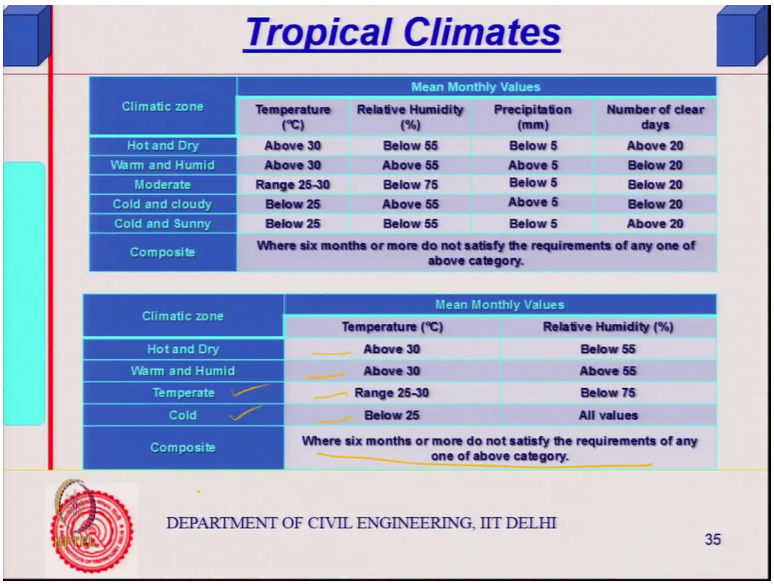
Energy Efficiency, Acoustics & Daylighting in building
Prof. B. Bhattacharjee
Department of Civil Engineering
Indian Institute of Technology, Delhi

Lecture - 08
Comfort & Heat Transfer Concepts

You must be you know, you can recall in the last class we looked at, at the end we looked at gist of tropical climates and what we said was, generally the tropical climates we classify them, main classification is hot dry, warm and humid and.

(Refer Slide Time: 00:24)



Climatic zone	Mean Monthly Values			
	Temperature (°C)	Relative Humidity (%)	Precipitation (mm)	Number of clear days
Hot and Dry	Above 30	Below 55	Below 5	Above 20
Warm and Humid	Above 30	Above 55	Above 5	Below 20
Moderate	Range 25-30	Below 75	Below 5	Below 20
Cold and cloudy	Below 25	Above 55	Above 5	Below 20
Cold and Sunny	Below 25	Below 55	Below 5	Above 20
Composite	Where six months or more do not satisfy the requirements of any one of above category.			

Climatic zone	Mean Monthly Values	
	Temperature (°C)	Relative Humidity (%)
Hot and Dry	Above 30	Below 55
Warm and Humid	Above 30	Above 55
Temperate	Range 25-30	Below 75
Cold	Below 25	All values
Composite	Where six months or more do not satisfy the requirements of any one of above category.	

Student: (Refer Time: 00:42).

Composite monsoon, an Indian Standard of course, energy code e c b c, energy code, energy.

Student: conservation.

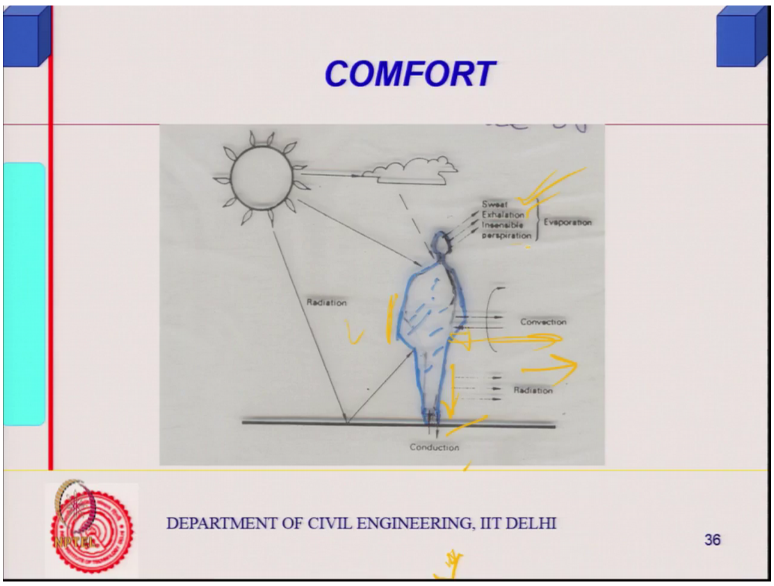
Conservation building code or national building code they classified into 5 zones, earlier it was 6, now they have made into five. So, hot and hot they call it hot and dry and then warm and humid and temperate cold and composite. Now, this is of course, this is typical of Indian scenario because in the tropical climate we have altitude, Himalayan areas and even though Deccan plateau, Nilgiris and all those Aravali, mount Abu for example, it is not all though it is in desert, but it is temperature is much lower, it will possibly fall somewhere maybe in the temperate climate whatever it is.

