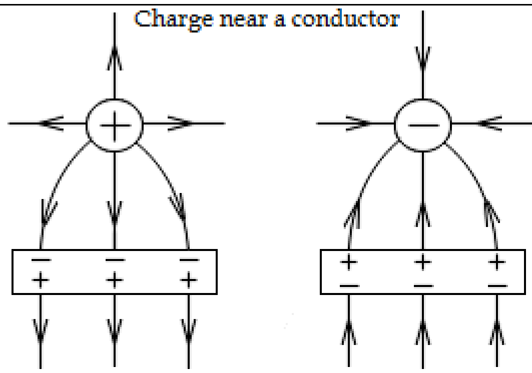


A positive charge and a positive plate

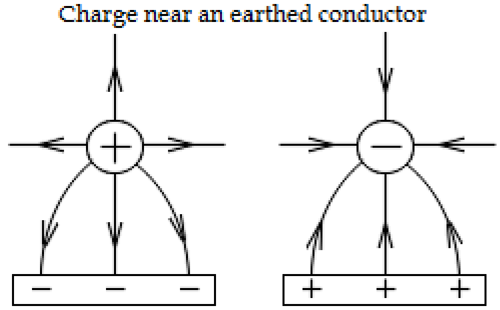


X - Neutral point

Charge near a conductor



Charge near an earthed conductor



Charge near the earth