TECH STUDY
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PHYSICS

HEAT

Heat

The flow of energy from a hotter object to a colder object is called heat.

SI unit of heat is Joule.

Hot and Cold

We can understand if an object is hot or cold by the sense of touch. However, it can trick us sometimes. Therefore, we use a thermometer

Temperature: It is the degree of hotness or coldness of an object. The unit of temperature is Kelvin.

For measuring the temperature three scales are used like Kelvin scale, Celsius scale and Fahrenheit scale.

Kelvin Temperature Scale: The Kelvin temperature scale is an absolute temperature scale with zero at absolute zero. Because it is an absolute scale, measurements made using the Kelvin scale do not have degrees. The kelvin (note the lowercase letter) is the base unit of temperature in the International System of Units.

Sir William Thomson honoured as Lord Kelvin, was a British, mathematical physicist and engineer who has been credited for the invention of Kelvin scale.

Kelvin temperatures are written with a capital letter "K" and without the degree symbol, such as 1 K, 1120 K. Note that 0 K is "absolute zero" and there are (ordinarily) no negative Kelvin temperatures.

The Kelvin scale is popular in scientific applications because of the lack of negative numbers. This scale is convenient for recording the very low temperatures for example, of liquid nitrogen. The lack of negative numbers also makes it easier to calculate differences between temperatures.

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The only temperature where the Kelvin and Fahrenheit values will be equal is at 574.25.

The Fahrenheit scale: It is a temperature scale based on one proposed in 1724 by physicist Daniel Gabriel Fahrenheit. It uses the degree Fahrenheit (symbol: °F) as the unit. The scale is now usually defined by two fixed points, the temperature at which water freezes into ice is defined as 32 °F, and the boiling point of water is defined to be 212 °F.

The centigrade or Celsius scale: It is introduced by Anders Celsius, is usually used in scientific laboratories. In this scale the lower fixed point or the ice-point is 0°C and the steam-point or upper fixed point is 100°Celsius.

Thermometer: It is a device that can be used to find out how hot an object is. In other words, we use a thermometer to measure the temperature of an object.

A thermometer has two important elements:

(1) A temperature sensor (e.g. the bulb of a mercury-in-glass thermometer or the pyro- metric sensor in an infrared thermometer) in which some change occurs with a change in temperature and

(2) Some means of converting this change into a numerical value (e.g. the visible scale that is marked on a mercury-in-glass thermometer or the digital readout on an infrared model).

Measuring the temperature of an object using a thermometer

Clinical thermometer

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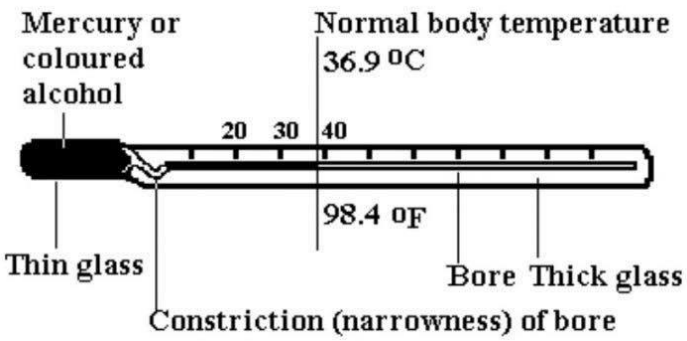

Figure: Clinical thermometer

- It is a device that is used to measure the body temperature of a person.
- It is made up of a glass tube of uniform thickness.
- The glass tube contains a bulb at one end which is filled with Mercury.
- The mercury level in the thermometer rises up in the thread-like portion of the thermometer which therefore indicates the temperature of the body.
- The level of the mercury can be measured by reading the scale given on the thermometer.
- The scale of the thermometer records the temperature in degree Celsius, generally, 35 degrees C to 45 degrees C, which is the range of human body temperature.
- On an average, the temperature of the human body is around 37 degrees C.
- The clinical thermometer has a small sharp curve (kink) present near the bulb. This prevents the Mercury level from falling down on its own in the thermometer.

How to use the clinical thermometer?

Firstly, wash the thermometer with an antiseptic solution.

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Before taking the reading, thermometer is given a few jerks to bring down the level of Mercury below 35 ^{o}C.

