HEAT TRANSFER

Heat transfer refers to the flow of heat through matter from a region of high temperature (hot body)to a region of low temperature (cold body).

Modes of heat transfer:

There are three ways by which heat is transferred and these are;

- Conduction.
- Convection.
- Radiation.

CONDUCTION:

This is the transfer of heat through matter from a region of high temperature to a region of lowtemperature without movement of matter as a whole.

NOTE:

In conduction, heat flows as a result of direct contact of molecules of a substance i.e. heat istransferred when one molecule contacts another molecule.

Therefore, conduction is best in solids (closely packed particles) and worst in liquids and gases(widely spaced particles).

CONDUCTION IN SOLIDS:

Heat transfer in solids occurs a result of;

- Excess energy of vibrations being passed from one atom to another.
- The excess kinetic energy given to the free electrons near the source of heat being carried bythese electrons as they move to the colder region.

Explanation of conduction in a metal (solid) using kinetic theory of matter:

When one end of a metal is heated, the temperature of the molecules of the metal near the heatsource increases.

The increased temperature increases the kinetic energy of the molecules of the solid thus they beginto vibrate violently. These molecules start to collide with the nearby molecules transferring heat to them. The process continues until heat is transferred to molecules at the other end of the metal.

NOTE:

- Heat transfer in conduction takes place by vibration of molecules but not actual movement of theheated molecules.
- Conduction is faster in good conductors than in bad conductors.

Factors that affect the rate of heat in metals:

- **Temperature difference between the ends of a metal:**

  Heat is transferred quickly when the temperature difference between the ends of the metal ishigh.

- **Length of the metal:**

  Much heat is transferred in a short time when the metal bar is short. Therefore, the rate of heattransfer increases when the metal is of smaller length than when the metal is of longer length

- Cross-sectional area of the metal:

  When the metal is thicker, much heat is transferred in a shortest time than a thin metal at thesame time. The rate of heat transfer in metals with large cross-sectional area and vice versa.

- **Nature of material of the metal:**

  Different materials used to make the metal have different thermal conductivities thus differentrates of heat transfer.

Good conductors of heat:

These are materials that allow heat to pass through them easily. i.e. they conduct heat easily.Examples include;

- All metals e.g. Iron, Aluminium, Copper, Steel etc.

Bad conductors of heat:

These are materials that do not allow heat to pass through them easily. i.e. they don't conduct heateasily.

Examples include;

- All non-metals e.g. Wood, Rubber, Plastics, Glass etc.

Applications (uses) of good and bad conductors of heat:

- Good conductors of heat are used in making of cooking utensils e.g. saucepans, kettles, fryingpans, etc.
- Bad conductors of heat are used in making handles of cooking utensils, insulators since theydon't allow heat to pass through them.

Question 1:

Explain why a metal feels cold when touched on a cold day.

Since a metal is a good conductor of heat, it conducts all the heat away from the hands. Thus, ourhands lose heat and this gives a sensation of coldness.

<u>Question 2</u>:

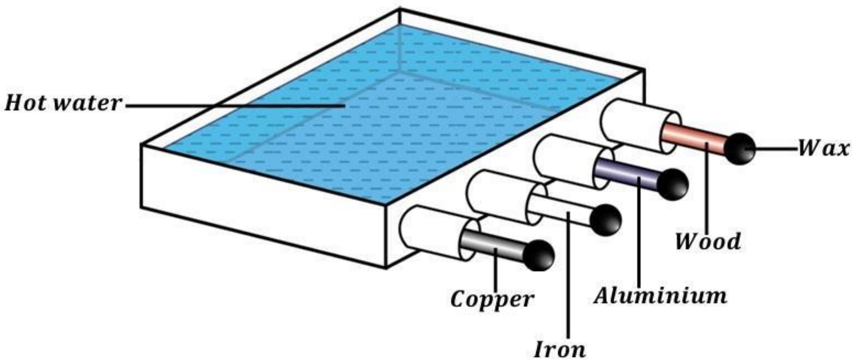
Explain why a cemented floor feels colder than a carpeted floor.

When we put our feet on a cemented floor, it conducts all the heat away from our feet since it is agood conductor of heat. Therefore, our feet lose heat and become cold.

When we put our feet on a carpeted floor, it doesn't conduct any heat from our feet since it's a badconductor of heat. Therefore, our feet do not lose heat thus they remain warm.

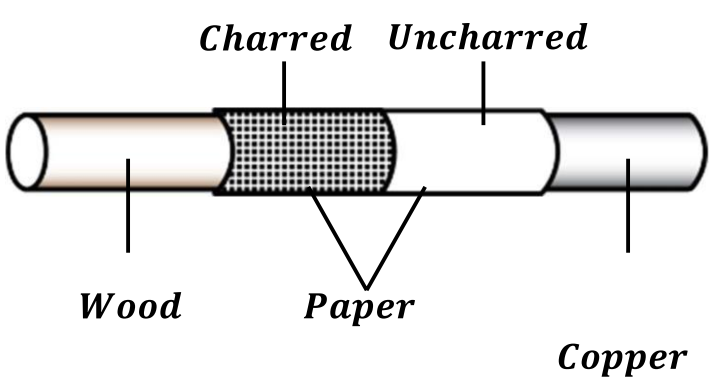
<u>An experiment to compare conductivities of different solids</u>

QN: Describe an experiment to compare the rate of heat transfer in different conductors.



- Identical rods of different materials coated with wax are dipped in hot water.
- After sometime, the wax starts to melt along the rods.
- Wax melts fastest along the copper rod and slowest along the wood rod.
- This shows that copper is the best conductor of heat and wood is the worst conductor of heat.

<u>Experiment to show that wood is a poor conductor of heat</u>:



- A composite rod is made by joining a wooden rod with a copper rod.
- A piece of paper is wrapped round the composite rod around the joint so that the wooden andcopper rod share the paper equally as shown below.
- The composite rod is passed through a Bunsen burner flame several times.

Observation:

- The part of the paper on the wood gets charred (burnt) while the part of paper on copper remainsuncharred (not burnt).

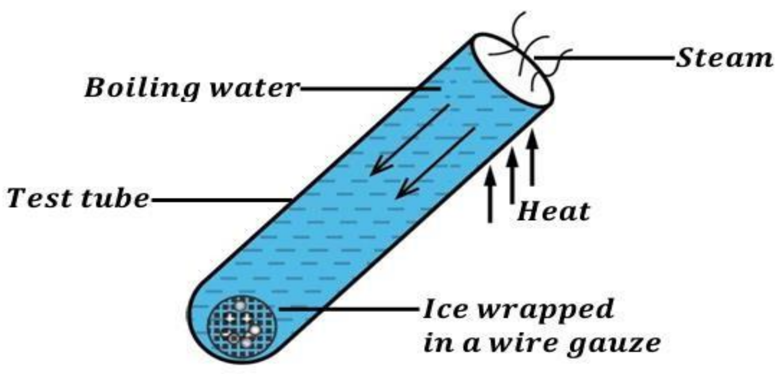
Explanation:

- Copper is a good conductor of heat. Therefore, copper conducts away heat quickly from the paper thus the temperature of part of the paper on it remains low. Hence, the part of the paper oncopper does not char.
- Wood is a poor conductor of heat. Therefore, wood does not conduct away heat from the paper thus the temperature of part of the paper on it remains high. Hence, the part of the paper on woodchars.

CONDUCTION IN LIQUIDS AND GASES:

Liquids and gases transfer heat at a very slow rate i.e. they are relatively poor conductors of heat.This is because their molecules are apart.

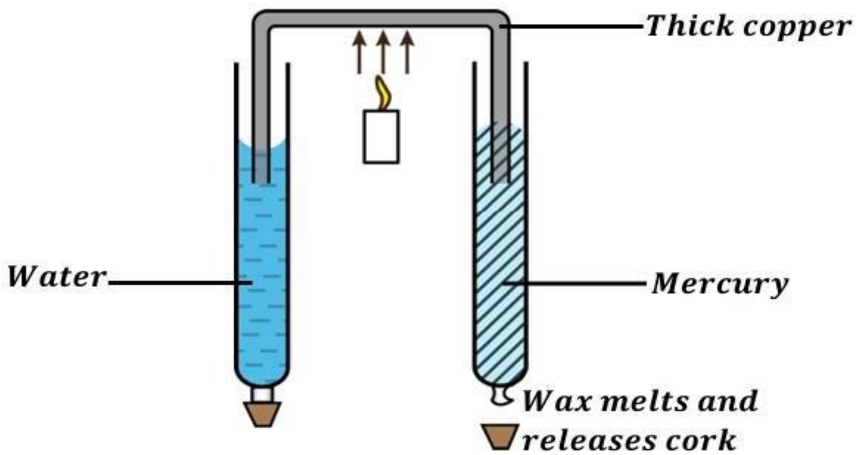
An experiment to show that water is a poor conductor of heat:



- Ice is wrapped in a wire gauze and then placed in the test tube. The wire gauze is used to keep iceat the bottom of the test tube.
- The test tube is then filled with water.
- The water near the mouth of the test tube is heated.

- It is observed that water at the top starts to boil before the ice at the bottom starts to melt.
- This shows that there is little conduction of heat from the top to the bottom by water hence wateris a poor conductor of heat

a<u>n experiment to show that mercury is a better conductor of heat than water</u>:



- Two test tubes are filled with equal volumes of water and mercury respectively.
- A cork is attached to the bottom of each test tube.
- A piece of thick copper rod is bent twice at right angles and its ends are put in the test tubesrespectively as shown above.
- The centre of the copper rod is heated such that heat is conducted equally into water and mercurytest tubes.
- After a short period of time, wax on the mercury-filled test tube melts and the cork falls whilethat on the water-filled test tube remains attached for a long period of time.
- This shows that heat reaches the wax faster through mercury than in water hence mercury is abetter conductor of heat than water.

<u>CONVECTION</u>:

This is the transfer of heat through a fluid from a region of high temperature to a region of lowtemperature by movement of the fluid itself.

NOTE:

- Convection occurs in only fluids (i.e. liquids and gases) because they can flow easily andcannot occur in solids since they can’t flow.
- Convection cannot occur in a vacuum because it requires a material medium.

