$$\text{Velocity} = \frac{2 \times d}{\frac{t}{N}}$$

$$V = \frac{2dN}{t}$$

Example

A student made 50 claps in one minute. If the velocity of sound is 330s, find the distance between the student and the wall.

$$V = \frac{2dN}{t}$$

$$60 \times 330 = \frac{2 \times d \times 50}{60} \times 60$$

$$\frac{60 \times 330}{100} = \frac{100d}{100}$$

198 = d

<u>d = 198m</u>

REVERBERATION

In a large hall where there are many reflecting walls, multiple reflections occur and cause or create an impression that sound lasts for a longer time such that when somebody makes a sound; it appears as if it is prolonged. This is called reverberation.

Definition of Reverberation

Reverberation is the effect of the original sound being prolonged due to multiple reflections.

ADVANTAGES OF REVERBERATION

In grammar, reverberation is used in producing sound. Complete absence of reverberation makes speeches inaudible.

DISADVANTAGES OF REVERNERATION

During speeches, there is a nuisance because the sound becomes unclear.

PREVENTION OF REVERBERATION

The internal surfaces of a hall should be covering the sound absorbing material called acoustic materials.

WHY ECHOES ARE NOT HEARD IN SMALL ROOMS?

This is because the distance between the source and reflected sound is so small such that the incident sound mixes up with the reflected sound making it harder for the ear to differentiate between the two.

<u>Question</u>

Outline four properties of electro magnetic waves.

Distinguish between (i) sound waves and light waves.

(iii) sound waves and water waves

A man standing midway between two cliffs makes a sound. He hears the first echo after 3s. Calculate the distance between the two cliffs (Velocity of sound in air = 330m/s)

Musical notes

Music

This is an organized sound produced by regular vibrations.

Noise

This is a disorganized sound produced by irregular vibrations.

Musical note

This is a single sound of a certain pitch made by a musical instrument or voice.

Characteristics of musical notes

Pitch

This is the loudness or softness of sound. It depends on the frequency of sound produced, the higher the frequency the higher the pitch.

Timber

This is the quality of sound produced, it depends on the number of overtones produced, the more the number of overtones, the richer and the sweeter the music and therefore the better the quality.

Overtone

This is a sound whose frequency is a multiple of a fundamental frequency of the musical note.

Beat

This refers to the periodic rise and fall in the amplitude of the resultant note.

Loudness

This depends on the amplitude of sound waves and sensitivity of the ear.

Amplitude

This is the measure of energy transmitted by the wave. The bigger the amplitude, the more energy transmitted by the wave and the louder sounder sound produced.

Sensitivity of the ear.

If the ear is sensitive, then soft sound will be loud enough to be detected and yet it will not be detected by the ear which is insensitive.

Pure and impure musical notes.

Pure refers to a note without overtones. It is very boring and only produced by a tuning fork.

Impure refers to a note with overtones. It is sweet to the ear and produced by all musical instruments.

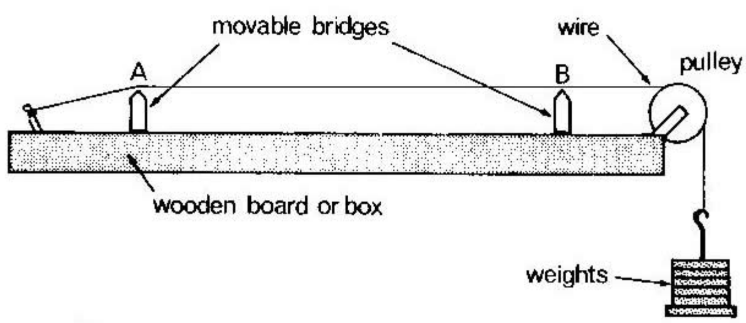
VIBRATION IN STRINGS

Many musical instruments use stretched strings to produce sound. A string can be made to vibrate plucking it like in a guitar or in a harp putting it in pianos. Different instruments produce sounds of different qualities even if they are of the same note.

Factors affecting the frequency of the stretched string.

(a) Length

For a given tension of the string, the length of the string is inverse the proportion to the frequency of sound produced. This can be demonstrated by an instrument called sonometer as shown below.



A- Fixed bridge

B- Movable bridge

C- Wheel

D- Stretched

R-Load

By moving bridgeB_2, higher frequency can be obtained for a short length AB and lower frequency for a long length AC. The relation can be expressed as F ∂ $\frac{1}{l}$

(b) Tension

Adding weights or removing them from its ends at load R the tension of the higher sonometer wire. It will be noted that the higher the tension, the higher the frequency of the note produced.