Then the thermometer is placed beneath of the tongue for about a minute.

Then you can take it out and observe the temperature reading on the thermometer.

Armpit temperatures are usually the least accurate. For older children and adults, oral readings are usually accurate — as long as the mouth is closed while the thermometer is in place.

What precautions should be taken while using a clinical thermometer?

Wash the thermometer before and after using it.

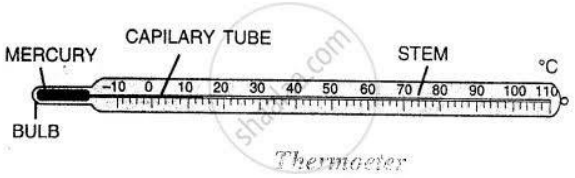
Make sure the temperature of the thermometer is below 35 ^{o}C before taking the temperature.

Keep the thermometer straight in order to see the mercury level precisely.

It should always be held with care or it can break down. You should not touch the bulb of the thermometer at all.

Laboratory thermometer

The laboratory thermometer is used to find out the temperature of the other objects such as water rather than human body temperature. It can measure the temperature from -10 ^{o}C to 110 ^{o}C.



What precautions should be taken when using a laboratory thermometer?

You should always follow the same precautions as that of the clinical thermometer.

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You should always hold the laboratory thermometer in a straight upright position without titling it.

The bulb of the thermometer should never touch the surface of the container in which the substance is kept.

However, the bulb of the thermometer should be completely immersed in the substance so that it covers the bulb from all the sides.

Differences and similarities between clinical and laboratory thermometers:

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Difference	
Clinical Thermometer	Laboratory Thermometer
Clinical thermometer is scaled from 35°C to 42°C	Laboratory thermometer generally is scaled from –10°C to 110°C.
Mercury level does not fall on its own.	Mercury level falls on its own when removed from the source of heat.
Temperature can be read after removing the thermometer from armpit or mouth.	Temperature is taken while keeping the thermometer in source, such as liquid or anything.
To lower the mercury level jerks are given.	No jerk is required to get the mercury level down.
Clinical thermometer is used to take the body temperature.	Laboratory thermometer is used to take the temperature in laboratory.

Similarities	
Clinical Thermometer	Laboratory Thermometer
Made of glass tube	Made of glass tube
Filled with mercury	Filled with mercury
Graduated generally on Celsius scale	Graduated generally on Celsius scale

Other types of thermometers

Minimum-maximum thermometer: It is a thermometer used to measure the minimum and maximum temperature of the day by weather.

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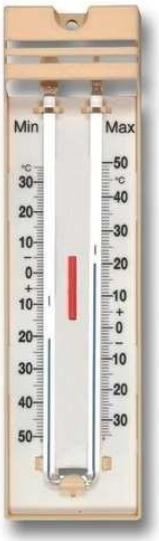

A combination maximum-minimum thermometer. It has a U-shaped glass tube whose bottom half is filled with mercury. The left-hand horn is filled with alcohol, and the right-hand horn is partially filled with alcohol; the remaining portion has a gas above it. A coloured glass index contains a thin iron pin in the center on both sides of the tube on top of the mercury. When the temperature increases, the alcohol in the left side expands and forces the mercury and the alcohol column on the right side into the gas chamber. The index in the right-hand tube also rises. When the temperature decreases, the alcohol in the left side contracts and the gas expands, forcing the liquid back into the left side and pushing the index along with it. The indices retain their position, which they achieve when the maximum and minimum temperatures are reached. They are reset with an external magnet.

Digital thermometer: It is sometimes difficult to handle a mercury filled thermometer especially when it breaks and the mercury falls out. However, nowadays digital thermometers are available to use. This type of thermometer does not contain mercury. It directly displays the correct temperature on a display screen.

To record a temperature orally using a digital thermometer:

Place the thermometer under the tongue. Close mouth around thermometer. Leave in place until you hear the beep (usually one minute or less) Read the level shown on the digital display.

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Thermometers are widely used in technology and industry to monitor processes, in meteorology, in medicine, and in scientific research. Food thermometers are used in food industry.