So, that is how it is, so this how the classifications we saw. Now, having looked into those classifications and their characteristics which we have seen earlier, I said that this is mostly useful when you are doing a kind of a tumble based design, but you know you get some rough idea, composite monsoon climate you have both heating and cooling those are the issues, thermal from thermal aspect, heating and cooling those are the issues right, daylight of course, you would like to get everywhere, other thing that noise is men made. So, therefore, there is not much to do at the moment to the climate.

If you look at it hot and dry, then humidity is low. So your, it is obviously, you would cooling is a requirement, but at the same time humid defining is also a requirement. You would not like to, you make it you know it is dry and warm and humid, again cooling is a requirement, but dehumidification maybe a requirement if it is an air conditioning system, but if it is natural, then natural ventilation can remove the moisture from the body.

So, that is how, that is the basically a kind of thumb rule you can understand. Now, we can follow the next part that is your, you can in fact, you can look into what you call thermal comfort and that would give you an idea why you are saying cooling or dehumidifying etcetera is required and we look into thermal comfort now.

(Refer Slide Time: 02:57)



So, in general if I look at thermal comfort, deep body temperature is 37.4 degree centigrade that is you know, that supposed to be the understanding. In fact, body will have it is heat transfer, this is the human body let say the sun is there, the cloud is there or wherever you are. So, you receive heat from outside, from the surrounding, even within a room you might receive heat because the walls are warm and it is transmitting heat, so there will be heat, you would be receiving by radiation. If you are touching with something, then there can be conduction, gain of heat also and if there is air around, surrounding air is there, then they might and it is hot, there may be some heat transfer because of hot air coming in contact with your body and heating it up and the circulation pattern might be there so.

If there is fluid around the body because as fluid around the body the air, then we convective heat transfer from that fluid to your body also as usual see them basic modes of heat transfer. So, gain; heat gain can takes place by conduction, by radiation and also by convection and there can be heat gain from the body because whenever we are, you see some parts of the body never stopped working for example, heart. So, it is pumping blood all the time, now it is pumping blood all the time; that means, certain work is being done and in that process everything all the energy some energy would be dissipated as heat because there will be losses at the artery boundary or veins boundary or whatever it is.

So, body generates heat all the time that is called metabolic heat generation. So, body generates heats all the time and it depends upon the activity that you are doing. For example, when you are doing something like lifting, it generates more heat, if you are doing secondary work it will be somewhat less, sleeping it will be least because many of those, many of only you know certain parts of the body is active, others are not.

So, that another mode of heat generation is a internal heat generation of a body. So, this is how body generates heat and receives heat. Now, how does it dissipate because it has to maintain that constant deep body temperature otherwise you will start feeling a kind of a discomfort, you know feel warm and if it goes below then also you feel cool. So, dissipation is loss of heat is again by conduction, there can be loss of heat by conduction heat loss can be there.

Radiation heat loss can be there, if the air or the surfaces surrounding is at lower temperature, then there can be conduction loss, convection loss as well, is the surrounding air is cool. So, cool air comes in contact with the body, gets heated up we will move upward. So, there could be local circulation things like that, together with that body can actually lose some heat by evaporation from the skin and this evaporation can occur if the moisture is present and if the surrounding air as a capacity to absorbed that moisture then it can lose heat, right evaporation, so that is latent heat can be loss.

