#1

Some material conduct heat well and others don't.
Those materials which are good at conducting heat are known as conductors.

On the other hand, those which are not so good in conducting heat are known as insulators.

But we cannot just categorize every material into these two groups. We have to attach some quantity to express how much conductive a material is.

Thermal conductivity is used exactly for this purpose.

It is denoted by 'k'. Mathematically, it is defined using the Fourier Law of conduction. If you remember the Fourier law discussed yesterday, you will realize that k was actually the constant of proportionality in that equation.

Higher the value of k, more conducting will be the material.

DOUBT: Does K vary in direction?

ANS. Depends whether the material is isotropic or not

In HMT what is assumed?

In every subject, material is assumed to be isotropic and homogeneous.

unless mentioned otherwise.

#2

It is very important to understand the contrast between ‘specific heat, c’ and ‘thermal conductivity, k’.

Look.

Higher the value of c, more heat will be needed to raise the temp of the body. A high value of c means you have to supply more and more heat to that mass in order to increase its temperature. Where is this heat going? This heat is being STORED by the body and that is why it is increasing its temperature.

Now let’s look at k.

k denotes how much heat is being forwarded and not stored. If a body is storing more heat (high c), but forwarding less heat (low k), heat will not propagate.

Hence, these two properties are actually contrasting. We will relate them numerically when we will study thermal diffusivity.

#3

Is this order for thermal conductivity correct?

gases < liquids < solids.

ANS. Generally correct but not always true.

Why-

Actually solids are further classified into metals and non metals.

And some liquids (like mercury) have better k than some non-metals. So, this is not always true.

Hence the perfect way to say this is k of liquids is more than gases and k of metals is highest.

k of metals is more but non metals are poor conductors since they do not have free electrons. k of some non metals is even poor than few liquids (like mercury).

Hence it is not advisable to compare solids with liquids. Better to say metals have more. DO not compare solids with liquids.

#4

Though thermal conductivity is mainly the property of material but there are certain things on which it depends like temperature and pressure. Let's see them one by one for solids, liquids and gases.

#5

Effect of temperature:

• On gases: The molecules in gases are far apart. The probability of collision increase by heating them.

SO, thermal conductivity of gases increase with rise in temperature.

• On solids:

Thermal conductivity of any material is dependent on two things:
i. Motion of free electrons
ii. Molecular vibrations

For metals, the thermal conductivity is mainly a function of the motion of free electrons. As the temperature increases, lattice vibrations increase. Though they also contribute in conducting heat, but in metals nearly 70%

conduction is done by free electrons. So, increased lattice vibrations also obstruct the flow of free electrons, thus reducing the conductivity.

Whereas, things are different in case of non-metals. In case of non-metals, there are no free electrons. So, only the molecular vibrations are responsible for conduction of heat and hence for non-metals the conductivity increases with increase in temperature.

• On liquids: Liquids show the most erratic behavior on increasing temperature. For some, it may increase. For some, it may not. Different books aur materials have given different trend.

For GATE, Thermal conductivity of the liquids increases with the increase in temperature. You will find different different statements in books. Use what I am telling in GATE.

For liquids, NPTEL has mentioned it increases with increases in T. SO if some question comes about liquid , use what I have written above.

I am telling this just for liquids. For solids and gases, it is same everywhere.

#6

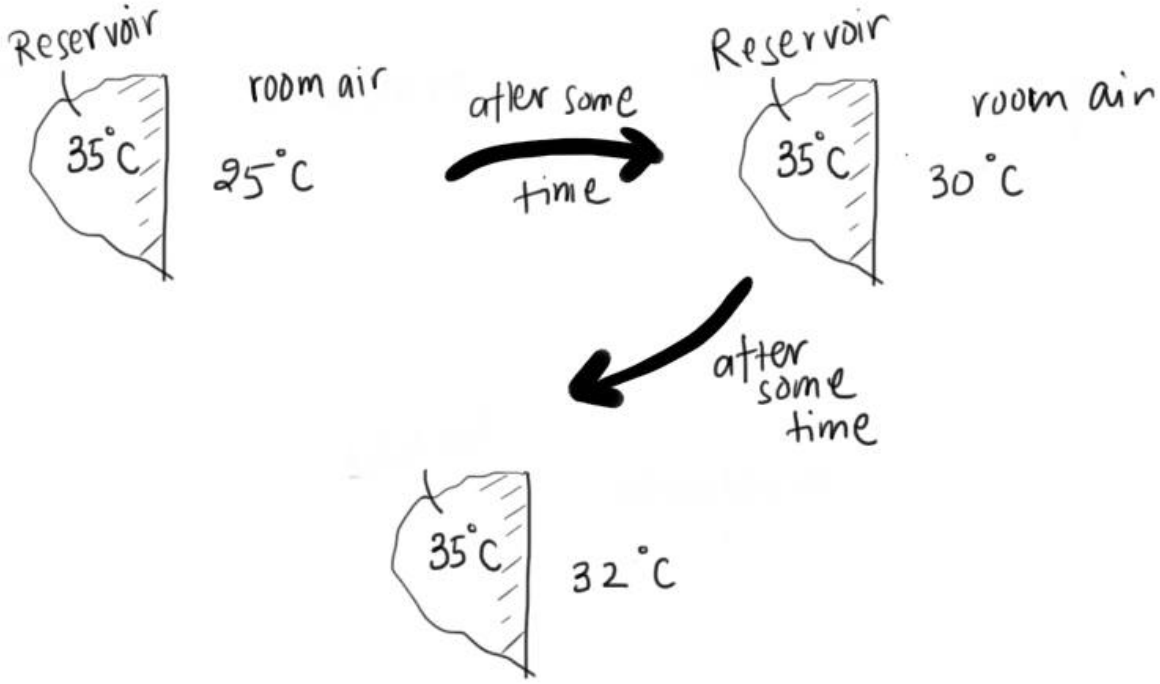
Variation of thermal conductivity with pressure:

Since liquids and solids are nearly incompressible, k remains almost constant with change in pressure.

However, for gases, k increase slightly with increase of pressure.

#7

Identify one engineering problem in the following heat transfer if purpose is to heat the room.



Doubt: I think there should be no external air addition in room from atmosphere..?

ANS: There is no atmosphere. just a hot body in the room.

You can see that as time progress, difference in temperature decreases, since delta T decreases, rate of heat flow decreases. Right?

We have seen that in Fourier law that delta T is proportional to rate of heat flow.

So, as the room will be getting heated up, it will take more and more time to increase its temp by same each degree.

What is the solution of this problem? If in some way, we can make the air flow and bring fresh cool room air in contact with the thermal reservoir, then rate of heat flow will again increase.

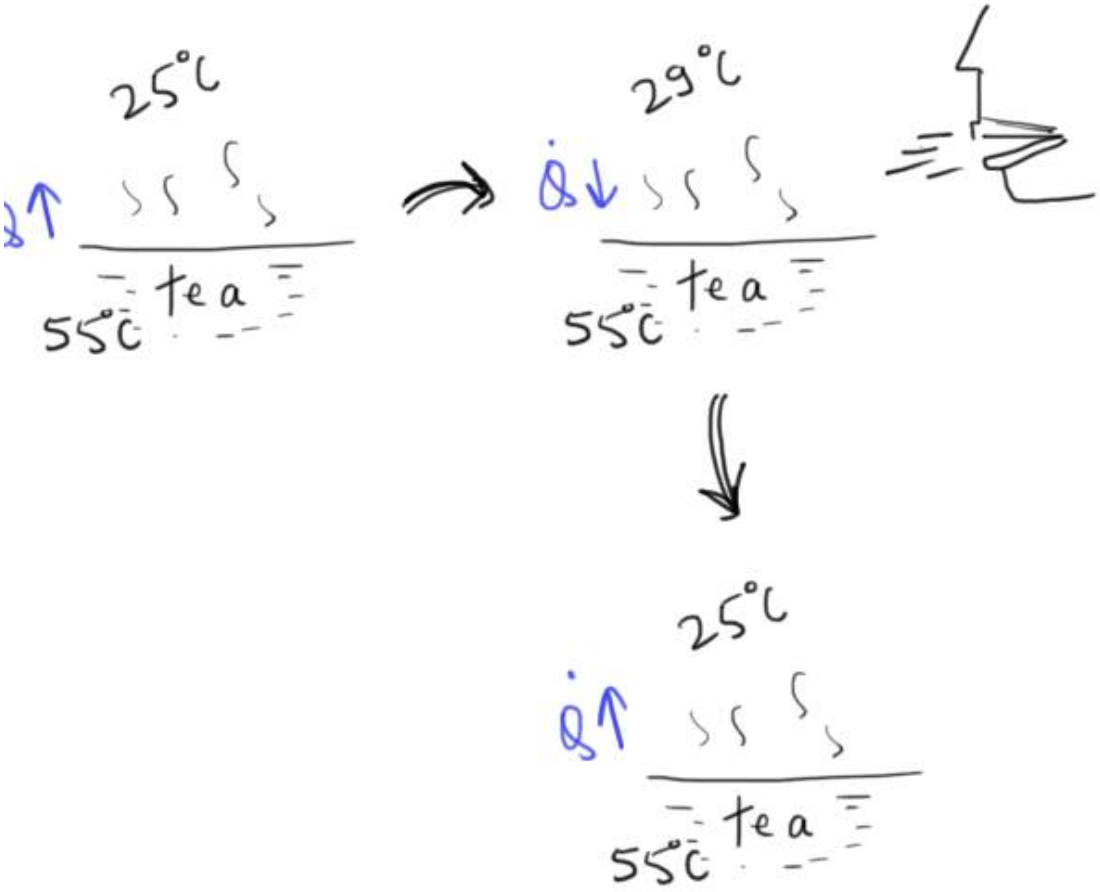
This mode of heat transfer is known as convection.