Thermostat

A thermostat is a component which senses the temperature of a physical system and performs actions so that the system's temperature is maintained near a desired set point.

Thermostats are used in any device or system that heats or cools to a set-point temperature, examples include building heating, central heating, air conditioners, water heaters, as well as kitchen equipment including ovens and refrigerators and medical and scientific incubators.

Transfer of heat

The flow of heat always takes place from and hot object to a cold object.
Conduction: The process of flow of heat from a hot object to a cold object is called Conduction. Some objects can conduct heat while others cannot.

Conductors: The objects that can allow the heat to flow through them are called Conductors. For Example, metals such as copper and aluminium

Insulators: The objects that do not allow the flow of heat from them are called Insulators. For Example, Wood and Plastic.

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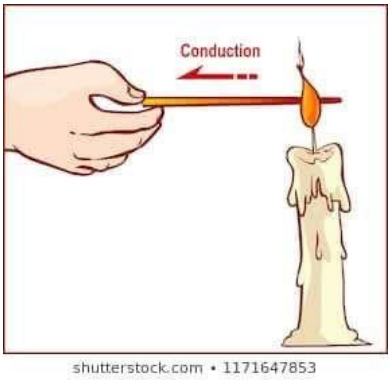

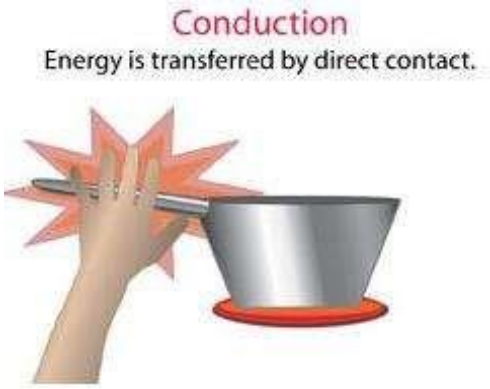

Convection: The transfer of heat in liquids and gases is called Convection. The molecules of the liquid or gases that are near the source of the heat get heated first. They become lighter due to the heat and move upwards. The colder particles being heavier take the place and this process continues until the whole liquid or the gas gets heated. That is why the area above the flame of a candle always feels hot but the area on the sides of the candle does not.

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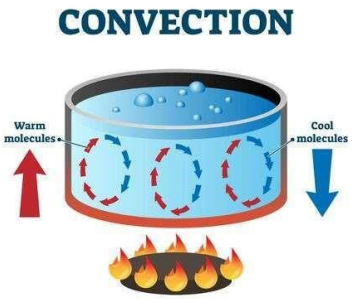
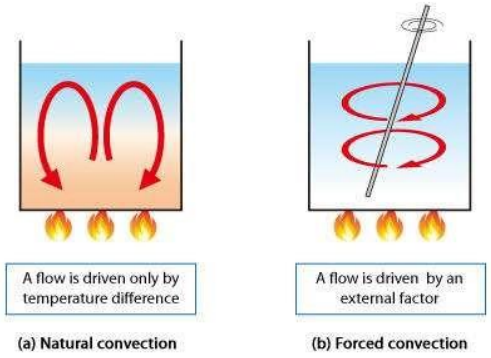


When a macroscopic particle of a fluid moves from the region of hot to cold region, it carries with it a definite amount of enthalpy. Such a flow of enthalpy is known as convection. Convection may be natural or forced. In natural convection, the movement of the fluid particles is due to the buoyancy forces generated due to density difference of heated and colder region of the fluid as shown in the figure. Whereas, in forced convection the movement of fluid particles from the heated region to colder region is assisted by some mechanical means too (eg, stirrer) as shown in figure.



Radiation: It is a process of transfer of heat in the form of waves, the sun's heat reaches the Earth's surface through radiation. Every hot object radiates some heat into the environment. Hence, many times an object gets heated just by being near to a hot object, For example: In a microwave, the substances are heated directly without any heating medium.