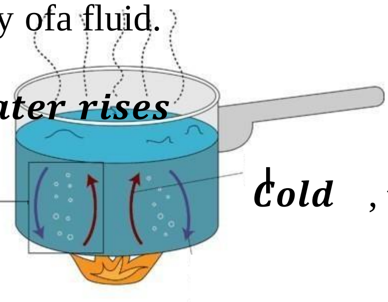
<u>Explanation of convection in fluids</u>:

When a fluid is heated, it expands and becomes less dense than the surrounding cold fluid.The heated fluid rises upwards and the space left is filled with the surrounding cold fluid.

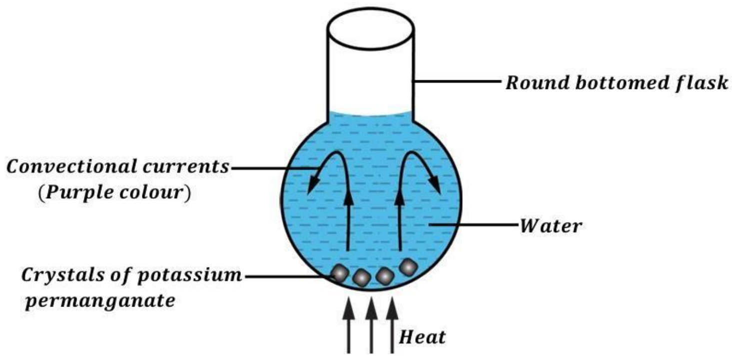
As the warm fluid rises, it gives heat to the surrounding cold fluid thus forming a cyclic movementcalled **convectional currents**.

Definition:

Convectional currents are rising and falling fluid caused by a change in temperature and density ofa fluid.



An experiment to show convectional currents in liquids:



Procedures:

- A round bottomed flask is filled with clean water.
- A few crystals of potassium permanganate are placed at the bottom of the flask using a glasstube.
- The bottom of the flask is gently heated.

Observation:

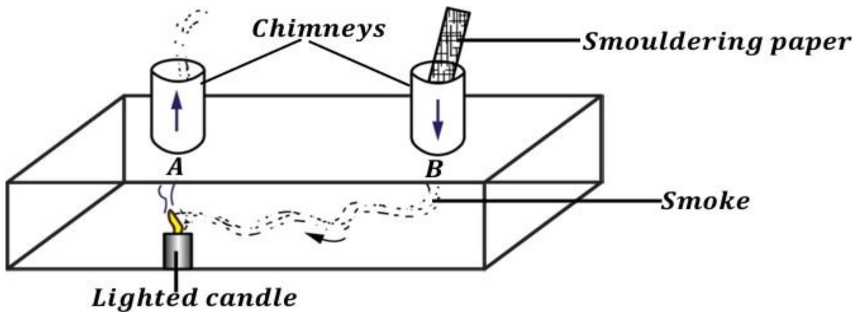
- It is observed that the purple colour of potassium permanganate is seen moving upwards and onreaching the top, it spreads and then moves downwards forming convectional currents.

Explanation:

- When the solution at the bottom of the flask is heated, it expands and become less dense than thesurrounding water thus moving upwards. The surrounding cold and dense water flows to the bottom to replace the risen water.

- So, the water circulates in the flask hence forming convectional currents.

An experiment to show convectional currents in gases:



Procedures:

- Fit two glass chimneys to the top of a box with a glass window.
- Light a candle and place it below chimney A.
- Introduce smoke into the box by placing a piece of smouldering paper in the other chimney B.

Observation:

- It is observed that all the smoke from chimney B moves out of the box through chimney A abovethe candle.

Explanation:

- When the air above the candle is heated, it expands and becomes less dense than the surroundingair thus rises and moves out through chimney A.
- Since the surrounding air (smoke) is cooler and denser, therefore, it sinks into the box throughchimney B to replace the risen hot air.
- The difference in densities of the air at the different chimneys sets up a convectional current.

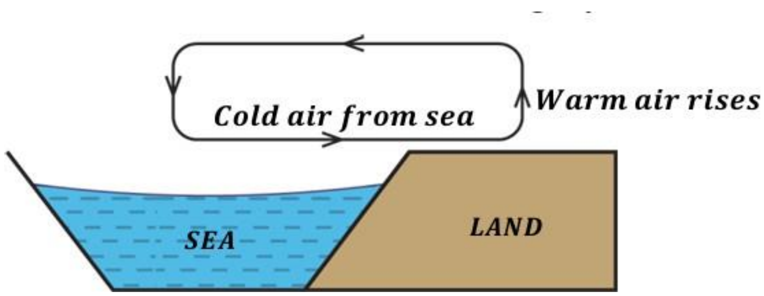
NOTE:

Convection occurs much more readily in gases than in liquids because they expand much more thanliquids when heated.

APPLICATIONS OF CONVECTIONAL CURRENTS IN DAILY LIFE

a) **<u>Sea breeze</u>:**

This is the cool air that blows from sea to land during day time.

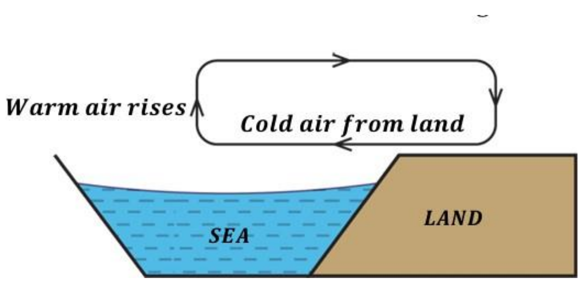


- During day, the land is heated more than the sea by the sun because land is a good absorberof heat and has a lower specific heat capacity than the sea.
- The increase in temperature of land causes the air above the land to expand and become lessdense thus rising up.
- The space left by the warm air above the land is filled up by the cold air

that blows from sea.This results into a sea breeze during day time

b) **<u>Land breeze</u>:**

This is the cool air that blows from land to sea at night.



- At night, the land is no longer heated by the sun so it cools very rapidly than the sea since land is a good emitter of heat than the sea. Therefore, the sea is warmer than the land at night.
- The warm air above the sea rises up since it is less dense.
- The space left by the warm air above the sea is filled up by the cold air that blows from land.
- This results into a land breeze at night.

Please copy these notes in your physics book, OR if not sure where to start write at the back or whatsapp the teacher for guidance (0780608296)

c) **<u>Ventilation</u>:**

- Air inside a room is heated up on a hot day. This heated air (warm air) expands and becomes lessdense thus rising up and flow out through the ventilators.
- The space left by the risen warm air is filled up with fresh cool air which passes through thewindows and the doors.
- This results into circulation of air in the room thus forming convectional currents.

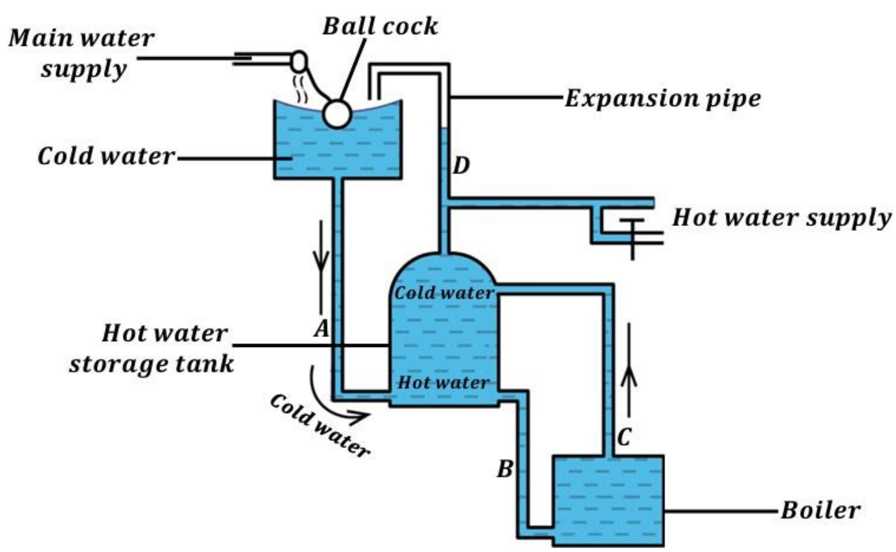
<u>Question1</u>:

Explain why ventilators are constructed above the windows and doors.

The ventilators help to move out hot air from the room. Since hot air is less dense than cold air, itrises up and moves out of the room through these ventilators. The cool air which is denser sinks into the room through the windows and doors. This circulation of air helps to cool the room.

If the ventilators were put near the floor, the hot air would not leave the room but just stays at theupper part of the room thus keeping the room hot.

d) **<u>Hot water domestic supply system</u>:**



- Cold water is supplied to the boiler through the cold-water supply pipes A and B.

- In the boiler, cold water is heated, expands and becomes less dense thus raising up to the hot water storage tank through pipe C. At the same time an equal volume of cold-water flows to the boiler through the supply.
- As more cold water is supplied to the boiler, hot water is displaced upwards and supplied to the hot water supply taps.

NOTE:

- ❖ The expansion pipe D allows escape of dissolved air which comes out of the water when it is heated. Therefore, if the expansion pipe is not there, the dissolved air which comes out when water is heated may cause air locks in the pipes thus causing explosion.

- ❖ Pipes A and B are connected to bottom part of hot water storage tank and boiler respectivelybecause they carry cold water which is denser.
- ❖ Pipe C leaves the boiler at the top and enters the hot water storage tank at the top part becauseit carries hot water which is less dense.

Question 2:

Explain how a chimney makes life comfortable in a kitchen.

A chimney helps to drive out smoke and oily-filled air during cooking thus reducing indoorpollution in the kitchen.

During cooking, smoke and some oily-filled air which are denser are produced thus rising up andmoves out of the kitchen through the chimneys thus making the kitchen more conducive.

e) Electric kettles have their heating coil at the bottom:

The heating coil (element) of an electric kettle is placed at the bottom. Therefore, one can boilany amount of water that can cover the element effectively. Hot water which is less dense thancold water rises above the hot element to the top of the water and the denser cold water sinks down to the hot element. This sets up convection currents which make the water to boil uniformly

<u>RADIATION</u>:

This is the transfer of heat from one place to another by means of electromagnetic waves.

Since electromagnetic waves do not require a material medium to transfer their energy, thereforeradiation does not need a material medium for heat energy to be transmitted.

Examples of heat transfer by radiation include;

- Heat from the sun reaching the earth.
- A hot body or fire losing heat to the surrounding.

NOTE:

- Heat transferred by means of radiation can travel through a vacuum.
- Radiation is the fastest means of heat transfer since it travels at the speed of light.
- The energy from a hot body is called <u>radiant energy</u>.