(c) Mass per unit length (m)

Keeping length (l) and tension (t) constant, the frequency of sound produced depends on the mass per unit length of the string. Heavy strings produce low frequency sounds. This is seen in instruments such as guitar, base strings are thicker than solo stings. If the tension and length are kept constant, the frequency of sound is inversely proportional to the mass of the strings thus a thin short and taut string produces high frequency sound. (F ∂ $\sqrt{\frac{1}{m}}$)

Example

A musical note has frequency of 420H_z and length (l), if the length of the string is reduced by $\frac{1}{2}$, find the new frequency.

$$F \partial \frac{1}{l} \longrightarrow f = \lambda \frac{1}{l} \longrightarrow fl = k \text{ (constant)}$$

$$f_1 l_1 = f_2 l_2$$

$$420k = f_2 \times \frac{1}{2}$$

$$f_2 = 420 \times 2$$

$$= 840 \ H_z$$

Vibrating strings

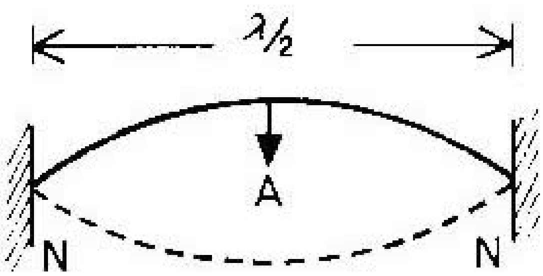
The ways in which a string vibrates are called harmonics. The sound is produced when notes are performed at both ends of a stationary wave.

A stationary wave is a wave formed when two progressive waves of the same frequency and wave length travelling in opposite direction meet producing nodes and antinodes.

Progressive wave is a wave in which energy is transmitted from one place to another and is not stores.

(i) Fundamental note (1st harmonics) string plucked midway.

Diagram

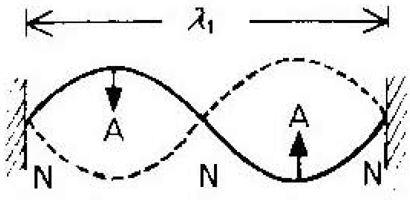


Let V = velocity of sound in air and l- the vibrating length of the string.

L = $\frac{1}{2}$ λ ⟶ λ = 2L

but f_0 = $\frac{V}{\lambda} = \frac{V}{2l}$ - fundamental frequency $f_o = \frac{V}{2l}$

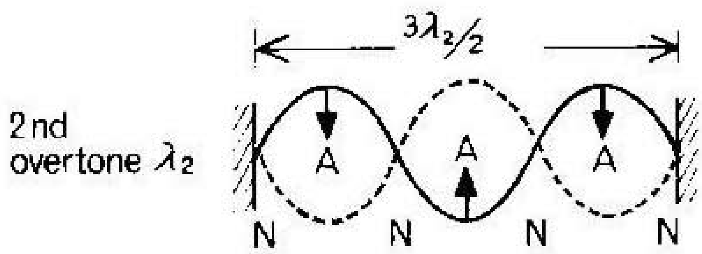
(ii) 2nd harmonics (1st overtone): string plucked $\frac{1}{4}$ way



$$L = \lambda$$

$$f_1 = \frac{V}{l} = f_1 = 2f_o$$

(iii) 3rd harmonics (2nd overtone): string plucked $\frac{1}{6}$ way from one end.



$$L = \frac{3\lambda}{2} \rightarrow \lambda = \frac{2l}{3}$$

$$f_2 = \frac{V}{\lambda} = \frac{V}{\frac{2}{3l}} = \frac{3v}{2l}$$

$$f_2 = 3f_o$$

Thus harmonics obtained from vibrating strings are f_o, $2f_o$, $3f_o$ etc. hence both even and odd harmonics are obtained.

A- Antinodes- these are points that are permanently at rest. No disturbance occurs at these points.

RESONANCE

This is when a body is set into vibrations with its own natural frequency by another near by body which vibrates with the same frequency.

Applications of Resonance.

- In determining the speed of sound in air using a tuning fork and the resonance tube.
- In tuning strings of a musical instrument e.g a guitar and tuning electrical circuits which include indicators.

Dangers of Resonance

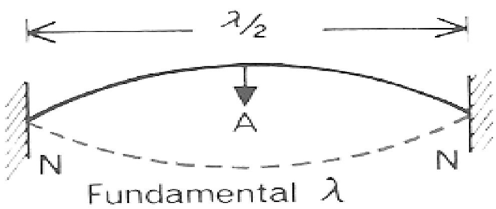
- Causes bridges to collapse as soldiers match across them. This can be prevented by stopping the matching.
- Causes buildings to collapse due to earthquake.
- Chimneys can also collapse due to strong resonance.

Vibrations of air in pipes.

(a) When a wave of a particular wave length and frequency is sent into a closed pipe, reflection of the wave occurs at the bottom of the pipe. The reflected wave will interfere with the incidence when the length of the wave is adjacent so that a node is reflected at the reflected surface, a standing wave is produced.

The air column is now forced to vibrate at the same frequency as that of the source of the wave which is a natural frequency of the air column.