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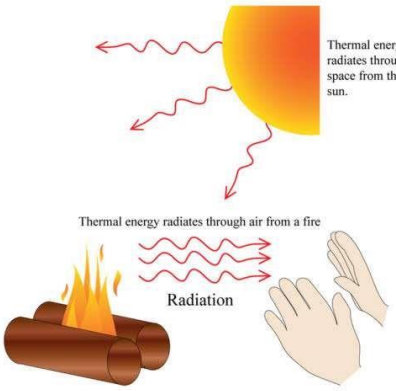
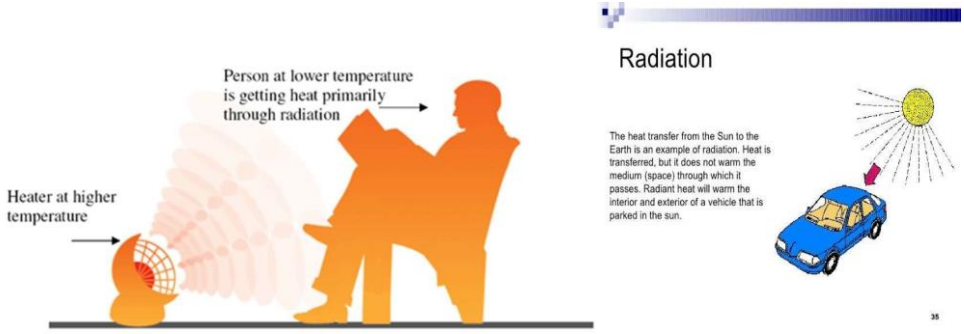


We have seen that a medium is required for the heat transfer in case of conduction and convection. However, in case of radiation, electromagnetic waves pass through the empty space. Electromagnetic waves travel at the velocity of light in vacuum. These waves are absorbed, reflected, and/or transmitted by the matter, which comes in the path of the wave. Here we are taking example of thermal radiation only. Thermal radiation is the term used to describe the electromagnetic radiation, which is observed to be emitted by the surface of the thermally excited body. The heat of the Sun is the most obvious example of thermal radiation.

There will be a continuous interchange of energy between two radiating bodies, with a net exchange of energy from the hotter to the colder body as shown in the figure given below.



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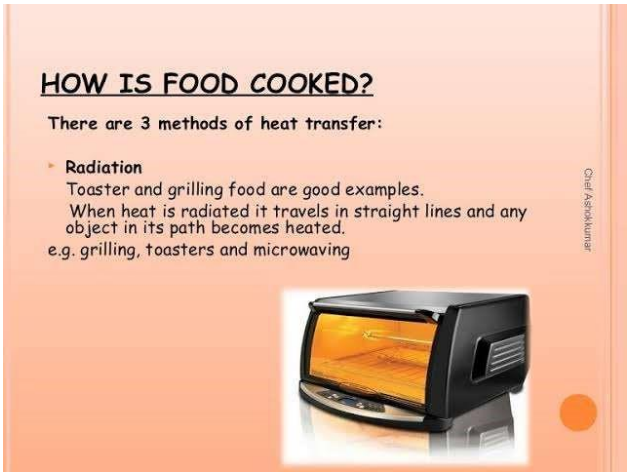
Heat transfer by radiation occurs when microwaves, infrared radiation, visible light, or another form of electromagnetic radiation is emitted or absorbed. An obvious example is the warming of the Earth by the Sun. A less obvious example is thermal radiation from the human body.



Sea Breeze and Land Breeze

Sea breeze: It is a breeze blowing toward the land from the sea, especially during the day owing to the relative warmth of the land. The land heats up quickly by conduction and air rises. The air moves towards the sea and falls since it is denser. The air creates an area of high pressure over the sea while the land has low pressure since it is hotter when compared to the ocean's surface. The sea absorbs heat more slowly during the day and transmits it to greater depth so it remains cool. A cool sea breeze moves from the sea towards the land. The sea breeze is capable of reducing temperatures by as much as 15°C along coastal areas and may produce fogs.

Land Breeze: Land breeze in other hand is coastal breeze blowing at night from land to sea, caused by the difference in the rate of cooling of their respective surfaces. . At night the reverse happens, Land quickly loses its heat while the ocean cools at a slower rate because water has a higher heat specific capacity. This means air over the water is less dense and begins to rise creating low pressure above the ocean's surface. Cooler dense air from the land begins to move to the water surface to replace the warm rising air. A cool gentle breeze blows towards the ocean. This is called a land breeze.

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