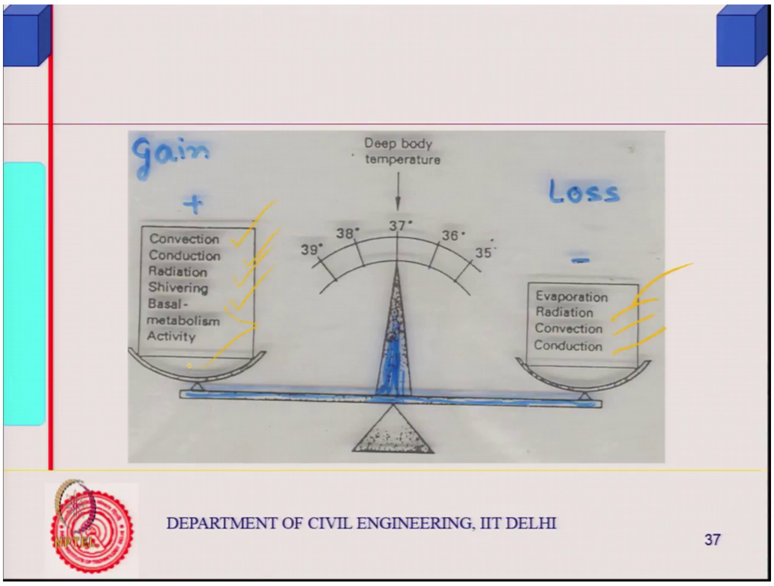
So, you can see that, loss by suet mechanism, what happens, when you are let say you are jogging or something, surrounding temperature is also quite high and your generating metabolic heat at a very high rate, in such situation what will happen. Body cannot lose heat because body may not be able to lose heat because the outside air is warm, is not able to in a closed room let us say you are doing and the surfaces are also quite hot.

So, radiation heat transfer is not possible I mean is less and because surface is at higher temperature, your body temperature and surface temperature difference may not be too large, air temperature and your body temperature difference may not be loo large. So, what happens in under such circumstances, constensus or if the body wants to dissipate heat at a faster rate, then otherwise naturally occurring, what it does it? It first increases the blood circulation of the skin, so skin temperature increases, such that down skin temperature is higher than the surrounding heat losses can occur because heat flows from higher temperature to lower temperature, sensible heat.

If that is the 1 mechanism, second mechanism is, it start generating moisture at your surface, you know the tissues at the skin tissues would start actually generating moisture, if it is a body moisture. So, we can have dehydration, if it is too bad a situation lot of moisture loss could from the body would be there. So, what it do? It would, then if the surrounding air is dry, evaporation loss would occur and it will take the latent heat of evaporation from the skin itself and thereby body temperature will come down. So, you suet mechanism besides that our breathing, exhalation we lose some heat through that as well.

So, we can see this is exhalation and then sensible heats actually, various kind of this is this can many of these, even this exhalation also we lose some moisture. So, all this causes, some sort of evaporation loss from the body. Now, just in cold situation, what happens is, loss of heat from the body is too much from the skin, outside is quite too cold. So, your body deep body temperatures tends to go down, body start should be generating more heat then. So, shivering mechanism allows additional heat to be generated in winter and in summer sweating mechanism causes. So, that is how and all doing all this body tries to maintain of course, deep body temperature to the required level that is 37.4.