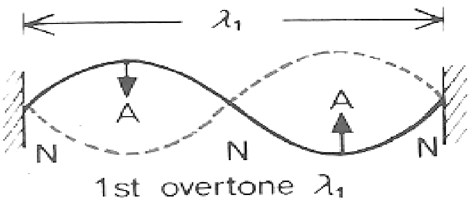
1st harmonic vibration



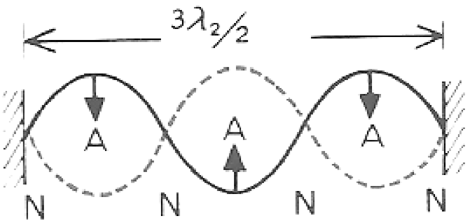
In 1st harmonics $\frac{1}{4}\lambda = L + c \rightarrow \lambda =$ (L + c0 fundamental frequency

$$f_o = \frac{V}{\lambda} = \frac{V}{4(l+c)} \text{.......(i)}$$

2nd harmonics



3rd harmonics



In clos tc) are obtained because of the presence of odd harmonics, closed pipes are not as rich as open pipes.

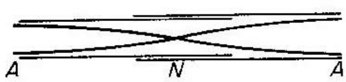
In closed pipes, nodes are formed at closed ends and antinodes at open end.

Open pipes

In open pipes, standing waves resulting into resonance are created when the incident waves are reflected by the air molecules at the other end. Possible ways in which waves travel are shown below:

In open pipes, the sound nodes are produced when antinodes are formed at both ends.

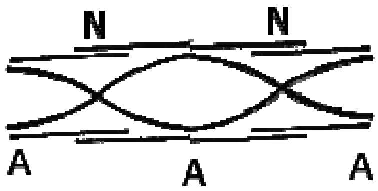
1st harmonic



$$L = \frac{1}{2}\lambda \rightarrow \lambda = 2L$$

$$f_o = \frac{v}{\lambda} = \frac{v}{2l} \text{.........(i)}$$

2nd harmonic

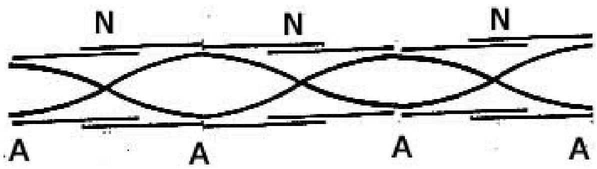


$$L = \lambda$$

$$\text{Frequency } f_1 = \frac{v}{\lambda} = \frac{v}{2l}$$

$$f_1 = 2f_0$$

3rd harmonic

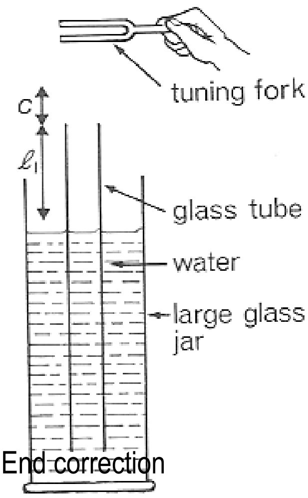


$$L = \frac{3}{2\lambda} \quad \rightarrow \lambda = \frac{2l}{3}$$

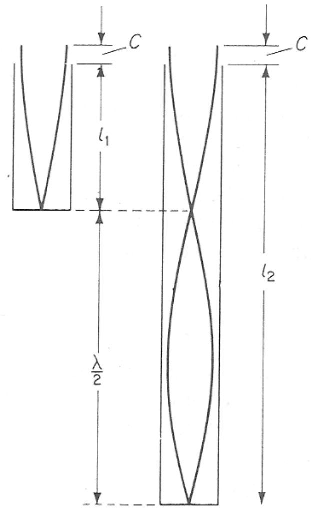
$$f_2 = \frac{v}{\lambda} = 3\left(\frac{v}{2l}\right) \rightarrow f_2 = 3 f_0$$

Open pipes are preferred to closed pipes because they give both odd and even harmonics hence better quality sound.

Determination of velocity of sound by Resonance.



C – End correction



First and second positions of resonance

l_1 , l_2 - Length of air.

- Assemble the apparatus as in the diagram.
- Put a vibrating tuning fork just above the resonance tube.
- Gently lower the resonance tube until the 1st resonance (loud sound) occurs.
- Measure the length l_1 at which it occurs.
- l_1 + c = $\frac{1}{4}$λ...... (i)
- Raise the resonance tube until the 2nd resonance (loud sound) occurs.
- Measure l_2 + c = $\frac{3}{4}$λ...... (ii) as in diagram (b)
- Subtract equation (i) from (ii) to eliminate c
- (l_2 - l_1) + (c-c) = $\frac{3}{4}$λ - $\frac{1}{4}$λ
- l_2 - l_1 = $\frac{1}{2}$λ
- Wave length λ = 2 (l_2 - l_1)...... (iii)

Hence the speed/velocity. V= fλ

V= 2f ($l_2 - l_1$)

Question.