<u>Factors affecting the rate of heat transfer by radiation</u>:

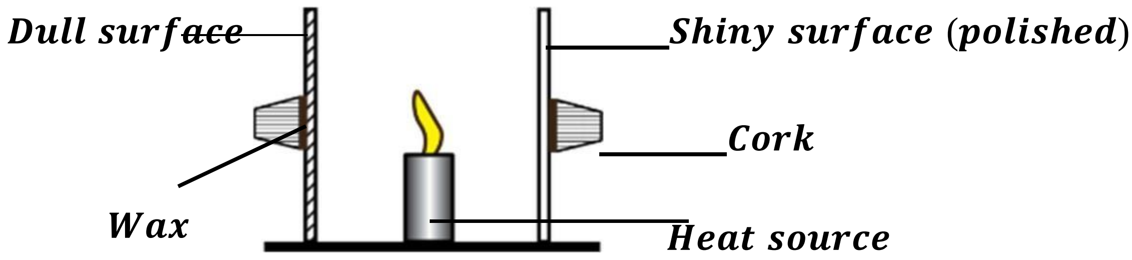
- <u>Temperature of the body</u>: *A hotter body radiates heat faster compared to a cold body.*
- <u>Surface area of the body</u>: *Bodies with large surface areas (bigger areas) radiate much heatenergy per second.*
- <u>Nature of the surface of the body</u>: *Dull surfaces radiate heat energy faster than highly polishedsurfaces.*

GOOD AND BAD ABSORBERS OF HEAT

<u>Good absorbers</u>:	These absorb most of the heat radiations and reflects less heat energy. Dull and black surfaces absorb most of the heat and reflect a few so they are good absorbers of heat.
<u>Bad absorbers</u>:	These don't absorb most of the heat radiations but reflect most of heat radiations. Shiny or polished surfaces reflect most of the heat radiations so they are bad absorbers of heat.

Please copy these notes in your physics book, OR if not sure where to start write at the back or whatsapp the teacher for guidance (0780608296)

An experiment to show the absorption of radiation in a surface:



Procedures:

- A dull and shiny (polished) surface are placed vertically at a short distance from each other.
- A cork is fixed on the back side of each surface by using wax.
- A heat source is placed mid-way between the two surfaces so that each surface receives the sameamount of radiation.

Observation:

- It is observed that the wax on the dull surface melts first and the cork falls off before the wax onthe shiny surface melts.

Explanation:

- A dull surface absorbed much heat faster than the shiny surface thus a dull surface is a good absorber of heat radiation than the shiny one. The shiny surface just reflects the heat away from it.

Applications of good and bad absorbers

- Buildings in hot countries are painted white and roof surfaces are made shiny because white andshiny surfaces are bad absorbers of heat radiation thus keeping the rooms cool.
- Petrol tanks on vehicles are polished to reflect away radiant heat.
- White coloured clothes are worn in dry season so that they reflect away heat thus keep us cool
- Sweaters and blankets are made with dull colours to absorb heat.
- The bottoms of cooking utensils are made black to absorb heat from the fire.

GOOD AND BAD EMITTERS OF HEAT

Basically, we say that the body emits heat if it can cause the temperature of a nearby body toincrease. A body relatively can't emit heat if it can't absorb it.

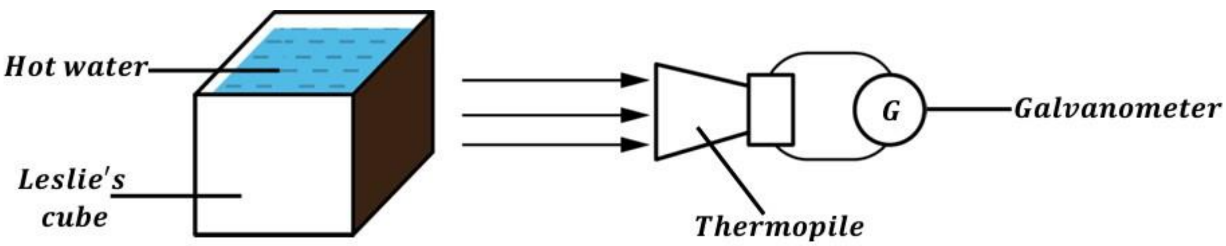
Good emitters:	These absorb most of the heat radiations and reflects less heat energy. Dull and black surfaces emit most of the heat so they are good emitters ofheat.

Bad emitters:	These don't absorb most of the heat radiations but reflect most of heatradiations. Shiny or polished surfaces reflect most of the heat radiations so they are bademitters of heat.

NOTE:

- Good absorbers of heat are also good emitters of heat.
- Bad absorbers of heat are also bad emitters of heat.

An experiment to show good and bad emitters of heat (radiators of heat)



Procedures:

- A hollow copper cube (Leslie's cube) with each side having a different surface (i.e. black, whiteand shiny surface) is used.
- The cube is filled with hot water.
- The radiation from each surface is detected by a thermopile and the deflection of thegalvanometer observed.

Observation:

- The deflection of the galvanometer is greatest when the thermopile is facing the black surfaceand least when facing the shiny surface.

Explanation:

- The dull black surface emits a lot of heat radiation than the shiny surface thus a great deflection of the thermopile. Therefore, the dull and black surface is a good radiator or emitter of heat whilea shiny or polished surface is a poor emitter of heat radiations.

Applications of good and bad emitters

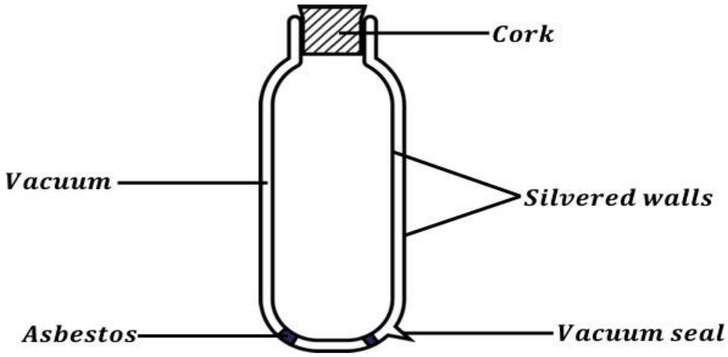
- Tea pots and kettles are polished so that they don't emit heat to the surrounding thus keepingliquids inside hot.
- Cooling fins on refrigerators are painted black so that they can emit heat quickly to thesurrounding.

APPLICATIONS OF RADIATION

VACUUM FLASK (THERMOS FLASK):

This is a flask with two silvered walls enclosing a vacuum which keeps its contents at a fairlyconstant temperature.

The vacuum is designed to either keep hot things hot or cold things cold.



How heat losses are minimised in a vacuum flask:

- ❖ **Cork:** A cork is a poor conductor of heats so it doesn't allow heat to pass through it.Therefore, it minimizes heat loss by conduction.
- ❖ **Vacuum:** A vacuum is a space without air. It minimizes heat loss by convection andconduction.
- ❖ **Silvered surfaces:** These are highly polished surfaces which minimize heat loss byradiation.

  Silvered surfaces are poor radiators (emitters) of heat, therefore noheat is allowed to go in and out of the flask.

NOTE:

- □ The vacuum seal seals the vacuum. Therefore, if its broken, the vacuum will no longer exist thus causing heat losses through convection and conduction.
- □ When the hot liquid is kept in a vacuum flask for a long period of time, it eventually gets cold. This is because little heat is lost at a smaller rate since all flasks are not too perfect whereby some corks may conduct some heat, frequent opening of the flask etc.

CHOICE OF DRESSES AND CLOTHES:

On a hot day, a white dress is preferred to a dull dress because it reflects most of the heatradiations that fall on it hence keeping the body cool.

On cold days, a dull or black woollen dress is preferred because it absorbs most of the heatradiations thus retaining it for a longer period of time.

a) **GREEN HOUSE EFFECT:**

The greenhouse effect is a natural process that warms the Earth's surface. When the radiations from the sun reaches the earth's atmosphere, some it is reflected back and the rest is absorbed bythe greenhouse gases in the atmosphere. The greenhouse gases include water vapour, carbon dioxide, ozone and other gases.

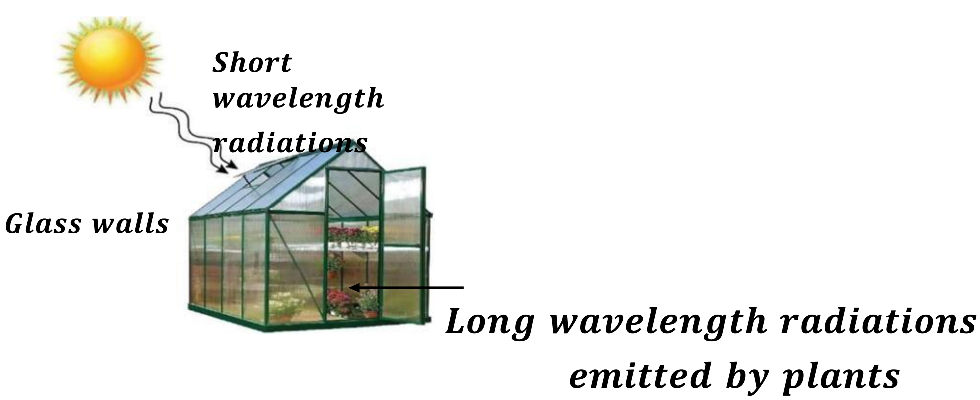
After absorbing the radiations from the sun, these greenhouse gases re-radiate these heatradiations to the earth thus warming the atmosphere of the earth's surface.

NOTE:

- When human activities like land clearing, deforestation, and burning fossil fuels increase, they increase the concentration of the greenhouse gases in the atmosphere thus causingthem to absorb more heat from the sun. This increased absorption of heat radiations fromthe sun leads to excessive warming of the earth. This is called **global warming**.

GREEN HOUSE

A green house is a house that supports plant growth by allowing in radiations from sun and preventing radiationsemitted by the green plants from escaping



How a green house works:

- The sun emits radiations of short wavelength to the earth. These radiations enter the green housethrough the glass walls.
- The plants and soil in the green house absorb these radiations hence their temperature is raisedthus becoming warmer.
- The warm plants and soil in the green house re-radiate (re-emit) radiations of long wavelength.
- Since long wavelength radiations are less penetrative, they are unable to pass through the glasswalls of the green house thus causing the temperature inside to continue rising.