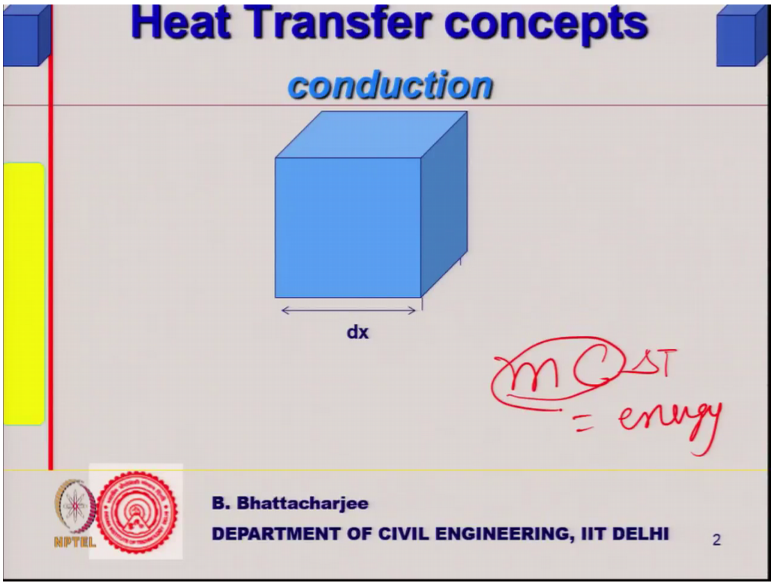
(Refer Slide Time: 09:39)



So, the losses as you can see losses are by evaporation, radiation, convection and conduction, gain is by convection, conduction, radiation, shivering and metabolic activity, basals make a metabolic activity, by that the gain takes place. Everything, do not go on simultaneously because shivering and sweating will not occurs together. So, that is how it is. So, that is thermal comfort, will come back to the sometime later on again. We will come back to the sometime later on again, when we are you know, we have looked into basic mechanism of heat transfer. So, I thought I will give an introduction.

So, now you can look, because supposing I want to find out the heat transfer from the body put it in generalize equation form because that is how we generalize, this is the algebraic or mathematics can generalized the whole thing, so this physical thing. So, when you want to do that, then what will do is, will actually before that we got to know the basic mechanisms of heat transfer. Now, since your background, in your background in civil engineering or architecture he may not have done much have a heat transfer, I would like to talk about some of the basics of heat transfer as well. So, that is what you will do.

(Refer Slide Time: 11:00)



So, first we will look into that and then heat flow basically heat flow we will look into, but heat treatment building will come later on, but basically first I will see look into heat flow itself. So, that is what it is, initially we will start with heat transfer concepts. Now, you see heat flows from sensible heat as I am saying, there are 2 mechanisms 1 is a sensible heat and measure of the heat content of a body is a temperature, temperature is an indicator of how much is a heat content of the body and heat flows from or for that matter any flow takes place from higher potential to.

Student: lower.

Lower potential, now, in case of heat flow, the potential is a temperature because it is basically, if you look at the heat content basic equation you would be remembering specific heat for example, how is specific heat is defined? It is a amount of heat required to change the or increase the temperature of the body through 1 degree centigrade. Of course, it is compared to specific heat of water that is from 14.5 to 15.5 and etcetera. So, unit mass of the body if you want to raise through the temperature.

So, you see all potentials if you look at it, potentials are defined in terms of for example, gravitational potential, would be h height, m g h is a potential energy per unit mass, if you take or electrical potential per unit charge etcetera, all you take in terms of per unit value. So, here mass for the temperature is nothing but is the temperature, is the amount of I mean sorry specific heat is defined as the energy required to raise the temperature through.

Student: unit mass.

Unit mass so.

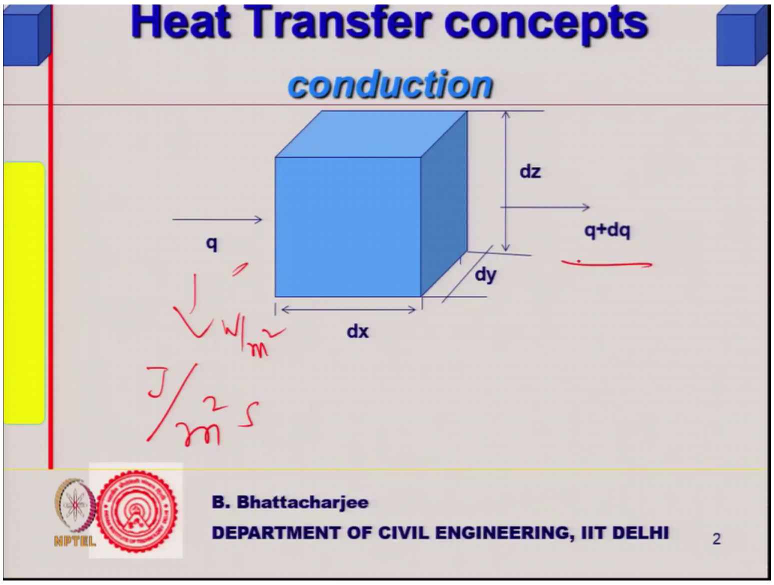
Student: (Refer Time: 12:50).