In an experiment the velocity of sound in air using a resonance tube, the following results were obtained:

Length of 1st resonance = 16.1cm

Length of 2nd resonance = 51.1cm

Frequency of tuning fork = 480 H_z

(i) Calculate the wave length of sound produced.
(ii) The end correction of the resonance tube.
(iii) The velocity of sound in air.

(i) $\lambda = 2\,(l_2 - l_1)$

= (51.1 – 16.1)

= 70cm

= 0.07m

(ii) $l_1 + c = \frac{1}{4}\lambda$

$16.1 + c = \frac{1}{4} \times 70$

C = 17.5 – 16.1

= 1.4cm

(iii) $V = 2f(l_2 - l_1)$

$= 2 \times 480\,(\frac{51.1-16.1}{100})$

= 33600cm

= 336m/s

2 The frequency of the 3rd overtone (4th harmonic) produced by an open pipe is 840H_z. Given that the velocity of sound in air is 330m/s, calculate;

(i) Length of the people
(ii) Fundamental frequency

3 A pipe closed at one end has a length of 10cm, if the velocity of sound is 340m/s; calculate the frequency of the fundamental note.

4 A tuning fork of 256H_z was used to produce resonance in a closed pipe. The first resonance position was 22cm and the 2nd resonance position was 97cm. Find the frequency of sound waves.

(b) An open tube produced harmonics of fundamental frequency 256H_z, what is the frequency of the 2nd harmonics.

HEAT

MODES OF HEAT TRANSFER
Heat
It is a form of energy that changes the internal kinetic energy of a substance.
It is transferred in three different ways, conduction, convection and radiation

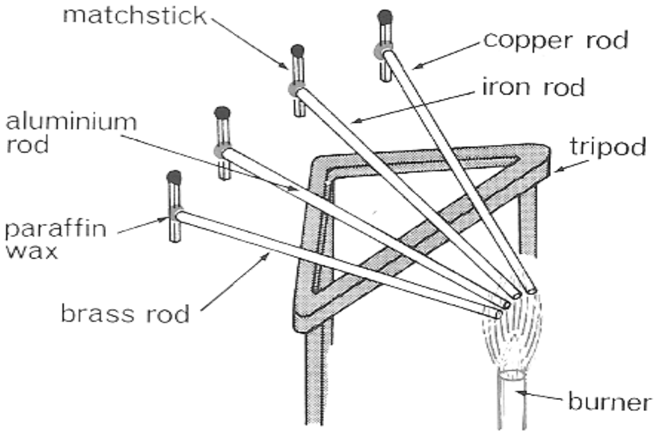
Conduction
It is the flow of heat through a material that does not require movement of the material medium e.g. in metals when they are heated their molecules vibrates faster along their mean position and pass on the heat to the molecules on the cooler parts of the metals also electrons that are always moving about the metal transfer from the hot to the cold end.

Heat conduction is best in metals and worst in gases because of the distant spread of molecules in gases it is not highly possible to have heat transfer in gases

Factors affecting conduction in metals

- Increase in the cross section area of the metal increases the rate of conduction.
- Decrease in the length of the metal bar
- Increase in the temperature difference
- Different metals conduct heat differently.

Experiment to compare conduction in metals.



Procedures.

- The fix cork with wax at one end of each rod and place them on a tripod stand with their end put together
- Heat the ends with a Bunsen flame , heat is conducted along each rod towards the cork
- The cork drops off whenever the wax melts
- The best conductor will drop its cork first and the worst conductor drops its cork last or not at all.

Application of heat conduction

- Good conductors are used in frying and cooking
- Bad conductors are used on handles of frying pans i.e. handle are made of plastic, wood, rubber.

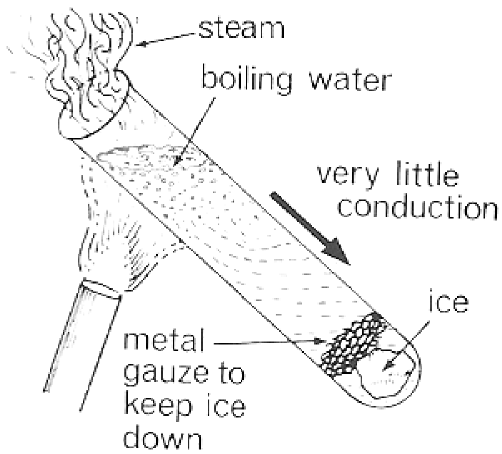
Explain why metals feel colder when touched than bad conductors

This is because metals carry heat away from the hands due to high degree of conduction while bad conductors do not conduct heat.

N.B

Liquids and conducts heat very slowly this is because their molecules are apart.