EXERCISE:

1. a) Explain why the sea remains cooler than land during daytime and warmer than land at night.

   b) State two factors that affects the rate of heat transfer along a metallic rod.

   c) Describe an experiment to show that water is a poor conductor of heat.

2. a) Draw a well labelled diagram of a thermos flask.

   b) Explain how the features on the thermos flask above enables to keep a liquid warm.

3. State two circumstances where the warm liquid in the flask above can get ultimately cold. Explain the following observations;

   i) A person should crawl on the floor in a smoke-filled room.

   ii) Ventilators are put near the ceilings of houses.

   iii) Houses in North-African countries like Egypt are painted white.

   iv) Flames of fire move upwards.

4. a) Distinguish between Conduction and radiation.

   b) Explain why the metallic blade of the knife feels cold on a cold day.

   c) Describe an experiment to show that wood is poor conductor of heat than copper.

5. a) Explain why a black coat is usually worn on a cold otherwise not on a hot day.

   b) In an experiment to demonstrate the poor conductivity of water, ice is wrapped in a wiregauze. Explain why this is so.

6. a) Define the term radiation.

b) Explain how a vacuum flask is able to keep a cold liquid cool for a long period of time.

c) Explain how global warming occurs in the earth's atmosphere.

7. Explain the following observations;

   i) Blankets are made of dull colours.

   ii) Car radiators are coiled and painted black.

8. A swimmer prefers to put on a wet cloth when diving in cold water. a) Define the term good emitter of radiation.

   b) Describe how a green house is able to support plant growth.

9. a) Explain the greenhouse effect and how it affects the earth's atmosphere.

   b) Explain why solar panels are painted black.

10. a) Describe an experiment to show convection in liquids.

    b) Explain why electric kettles have their heating element at the bottom.

THERMAL EXPANSION OF MATTER

All the three states of matter (solids, liquids and gases) change in volume when heated

Definition:

Expansion is the increase in size of matter whenever matter is heated.This increase in size of an object occurs in all directions.

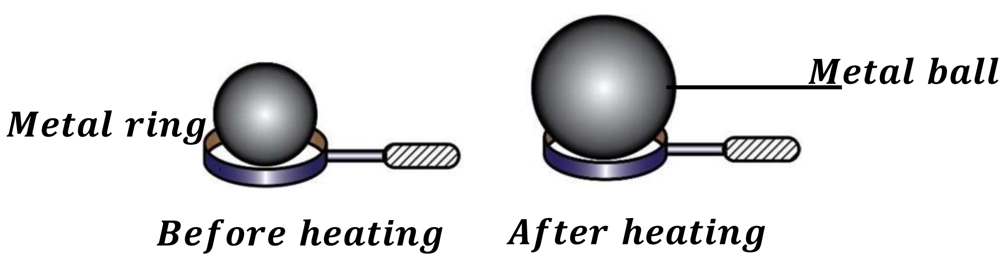
Definition:

Contraction is the decrease in size of matter whenever matter is cooled.

EXPANSION IN SOLIDS

All solids expand when heated. Some solids expand greatly and others very little.

An experiment to demonstrate thermal expansion in solids:



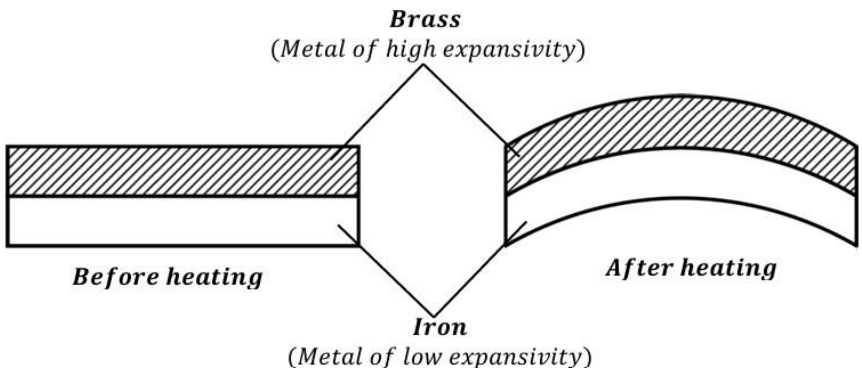
- A metal ball which just passes through the metal ring is used.
- The metal ball is heated for some time.
- It is observed that after heating the ball, it could not pass through the metal ring. This is becausethe ball has expanded when heated.
- When the metal ball is cooled, it passes through the metal ring again. This indicated that oncooling, the metal ball had contracted.

APPLICATIONS OF THERMAL EXPANSION

Thermal expansion in solids is applied in the following;

a) **Bimetallic strip:**

This is a strip made when two metals of different expansion rates are joined together e.g. Brass

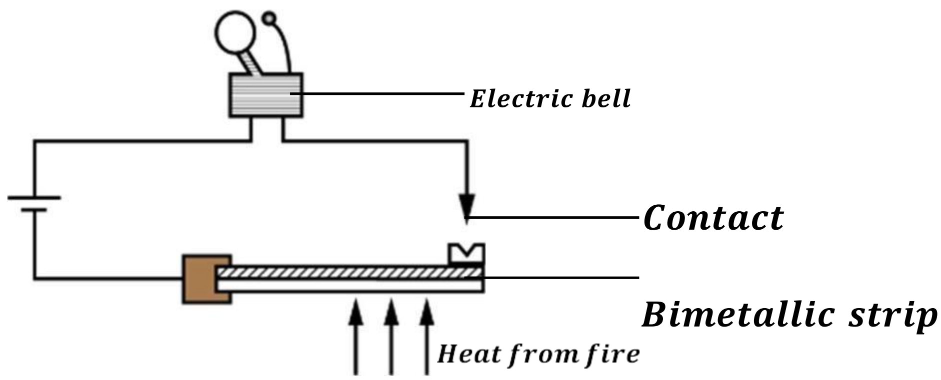


When a bimetallic strip is heated, it forms a curve with a metal that expands more on the outsideand the metal that expands less on the inside.

Uses of bimetallic strips:

- They are used in ringing bells of fire alarms.
- They are used in thermostats in electrical appliances.

Fire alarms:

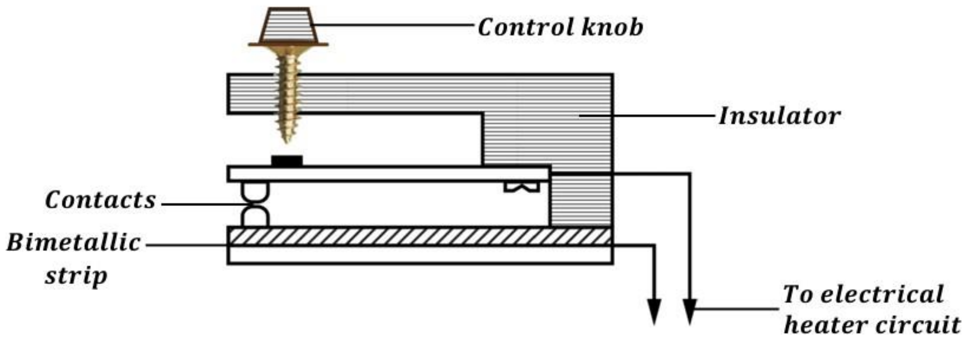


- When there is a fire outbreak in a room, the bimetallic strip is heated by fire. This causes it to bend outwards thus completing the electrical circuit.
- When the circuit is complete, current flows to the electric bell thus causing it to ring.

Thermostats:

A thermostat is a device that keeps the temperature of a room or an electrical appliance to remain constant.

Thermostats are used in the heating circuits of electric flat irons.

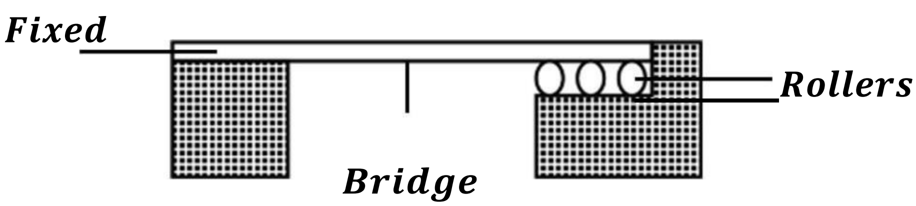


- The control knob is set to the required temperature.
- On reaching the required temperature, the bimetallic strip bends away thus breaking the circuit atthe contacts. This switches off the heater.
- On cooling, the bimetallic strip makes returns back to its original shape and makes contact againthus completing the circuit. This switches on the heater.

Other applications of thermal expansion (Disadvantages of expansion):

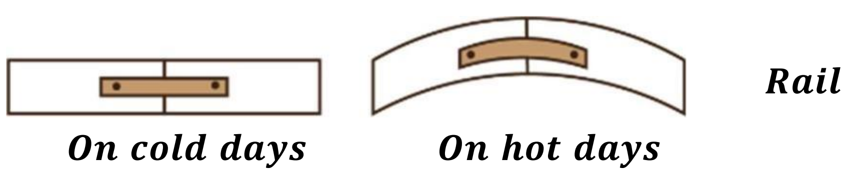
b) Bridges:

Girders in bridges are made of mainly steel. During cold days bridges contract and during hot days, the bridges expand. In order to allow room for expansion and contraction in bridges, the bridge is constructed with one end fixed and the other end placed on rollers. This helps it contractand expand freely without damaging the bridge.

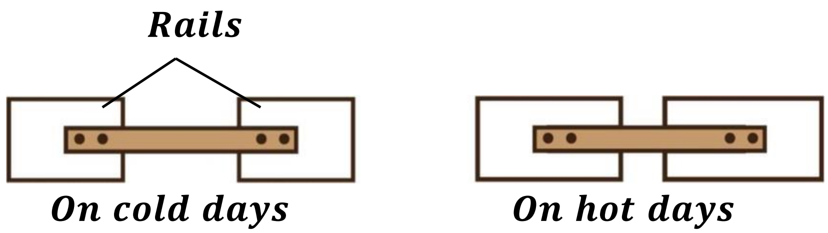


c) Railways:

On a hot day, the rails are heated and they and they are bent due to expansion. This causes themto get seriously damaged.