Convection = Conduction + Fluid flow.

Clearly, in the previous example, if the air was replaced by a cooler air at 25 degree C again,

rate of room heating would have increased again.

One more practical example of this is when you blow air over the tea to make it cool faster. Actually you are replacing the air over tea with fresh cooler air. So heat transfer rate increase again,



Doubt : Sir when glass of milk which is hot is immersed in a mug full of cold ,, thande pani vale mug me heat transfer karate hai vo kya convection heat transfer hota hai

Ans: Ideally, free convection..

8

The heat transfer rates in this case is higher than conduction.

Note that in conduction also, there was motion. But that was on molecular level . There was no bulk motion as I explicitly stated yesterday.

Whereas, in convection, bulk fluid medium flows and enhance heat transfer.

So basically when atomic motion converts to bulk motion.. conduction changes to convection..

Doubt: agar..kisi object ko heat deke melt kiya jaaye.. usme conduction hote hai kya yaa .. convection ho jayega ..

Ans. Kis kis k beech heat transfer krwa rhe ho phle ye btao

One solid is there.. we heat it.. toh conduction hoga.. uske baad agar heat karke temp increase hoke melt ho jaaye wo solid dn heat will get convected..

Ans : If you are talking about heat transfer within the molten part,then yes convection hoga.

#9

There are two types of convection depending upon whether the fluid motion was occurred on its own with no use of external agent or there was any external agent involved.

1. Free/Natural convection: No external agent like fan is used.
2. Forced convection: External agent (like fan/blower) is used to make the fluid flow.

If no external agent is used then how does the medium moves? See next post for the reason.

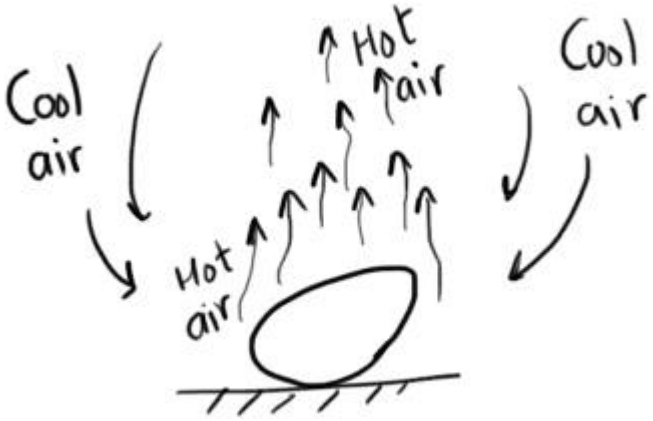
#10

Suppose a hot egg is placed in a room. The air in contact with the egg will get heated up. Gases expand on heating and there density decreases (they become lighter than the bulk air). Lighter air rises up into the medium (Just like big Hot Air Balloon in the Climax of Dhamaal 😛:).

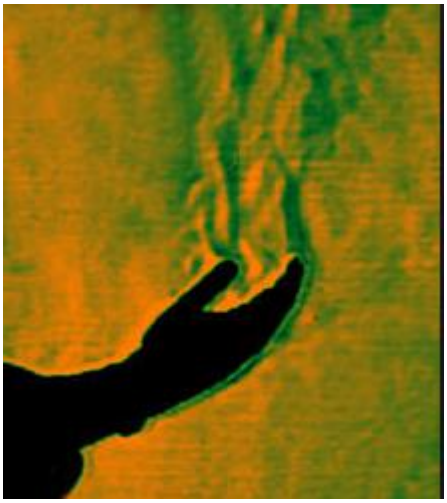
This makes the cooler heavier air to take its place. This cycle again starts and continues. Such currents are known as convection currents.

Notice that the circulation is happening without the help of any fan/blower.

This is an example of free/natural convection.



Natural Convection Current on Human Palm



Those who have not watched Dhamaal (You should!),
Hot Air Balloon :

This is it for today.

HAVE A NICE DAY.....