Experiment to show that water is a poor conductor of heat



Procedure

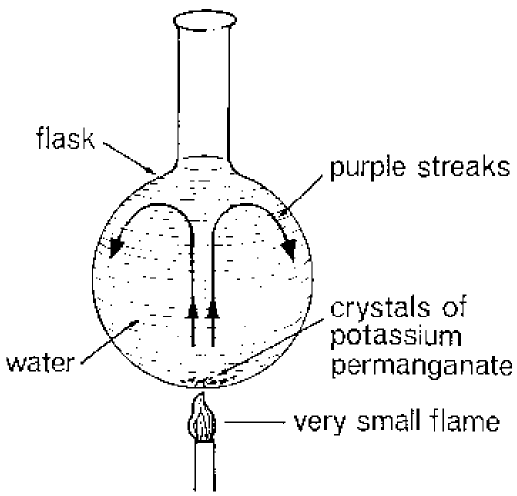
- Water is put in a test tube slanted as shown in the diagram above.
- The upper part of the tube is heated and convection currents are seen at the top of the tube, water begins to boil.
- Ice at the bottom remains not melted. This shows that water is poor conductor of heat.

Convection:

This is the heat transfer which involves bulk movement of molecules of the medium.

Convection cannot occur in vacuum because it requires a material medium. It occurs in fluids (liquid and gases) because they flow easily.

Experiment to demonstrate convection in liquids:



Proceure;

- Arrange the apparatus as in the diagram above.
- Use a straw and carefully put potassium permanganate crystals in water at the bottom.
- When heat is applied, purple streaks are observed moving upwards in the middle of the flask and down wards at the side of a flask in a circular form. The purple streaks show convection currents.

Explanation of convection currents:

When water at the bottom becomes hot, it expands and becomes less dense. It is therefore displaced by dense cold water from the top. In displacement of hot water by cold water, it sets up convection currents as observed by the purple loops.

Application of convection:

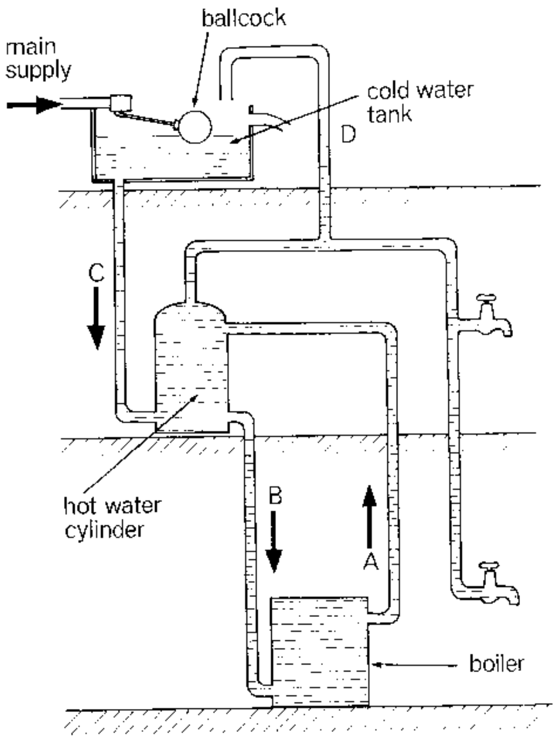
When warming a liquid, the heating element of an electronic kettle is placed at the bottom.

Domestic hot water system:

Cold water is supplied to the boiler along the cold water supply pipe. On warming, in the boiler the cold water warms up, expands and becomes less dense, so it rises up.

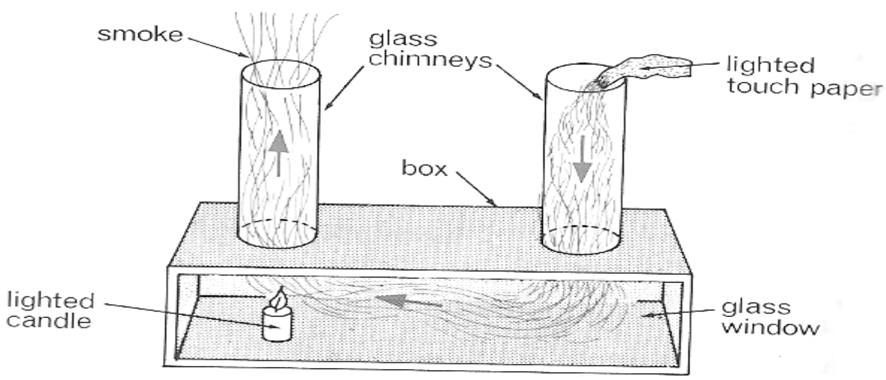
As more cold water is applied to the boiler, hot water is displaced upwards and supplied to the hot water taps along hot water pipes.

The ventilation pipe is used to release steam.



Convection in gases

Experiment to demonstrate convection in gases:



A lighted piece of paper will produce smoke at point A. The movements of smoke from A to B across point X and out through C shows convection.