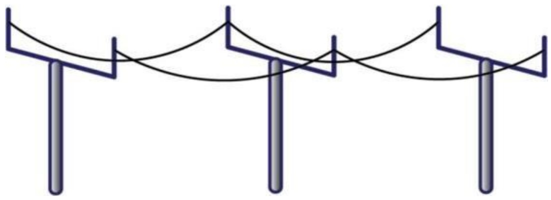


In order to give room for expansion during hot days, railway lines are constructed with gapsbetween the rails.



d) **<u>Transmission wires</u>:**

the wires used in transmission of electricity and telephone cables are loosely fixed (sag) in order to allow them expand freely during hot days and contract

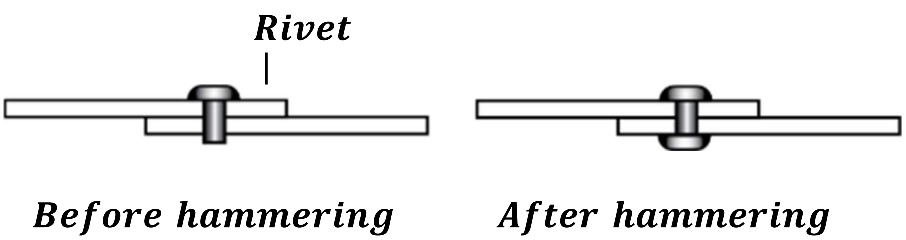


freely during cold days.

e) **<u>Rivets</u>:**

Rivets are tight joints obtained by riveting two metals together.

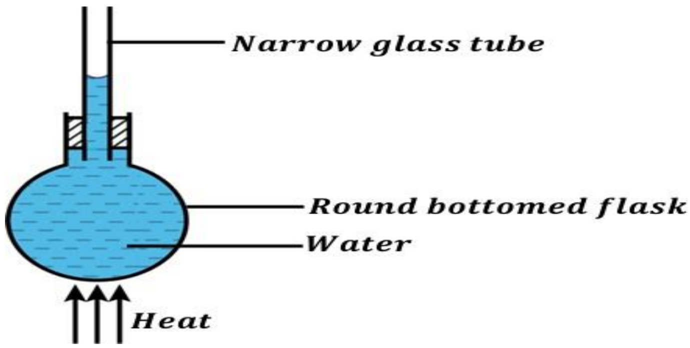
A hot rivet is pushed through a hole between two metals to be joined together and its end ishammered flat. On cooling, it contracts and pulls the two metals together.



EXPANSION IN LIQUIDS:

Liquids expand when heated. Different liquids have different expansion rates when equally heated. Liquids expand more than solids since their molecule are far apart compared to those of solids thus their intermolecular forces are weak.

<u>An experiment to demonstrate expansion of a liquid e.g. water</u>:



- The flask is completely filled with coloured water.
- A narrow glass tube is passed through the hole of the cork and the cork is fixed tightly into theflask.
- The initial level of water in the narrow glass tube is observed.
- The bottom of the flask is then heated.
- The new level of water in the narrow glass tube is observed.

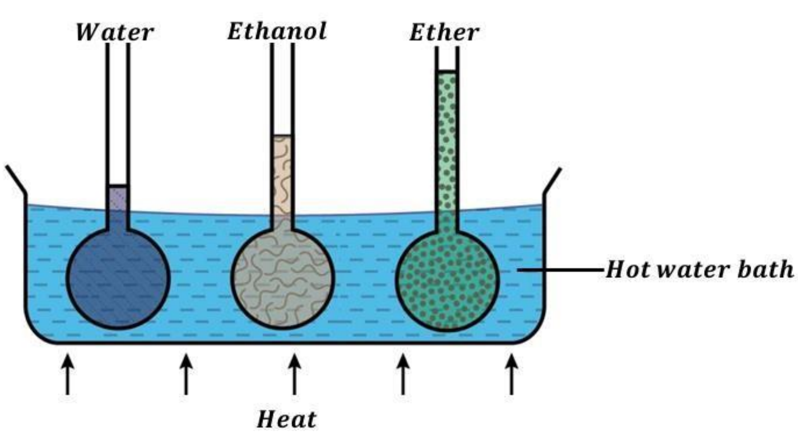
Observation:

It is observed that the level of water in the narrow glass tube first falls and then starts to rise again.

Explanation:

- When the flask is heated, the flask gets heated first before the heat is passed to the water inside it.Therefore, the flask expands first and increase in volume before the water causing a fall in the water level.
- However, when the heat reaches the water, it expands and increase in volume thus its level startsto rise in the narrow tube.

An experiment to compare the expansions of different liquids:



- Three identical glass flasks are filled with water, ethanol and ether respectively to the same level.

- The glass flasks are heated by placing them in hot water which is maintained at the sametemperature.
- It is observed that after some time, the liquid levels rise to different levels. This shows thatdifferent liquids expand differently for the same temperature change.
- It is also observed that ether expands more than ethanol and water.

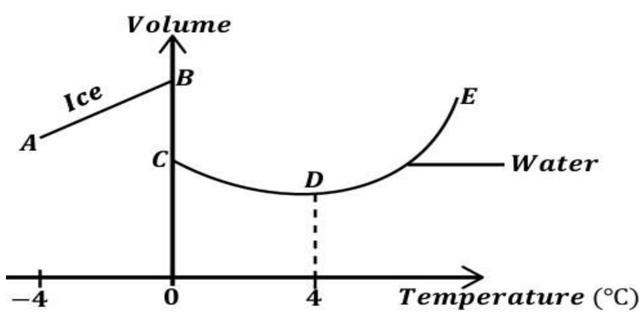
ANOMALOUS (ABNORMAL) EXPANSION OF WATER

Liquids expand steadily when heated i.e. when their temperature increases. Water has an abnormal behaviour whereby when its temperature rises from 0°C to 4°C, it contractsinstead of expanding. This situation is referred to as the **anomalous expansion of water**.

Definition:

Anomalous expansion of water is the abnormal behaviour of water whereby it contracts instead ofexpanding when its temperature rises from 0°C to 4°C.

Volume against temperature graph showing expansion of water



AB: As ice is heated, it expands until when its temperature reaches 0°C where it melts to form water.

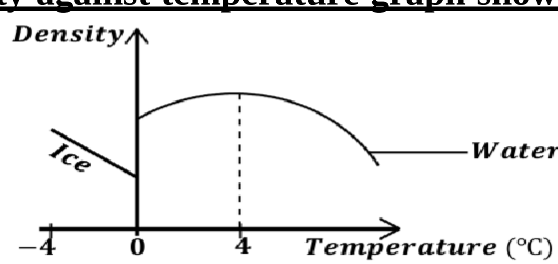
BC: Ice melts to form water at 0°C.

CD: As the temperature rises, the water 0°C contracts until 4°C.

DE: As the temperature exceeds 4°C, water starts to expand steadily.

From the graph, water has its minimum volume at 4°C. Thus, the density of water is maximum whenthe temperature is 4°C.

Density against temperature graph showing expansion of water



From the graph, the density of water is maximum at 4°C.

NOTE:

- □ At 0°C, the volume of ice is greater than the volume of water. Therefore, the density of ice is less than the density of water. This explains why ice floats when mixed with water.

Question: Explain why ice floats on water.

This is because for a given mass of ice at* 0°C*, its volume is always greater than the volume of water. Therefore, the density of ice is always less than the density of waterthus causing it to float on water.

<u>Biological importance of anomalous expansion of water</u>

QN: ***Explain how anomalous expansion of water helps to preserve the lives of aquatic animals.***

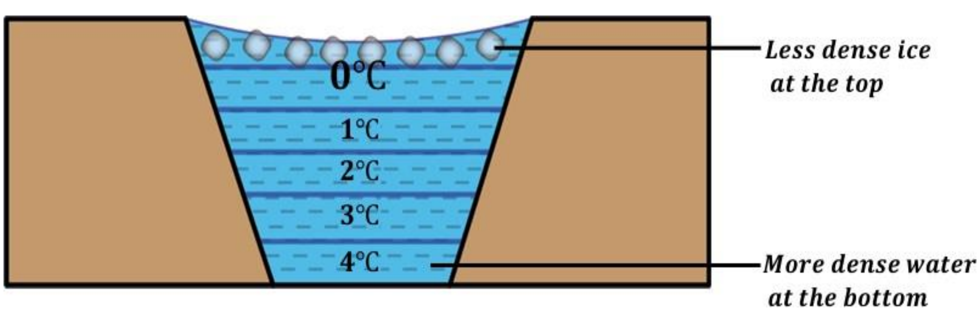
Preserving aquatic life in ponds and lakes:

The effect of anomalous expansion of water is that the coldest water always floats on top of thesurface of the other water since it is less dense.

Since water at 4°C is the heaviest (denser), this water settles at the bottom of the lake and thelightest(less dense) water settles at the top layer of the lake.

During winter, the water at the top is the first to freeze to ice. Since ice is a poor conductor of heat, itinsulates the rest of the water below it from the coldness of the winter.

This helps to preserve the lives of aquatic animals in water.

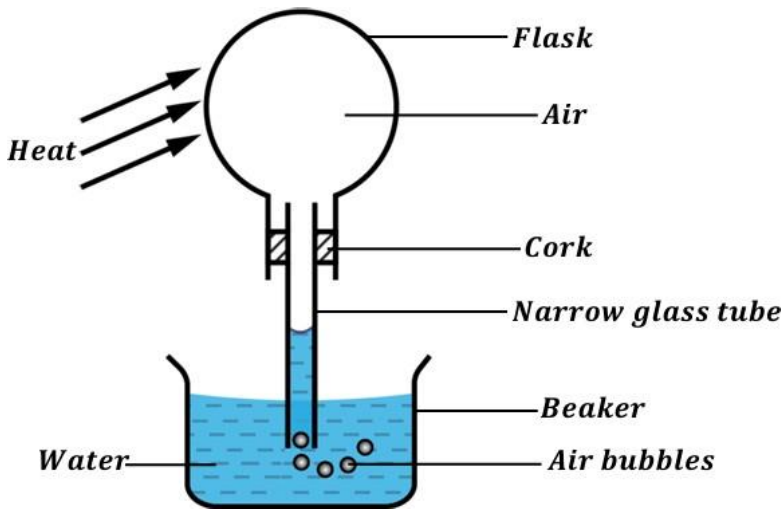


NOTE: Anomalous expansion also helps in weathering of rocks.

<u>Disadvantages of the abnormal expansion of water</u>:

- It prevents water from being used as a thermometric liquid.
- It causes the bursting of water pipes when water flowing through them freezes

EXPANSION IN GASES



When a gas is heated, the gas molecules gain more energy and move further apart thus occupyingmore space. Therefore, gases expand more than the liquids and solids since their molecules are widely spaced and their intermolecular forces are very weak.