Yeah for 1 degree centigrade, I mean you know specific heat is defined that. So, specific heat, so therefore, mass into specific heat C will be denoting it by C, delta T is actually energy, let me write it, write now not formally. So, energy per unit thermal mass that is basically your potential, any potential you define in that manner. So, temperature is nothing but kind of a potential. So, if there is a temperature difference heat will flow from higher temperature to.

Student: lower.

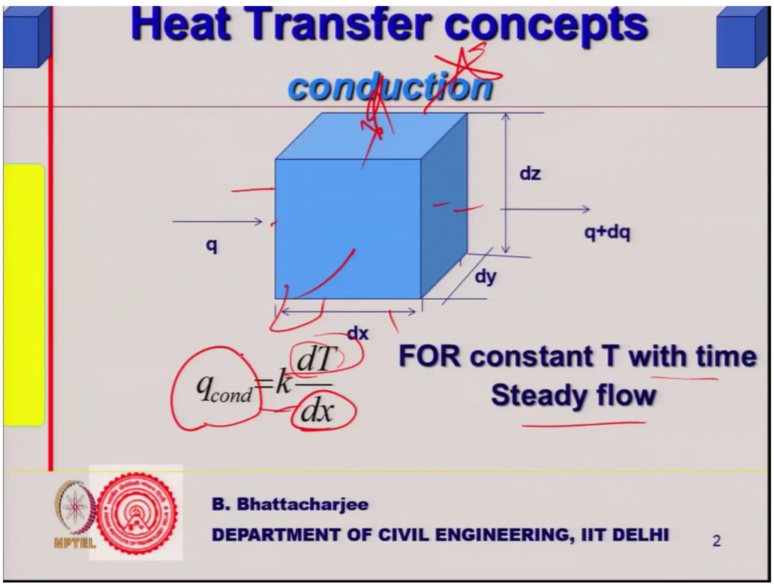
Lower temperature, it is analogic to electric potential, right, which is the work required to move a unit charge and if you look at a potential, in case of gravity then it will be work required to raise the body through unit height, something like that. So, something of this kind some analogy I am trying to draw. So, temperature difference causes heat flow, so conduction 3 modes of heat transfer there as you would be remembering, conduction is 1 of them, when heat transfer occurs through solid body because of temperature difference that is what is that mechanism we call it conduction.

(Refer Slide Time: 14:18)



So, let me considerate a d x element and let says other dimensions are d y and d z and I have some heat flowing from 1 side and the other side q plus d q, the other side the heat flow. Now, this is heat flux which will be written in terms of amount of energy joules, per meter square per second, rate of heat flow, heat flux per unit area, per unit time. So, these nothing what is the unit watt per meter square. So, heat flux is watt per rate of heat flow per unit area, and let say heat passing through this is, I mean this could be plus or minus q minus d q or whatever it is. So, that is what it is, right.