Explanation of how smoke moves:

Smoke moves by convection because;

- The air above the candle warms up, becoming less dense and then rises up through C.
- The dense cold air from the paper (smoke) enters X through chimney A to replace the risen air (smoke) causing convection currents.

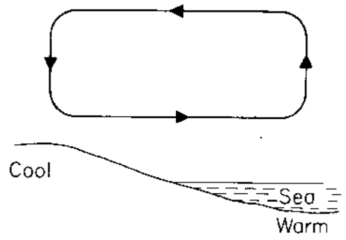
Application of convection in gases:

- Chimneys in kitchens and factories
- Ventilation pipes in VIP latrines
- Ventilators in houses
- Land and sea breezes

Land breeze;

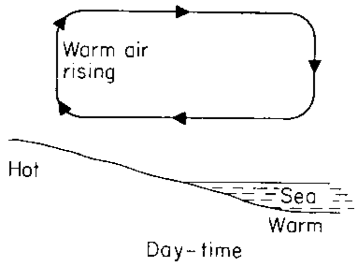
It occurs at night. At night land loses heat faster than sea water causing land to be cooler than the sea. As a result, causing air above the sea to become warm and less dense, so it rises.

The air above the land which is cold, replaces the warm air resulting in the land breeze.



Sea breeze:

Sea breeze occurs during day. During day the land absorbs more heat from the sun than the sea water. The land becomes warmer than the sea. So warm air rises which is replaced by the cold air from the sea.



VENTILATION:

Air inside a room, air gets heated up on hot days. Rooms are usually provided with ventilators above the floor, through which warm air find its way outside while fresh air enter through the doors and windows. In this way a circulation of air convection is set up.

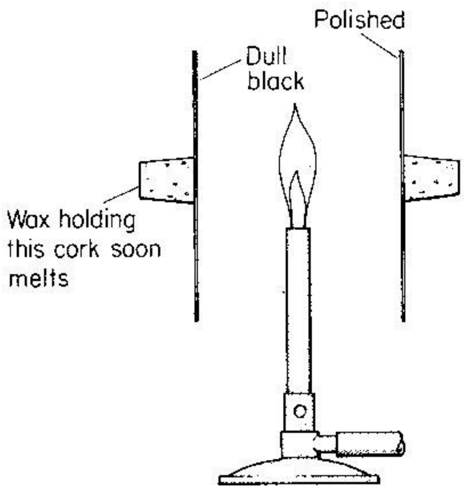
RADIATION:

This is the process of heat transfer in which the transfer of heat does not require a material medium.

Radiant heat is mainly comprised of infrared which makes the skin feel warm. It travels as fast as light and it is the fastest means of heat transfer. It can travel through a vacuum.

Good and bad absorbers of heat radiation:

Some surfaces absorb heat radiation better than others as illustrated below;



The polished surfaces stay cool and the wax on it, is not melted. After a few minutes the wax on the dull or black surface begins to melt. And cork eventually falls off.

A dull black surface is a good absorber of heat radiation while a polished surface is a poor absorber of heat radiation because shine surfaces reflect heat radiation instead of absorbing it.

Comparison of radiation of different surfaces:

Requirements: - A Leslie tube

- Thermopile (instrument that converts heat to electrical energy).

Hot water   metre

Leslie tube

Thermopile

One side of the tube is dull black, the other is dull white and the last one is made shiny polished.

The tube is filled with hot water and radiation from each surface is detected by a thermopile.

When the radiant heat falling on the thermopile is much, it registers a large deflection of the point.

With different surfaces of the tube made to face the thermopile one at a time. The following results are obtained:

- The greatest deflection at the pointer is obtained when dull dark surface faces the thermopile.
- The least deflection is obtained a highly polished shiny surface faces the thermopile.
- The dull surface is a good radiator or emitter of heat radiation while a polished shiny surface is a poor emitter of heat radiation.

Laws of radiation:

- Heat radiation travels in a straight line.
- Good absorbers of heat radiation are also good emitters.
- Temperature of the body remains constant when the rate at which absorbs heat radiation is equal to the rate at which radiates heat energy.
- Bodies only radiate heat when their temperatures are higher than those of the surroundings and absorb heat from the surroundings if their temperatures are low.

Application of radiation:

a. Thermos/vacuum flasks
b. Black and dull surfaces

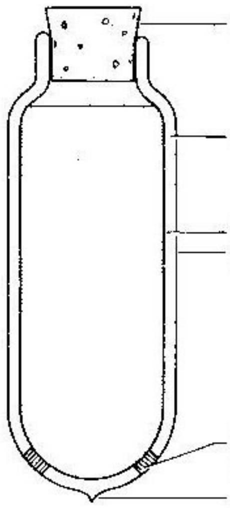
i) Car radiators are painted black to easily emit heat
ii) Cooling fins of a refrigerator are black to easily emit heat.
iii) Solar plates or panels are black to easily emit heat.

c. Polished and white surfaces

i) White washed buildings keep cool in summer.
ii) Roots and petro tanks are aluminum painted to reflect radiant heat.
iii) White coloured clothes are won in summer to keep us cool.
iv) Silver tea pots, kettles and saucepan retain heat for a long time.