<u>An experiment to show expansion in gases</u>:

- Water is poured in a beaker.
- A narrow glass tube is passed through the hole of the cork and the cork is fixed tightly into theflask.
- The flask is then inverted and dipped in the beaker filled in water.
- The flask is then gently heated.
- It is observed that level of water in the narrow glass tube falls and air bubbles are seen coming out from the other end of the tube. This shows that air expands when heated and pushes the waterin the tube downwards.
- On cooling the flask, air in the flask contracts and water rises up in the narrow glass tube sincemore space has been created in the flask.

APPLICATIONS OF EXPANSION IN GASES:

It is applied in;

Hot air balloons:

When air in the balloon is heated, it expands and becomes less dense thus rising.

LIGHT

Light is a form of energy that travels in a straight line and enables us to see. Light is often produced by very hot bodies. The study of light is called **optics.**Objects are only seen if light from them enters our eyes.

LUMINOUS AND NON LUMINOUS OBJECTS

Luminous objects are objects are objects that produce their own light.

Examples include: The sun, candles, the torch, bulb, lamps.

Non luminous objects are objects that we see but don't produce their own light. They reflect it fromluminous sources.

Examples include: The moon, human body, a wall, books, plants.

OPAQUE, TRANSLUSCENT, TRANSPARENT OBJECTS

1. **OPAQUE OBJECTS**

These are objects which do not allow light to pass through them.They include the following;

- Wall
- Human body
- Wood
- Etc

2. **TRANSLUSCENT OBJECTS**

These are objects which allow little light to pass through but we cannot see through them.They include the following;

- Oiled paper
- Some glasses used in toilet and bathroom windows
- Some iron sheets

3. **TRANSPARENT OBJECTS**

These are objects which allow light to pass through and we can see through them.Examples include;

- Glass car windscreens
- Colourless liquids
- Spectacles

TERMS USED IN LIGHT

(i) A ray

This is the direction of the path followed by light.

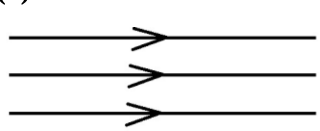
It is represented in diagrams by a straight line and an arrow.

(ii) A beam

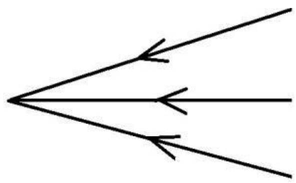
This is a group of light rays.

Types of beams

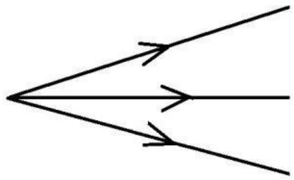
(a) Parallel beam



(b) Converging beam



(c) **Diverging beam**



PROPERTIES OF LIGHT

- ✓ Can travel in a straight line
- ✓ Can be reflected and refracted.
- ✓ Can be polarized
- ✓ Has a velocity of 3.0×10^8m/s in vacuum or air.
- ✓ Can travel through a vacuum.

RECTILINEAR PROPAGATION OF LIGHT

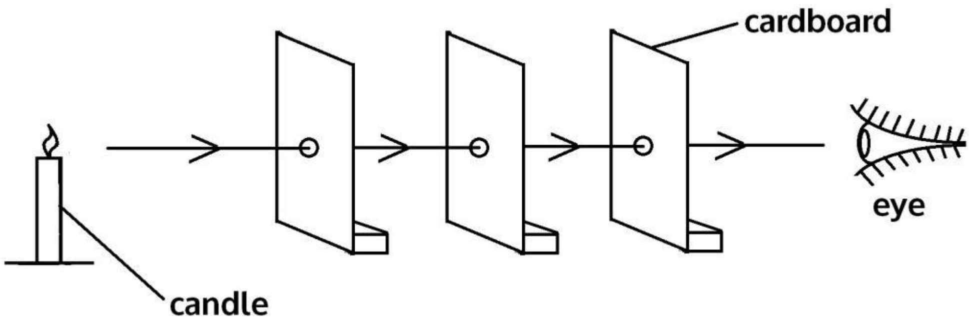
This is a property of light travelling in a straight line.

AN EXPERIMENT TO SHOW THAT LIGHT TRAVELS IN A STRAIGHT LIGHT

Three cardboards with holes in their centres are set up so that their holes are in a straight line. To ensurethat the holes are in a straight line, a thread is passed through them.

A candle is lit and then placed at one end of the cardboards. When observed from the opposite end, thelight is seen through the holes.

If one of the cardboards is displaced slightly, light is not seen. This shows that light travels in a straightline.

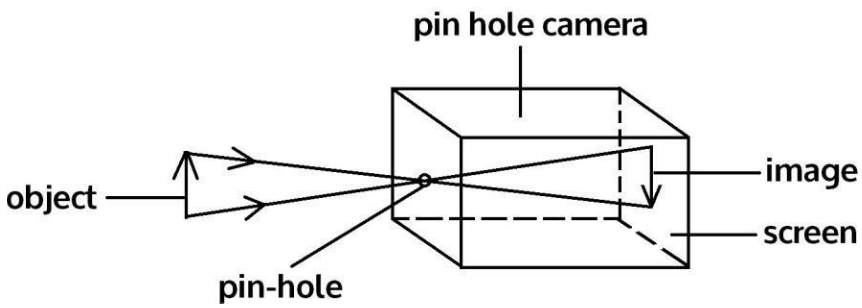


APPLICATIONS/ USES OF RECTILINEAR PROPAGATION OF LIGHT

(i) It is used in the pin hole camera
(ii) It is used in the formation of shadows by opaque objects
(iii) It is used in the occurrence of eclipses

THE PIN-HOLE CAMERA

This is a camera which consists of closed box with a small hole on one face and



a screen on theopposite face.

The image of the object is formed on the screen.

PROPERTIES OF THE IMAGES FORMED IN A PIN-HOLE CAMERA

- It is upside down (inverted)
- It is real because is formed on the screen

Note: The image formed will be seen more clearly if the experiment is done in a dark room with thecamera facing a bright object outside.

EFFECTS OF THE SIZE OF THE HOLE OF A PIN HOLE CAMERA

If the size of the hole is increased, the image will be blurred and brighter. This is because the bigger hole is equivalent to a group of small holes close together where each hole produces its own image andthese images overlap.

EFFECT OF HAVING TWO OR MORE HOLES

If there are two holes, two images will be formed because each hole forms its own image.

MAGNIFICATION OF A PIN-HOLE CAMERA

Magnification is the ratio of image height (size) to object height.

Note: Magnification has no units. This is because it is a ratio of two similar units.

FACTORS AFFECTING THE SIZE OF THE IMAGE

(i) The distance of the object from the hole. The bigger the distance of the object from the hole, thesmaller the size of the image and vice versa.

(ii) The distance of the screen from the hole. The bigger the distance of the screen from the hole, thebigger the image.

Note: The image may be diminished or magnified depending on the above factors.

EXAMPLES

1. An object of height 20cm is placed 10cm away from the hole of a pin hole camera. If the screenof the camera is 2.5cm away from the hole, find;
   (i) the magnification
   (ii) the height of the image

   Solution

2. Calculate the height of a building 300m away from the pin hole camera which produces animage 2.5cm high if the distance between the screen and the pin hole is 5cm.

Solution

EXERCISE

1. The length of a pinhole camera is 2.5cm. An object 2m high is placed 10m from the pin.Calculate the height of the image produced.
2. The length of a pinhole camera is 20cm. Determine the height of a storied building 300m awayfrom the pinhole if the image formed on the screen of the pinhole camera is 2.5cm high.
3. The distance between the pin-hole and the screen of the pin-hole camera is 10cm. the height ofthe screen is 20cm. At what distance from the pin-hole must a man 1.6m tall stand if a full length image is required?
4. An object of height 5m is placed 10m away from the pin hole camera. Calculate the size of theimage and the length of the pin-hole camera if the magnification is 0.01?
5. The screen of a pin-hole camera is 20cm away from the pin-hole. A student of height 1.6mstands 8m from the pin-hole. Find the height of the student's image.
6. An object 20cm high forms an image on a screen of the pin-hole camera. If the distance betweenthe object and screen is 24cm and the distance between the object and the pin hole is 6cm find
   (a) The magnification of the image.
   (b) The size of the image

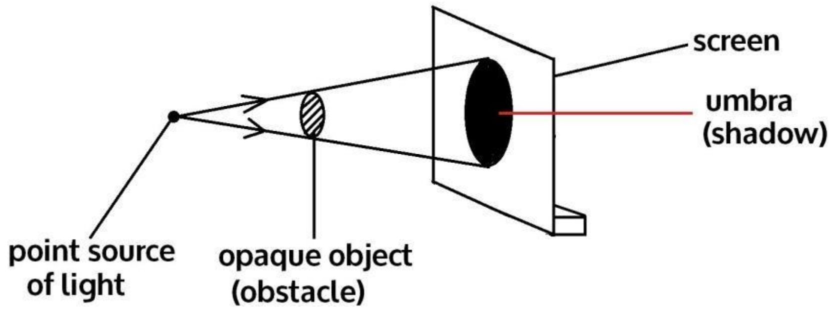
SHADOWS

A shadow is a region of darkness formed behind an opaque object when it obstructs light.

When an opaque object is placed between a source of light and a screen, a shadow is formed on thescreen. This is because light travels in a straight line and is not able to go round the object.

SHADOW FORMED BY A POINT SOURCE OF LIGHT

A point source is a very small source of light. It gives a sharp shadow which is equally dark all over.This shadow is called **umbra.**

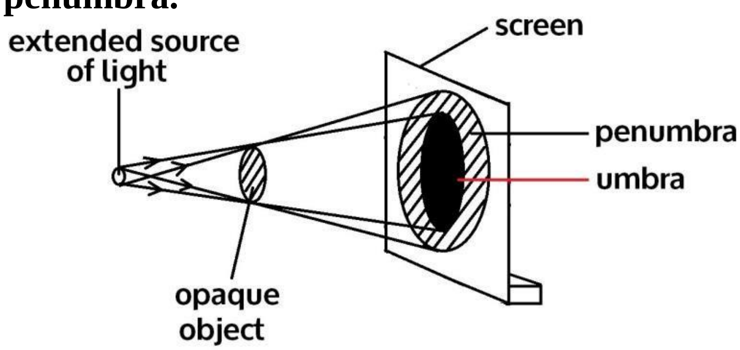


The point source can simply be made by putting a small hole in a tin inside which a source of light isplaced.

SHADOW FORMED BY AN EXTENDED SOURCE OF LIGHT

An extended source is a large source of light. It forms a fully dark shadow at the central regionsurrounded by a partial dark shadow of an opaque object.

The fully dark shadow is the **umbra** and the partially dark shadow is the **penumbra.**



ECLIPSES

An eclipse is a shadow formed on the moon or on the earth due to obstruction of light from the sun.

TYPES OF ECLIPSES

There are mainly two eclipses;

(i) Solar eclipse (eclipse of the sun by the moon)
(ii) Lunar eclipse (eclipse of the moon)

SOLAR ECLIPSE (ECLIPSE OF THE SUN)

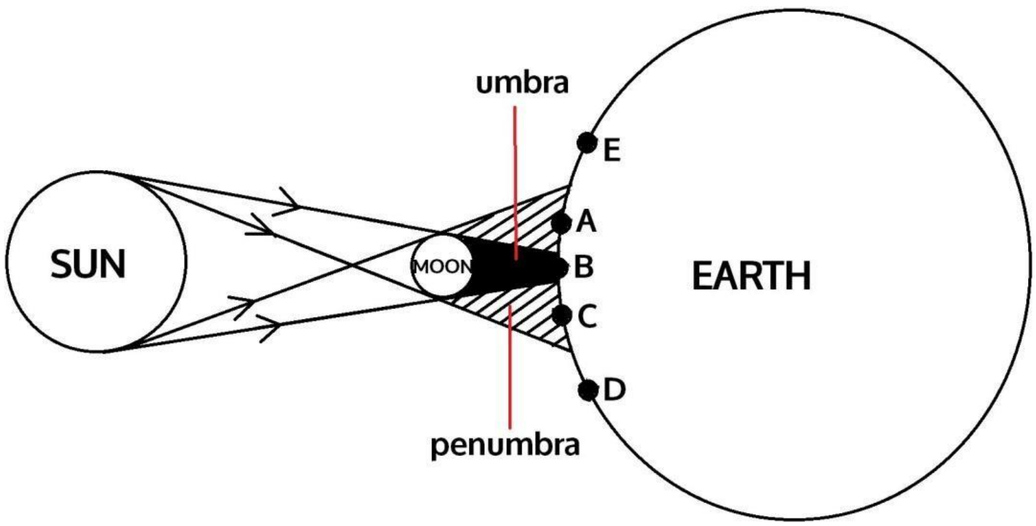
This type of eclipse includes the following;

(a) Total solar eclipse
(b) Annular solar eclipse

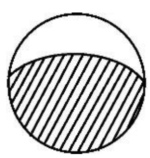
(a) TOTAL SOLAR ECLIPSE

An eclipse of the sun (solar eclipse) occurs when the moon passes between the sun and the earth and allare in a straight line.

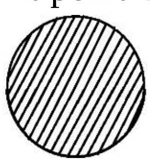
The shadow of the moon falls on the earth. The sun acts as an extended source of light.



At point A or C, a partial eclipse of the sun occurs i.e part of the sun is not seen.



At point B, total eclipse of the sun occurs i.e the sun cannot be seen at all.



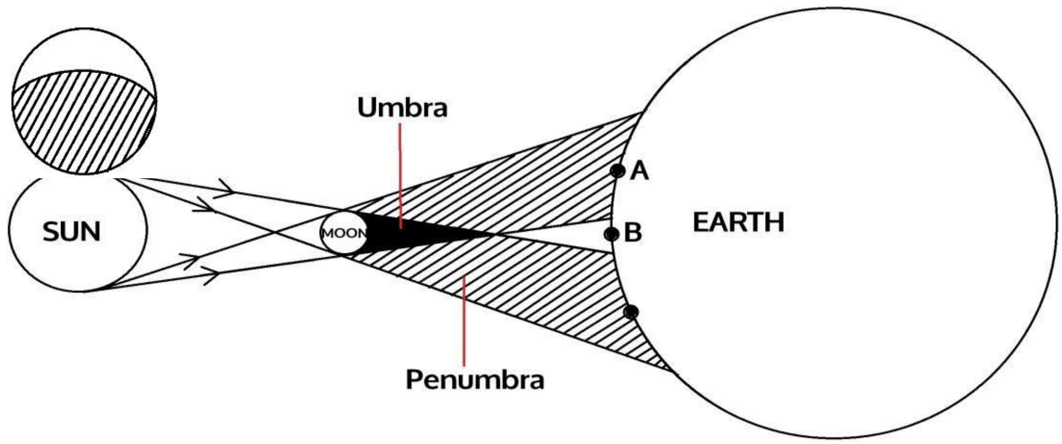
At point D or E, no eclipse occurs i.e the sun is fully seen.

(b) ANNULAR SOLAR ECLIPSE

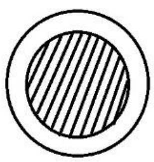
This is an eclipse of the sun which occurs when the moon is very far from the earth and the tip of theumbra does not reach the earth.

It is caused by the fact that the moon does not move around the earth in a perfect circle.

At point A, a partial eclipse of the sun occurs i.e only part of the sun is seen.



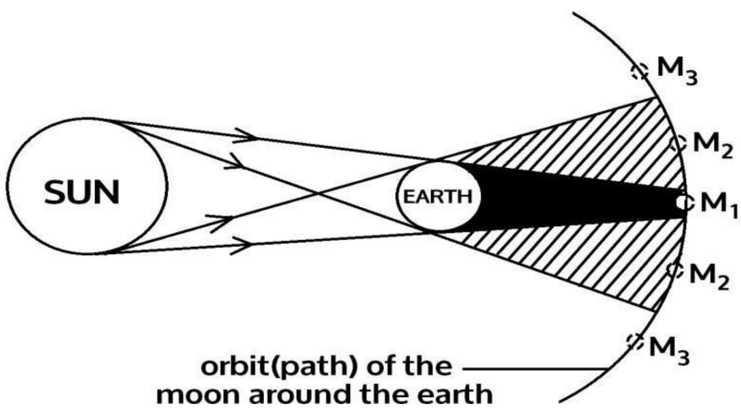
At point B, an annular eclipse is seen i.e only the outer part of the sun is seen but the central region ishidden.



NOTE: A total eclipse seen from one place may last about seven (7) minutes. In this time, the skyappears dark and stars can be seen although it is day.

LUNAR ECLIPSE (ECLIPSE OF THE MOON)

Lunar eclipse occurs when the earth is between the moon and the earth and the three are in a straight line.



The shadow of the earth falls on the moon and the moon cannot be seen because it receives no light for reflection.

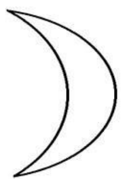
At M1, total eclipse of the moon

occurs.At M2, partial eclipse of

the moon occurs.At M3, no

eclipse occurs.

Note: During eclipse of the moon (lunar eclipse), some small amount of light may fall on the moon,making it visible as an outline.



REFLECTION OF LIGHT

This is the bouncing back of light rays from a shiny surface.

Reflection of light depends on the nature of the surface. The surface may be smooth or rough.

TYPES OF REFLECTION

They include;

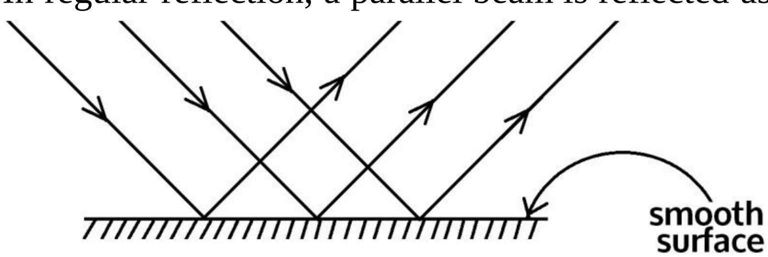
(i) Regular reflection

(ii) Irregular reflection or diffuse reflection

REGULAR REFLECTION

This is the type of reflection which occurs on a smooth surface.

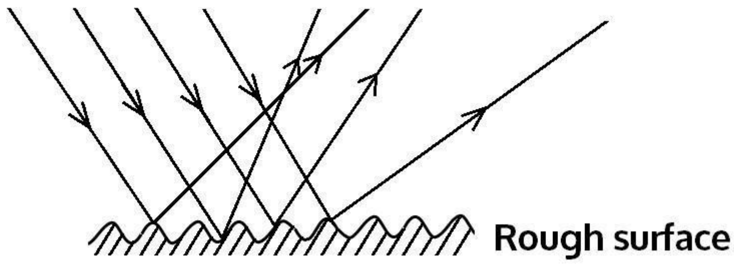
In regular reflection, a parallel beam is reflected as a parallel beam.



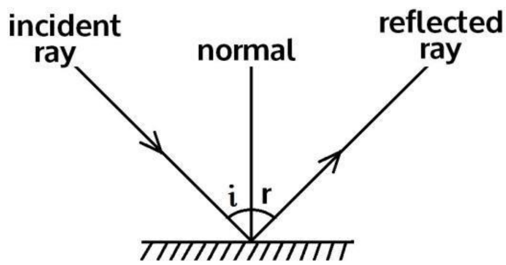
IRREGULAR REFLECTION

This is the type of reflection which occurs on a rough surface.

In irregular reflection, a parallel beam of light is reflected in all directions.



TERMS USED IN REFLECTION



O is the point of incidence *i* is the angle of incidence *r* is the angle of reflection

(i) **The incident ray**

This is the ray that strikes the reflecting surface at the point incidence.

(ii) **The reflected ray**

This is the ray that is bounced off the reflecting surface at the point of incidence.

(iii) **The normal**: Is a line drawn perpendicular to the reflecting surface at the point of incidence.

(iv) **Angle of incidence (** *i* **)**

This is the angle between the incident ray and the normal at the point of incidence.

(v) **Angle of reflection (** *r* **)**

This is the angle between the reflected ray and the normal at the point incidence.

THE LAWS OF REFLECTION OF LIGHT

There are two laws of reflection:

(i) The incident ray, the normal and the reflected ray at the point of incidence all lie in the sameplane.

(ii) The angle of incidence is equal to the angle of reflection.