The vacuum flask:

It keeps hot liquids hot and cold liquids cold. It is very difficult for heat to travel in or out of the flask.



How flasks minimizes heat loss

The double walled glass vessel with a vacuum between the walls minimizes heat transfer by conduction and convection.

Silvered surfaces reduce heat loss by radiation.

The small amount of heat radiation from the hot substance inside the wall is reflected back across the vacuum by slivering on the outer wall

However the flask can lose heat through radiation, this radiation is reduced by slivered inner walls.

The cork prevents heat loss by conduction since it is a bad conductor of heat.

NB

The thermos flask becomes useless when the vacuum seal breaks, because the vacuum will no longer exists and heat loss by conduction and convection will occur.

Choice of dress

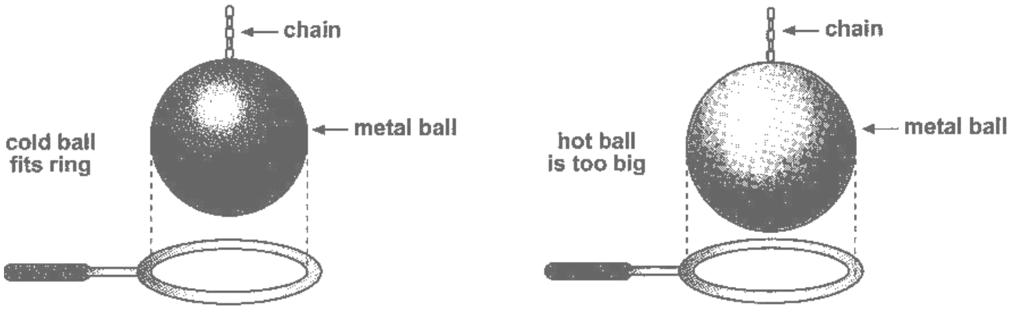
The choice of dress one puts on depends on conditions of the environment. On hot days, a white dress is preferable because it reflects most of the heat radiations falling on it.

On cold days a dull black woolen dress is preferred because it absorbs most of the heat incident on it and can retain for a longer time.

EXPANSION OF SOLIDS.

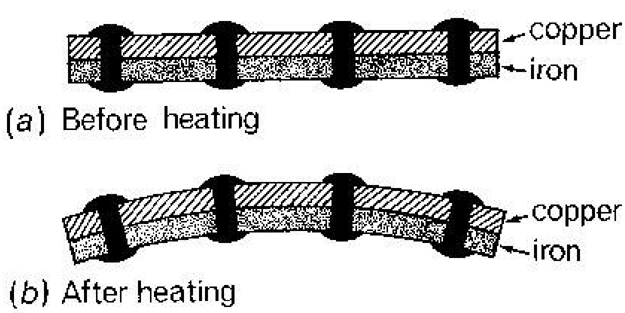
Expansion is an increase in size of a substance. When heated they increase in size in all directions.

Expansion of solids can be illustrated using a metal ball with a ring as shown below.



The metal ball passes through the ring when it is cold, but when heated, the ball doesn't pass through the ring any more, showing that it has expanded. It passes through the hole again when it cools, meaning that the metal contracts when it loses heat.

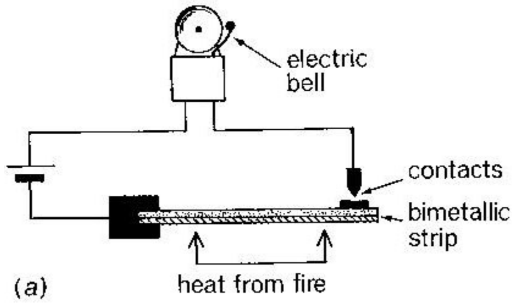
Different metals expand at different rates when equally heated, this can be shown using a metal strip made of two metals such as copper and iron bounded tightly together (bi- metallic strip) when the bi metallic strip is heated, the copper expands more than iron and the strip bends as shown.



Uses of a metallic strip (application of expansion of solids)

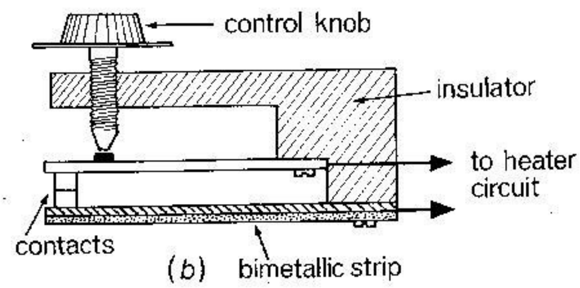
a) **Fire alarm**

Heat from the source makes the bi metallic strip bend and completes the electric circuit and the bell rings.



b) **Thermostat**

This is a device that makes temperature of appliances or room constant. The thermostat shown below uses a bi metallic strip in the heating circuit of a flat iron.



-When flat iron reaches, the required temperature.
-The strip bends and breaks the circuit at the contact and switch off the heater.
-The strip makes contact again after cooling a little and the heater is on again.

A nearly steady temperature results. If the control knob screwed, the strip has to bend more to break the circuit and this reads higher temperature.

Disadvantages of expansion

Expansion can cause a number of problems:

- Contraction of railway lines, bridges, oil pipes and putting up electrical transmission wires. Therefore allowance must be for expansion.

Railway lines are constructed with gaps left in between consecutive on hot days when the rails expand; they have enough room for expansion.

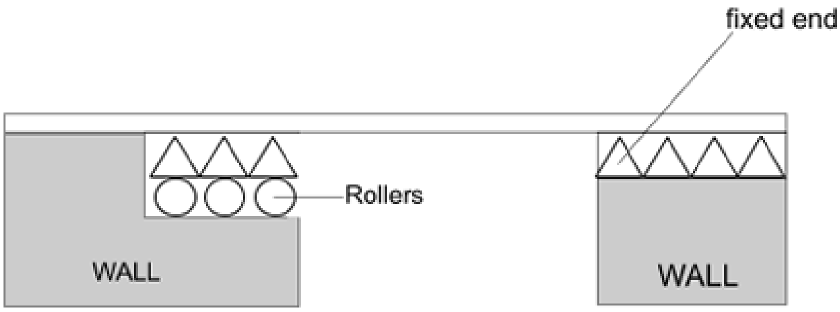
Cold days Hot days

If no gap is left in the rails, they bend on hot days.

Cold days hot days

Steel bridges

Those are constructed in such a way that one end os rested on rollers and the other end is normally fixed. This is to ensure that the structure can contact and expand freely at various temperatures without damaging the bridge.



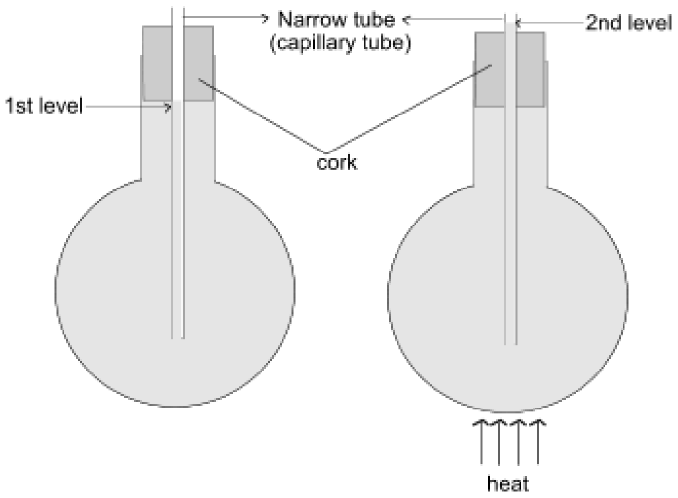
Transmission cables

Wires or cables in transmission or telephone cables are normally not pulled tightly during installation in order to allow room for expansion and contraction during extreme weather conditions.

EXPANSION IN FLUIDS

When liquids or gases (fluids) get hot , they expand just as solids do, but their expansion is greater than that of solids for the same amount of heat.

Experiment to demonstrate expansion in liquids



Procedure

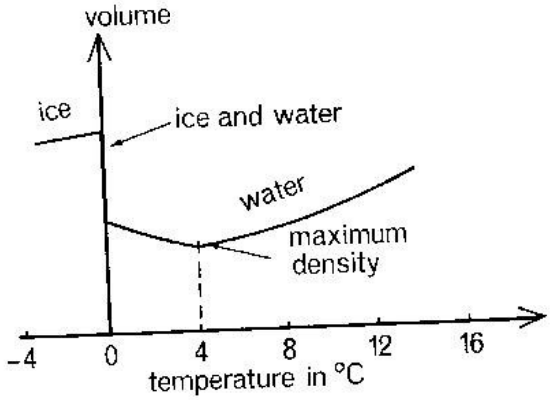
- Fill the flask completely with colored water. Pass the narrow tube through the hole of the cork and fix the cork tightly to the flask.
- Note the first level of water on a narrow tube
- Heat the bottom of the flask and observe the new level of water on the capillary tube.
- Therefore liquids expand when heated since there was a rise in the levels of water in the capillary tube.

Application of expansion property of liquids

This property is used in thermometer; the liquids used include alcohol and mercury.

Anomalous expansion of water

When water is heated over the temperature of 0 -4^{0}C it contracts instead of expanding and this is what is called anomalous (unusual) expansion of water.
The volume of water is minimum at 4^{0}C and its density is maximum beyond 4^{o}C the volume of water increases i.e. expands increase in temperature.



Application of anomalous behavior of water.