Please copy these notes in your book OR if you are not sure where, then copy these at the backof your book and for any further guidance whatsapp(0780608296)

AN EXPERIMENT TO VERIFY THE LAWS OF REFLECTION

Procedure

- The white sheet of paper is fixed on a soft board and a straight horizontal line AOB is drawn on thepaper at its centre.
- A perpendicular line ON is drawn at a point O using a protractor to represent the normal.Using a protractor, an angle $i = 20^0$ is measured and a line XO is drawn.
- Pins P_1 and P_2 are fixed vertically on line XO and a plane mirror is set up on AOB vertically with its reflecting surface facing the pins.
- Looking through the mirror, two pins P_3 and P_4 are fixed on the opposite side of ON such that they appear to be in a straight line with I_1 and I_2, the images of P_1 and P_2 respectively as seen from side Y.
- A line OY is drawn through P_3 and P_4 and the angle of reflection r is measured and recorded.
- The experiment is repeated for values if $i = 30^0$,40 □,50□,60□, 70 □ and the results are recorded in a table.

- It is observed that each values of angle of incidence *i* equals its angle of reflection, *r* .
- It is also observed that the incident rays, the reflected rays and the normal all lie in the same plane onthe paper.

This verifies the laws of reflection of light.

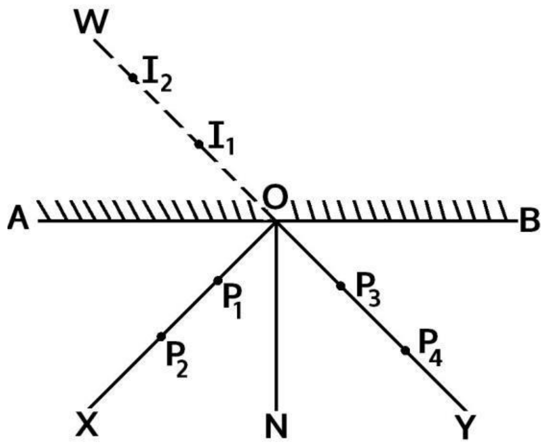
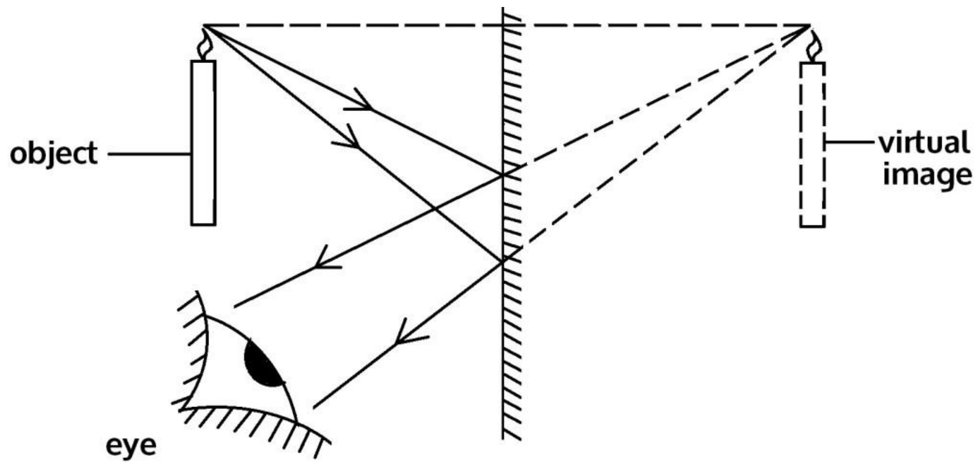


IMAGE FORMATION IN PLANE MIRRORS

The image of an object in front of a plane mirror is formed behind the mirror.

Rays from the object are reflected by the mirror and appear to be coming from behind the mirror.

The images are thus virtual because they are formed by an apparent intersection of



rays and cannot beformed on a screen.

Definitions

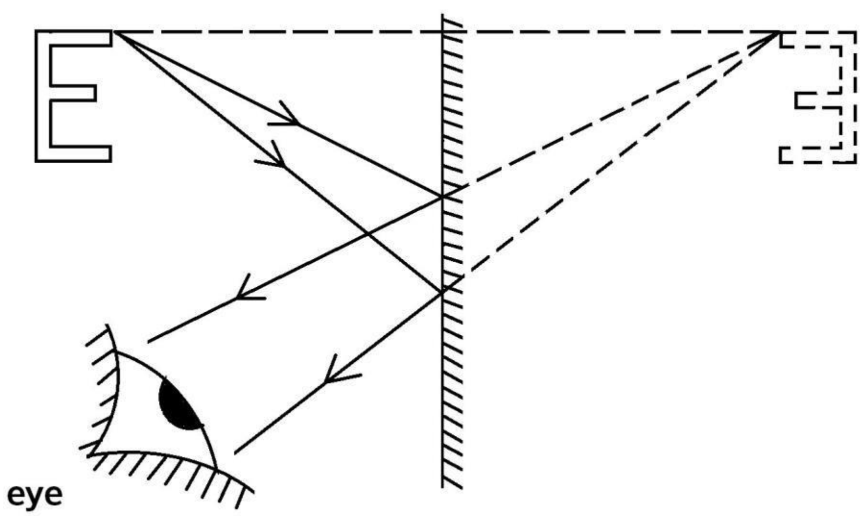
(i) **A real image** is an image formed by actual intersection of light rays and can be formed on ascreen.

(ii) **A virtual image** is an image formed by apparent intersection of light rays and cannot be formedon a screen.

LATERAL INVERSION

This is the tendency of left and right hand sides of an image to be interchanged in a plane mirror.

For example, if you close your right eye, your image in a plane mirror seems to

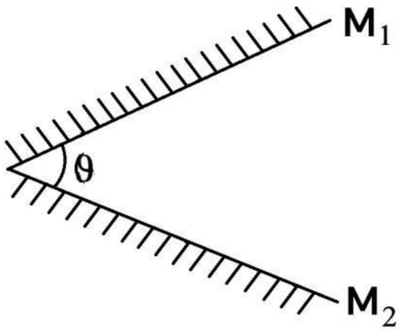


have closed the left eye.This is because of lateral inversion of the image.

PROPERTIES OF IMAGES FORMED IN PLANE MIRRORS

(i) The image is of the same size as the object
(ii) The image is at the same distance behind the mirror as the object in front of the mirror.
(iii) The image is laterally inverted.
(iv) The image is virtual.
(v) The image is upright (erect).

IMAGES FORMED IN TWO INCLINED PLANE MORRORS



If the angle between two plane mirrors M1 and M2 is then the number (n) of images seen is given by;

$$n = \frac{360}{\theta} - 1$$

EXAMPLES

1. Find the number of images seen when two plane mirrors are inclined at;
   (i) 90°
   (ii) 60°
   (iii) 45°
   (iv) 120°
   (v) 30

2. When two plane mirrors are inclined at an angle to each other, 7 images are formed. Find theangle of inclination of the mirrors.

USES OF PLANE MIRRORS

(i) They are used in periscopes
(ii) They are used in kaleidoscopes
(iii) They are used in salons as shaving and make-up mirrors

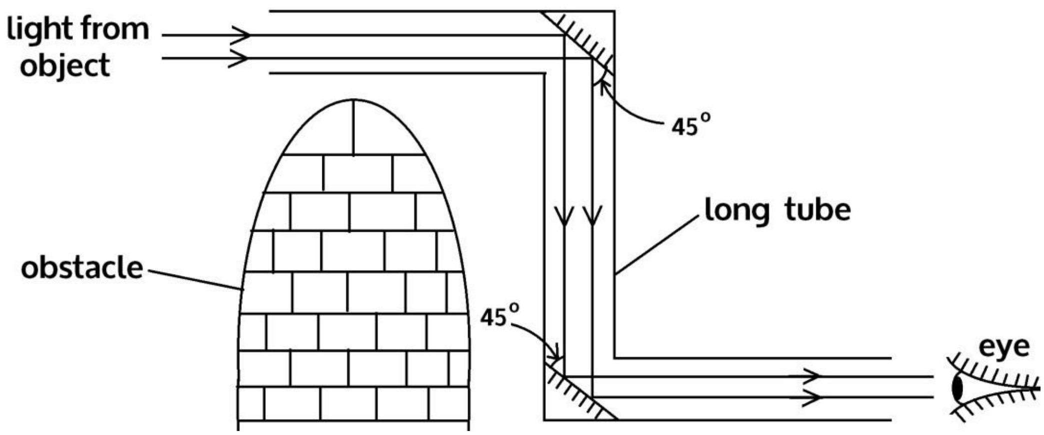
Please copy these notes in your book OR if you are not sure where, then copy these at the backof your book and for any further guidance whatsapp(0780608296)

(iv) They are used in sextants
(v) They are used as dressing mirrors

THE PERISCOPE

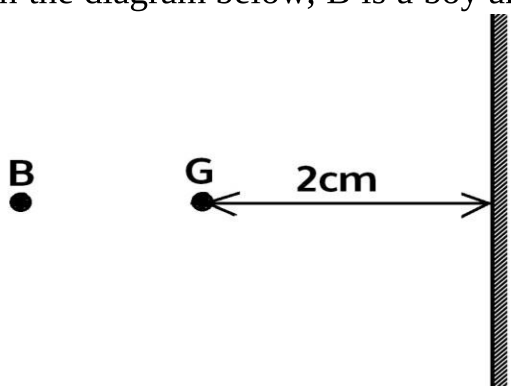
This is an instrument used to see objects over obstacles.
It consists of a long tube containing two plane mirrors fixed and facing each other angles of 45^0 to the line joining them

At each reflection, light from the object is turned through 90^0 such that the final image appears upright.



Question

In the diagram below, B is a boy and G is a girl all standing in front of a plane



mirror.

If the girl is 8m from the boy's image, how far is G from B?

Question

Give four examples where a periscope is used.

THE KALEIDOSCOPE

The kaleidoscope consists of two strips of plane mirrors M1 and M2 about 15cm long, placed at an angleof 60^0 a tube. At the bottom of the tube is a ground-glass plate to let in light.

Small pieces of brightly coloured glass are scattered on the ground glass plate. These pieces of coloured glass act as objects and on looking down the tube, five images are seen, which together with the object from a symmetrical pattern in six sectors.

Every time the tube is shaken to rearrange the pieces, more new patterns are formed.

PARALLEL MIRRORS

If two plane mirrors are placed parallel to each other and an object is placed between them, an infinitenumber of images is formed since the angle of inclination is zero