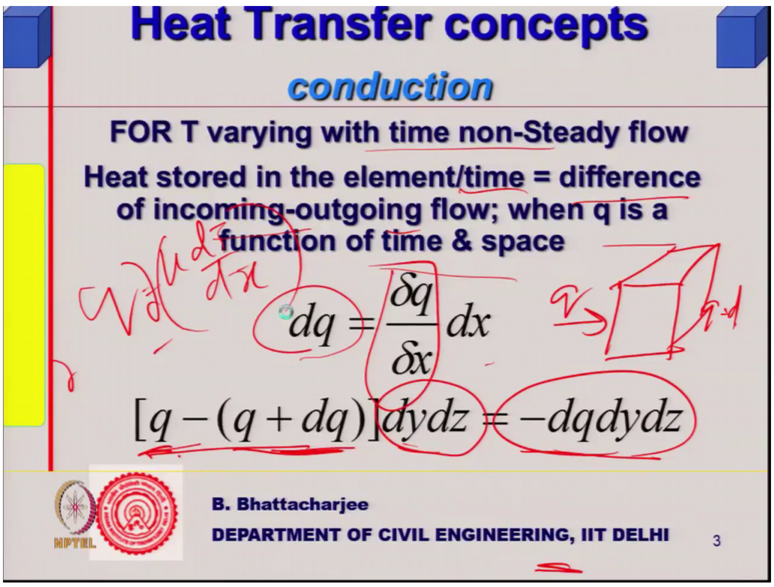
(Refer Slide Time: 15:05)



Now, Fourier's law, it says that q is proportional to temperature differential. For example, if I have sorry if I have temperature d t existing between these 2 temperature difference, existing between these 2 say over this distance d x, other side they are all insulated no heat flow is occurring, then heat conduction, heat transfer this Fourier's law, the amount of heat transfer or heat flux is proportional to temperature gradient and you would have seen similar equation Darcy's law. In soil mechanics you would have come across Darcy's flow through pores media or soil, where the flow is proportional to hydraulic head gradient, I mean sorry head gradient that is what you say and many places you will see that, it is related to that.

So, this Fourier's law, if 1 goes to the very fine level of conduction that is actually vibration crystal, vibration and all that, we are not interested, we all looking in the micro level. So, for constant T with time, there can be 2 situations when T here and T here is constant. I am saying no heat flow there, there is no heat flow on this direction, this direction or this direction or this direction only 1 dimension heat transfer is occurring and if I maintain constant temperature here, constant temperature at these 2 place that would be if the temperature is remaining constant still heat flow will occur because d t much till exist and that we call steady flow, steady or static where it is time in variant, it is not varying with time and as oppose to that, for T varying with time that is.

(Refer Slide Time: 16:48)



Student: (Refer Time: 16:53).

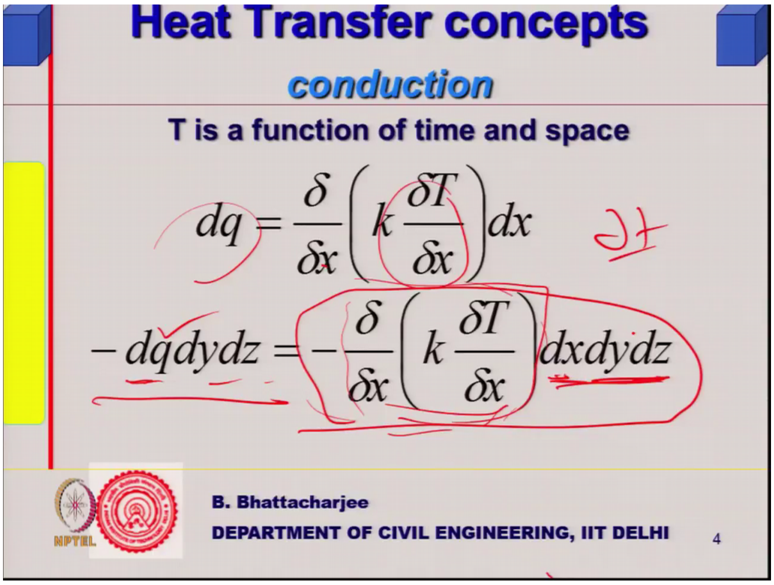
Non steady state flow, so in such a situation non steady state flow means there would be when there is non steady state that means, temperature is changing with time. So, under such situation, actually there must be some heat stored in the element because heat coming in, minus heat going out and my if my temperature is constant whatever is coming in must be going out otherwise temperature would have change. So, in a steady situation, heat coming in must be equals to heat going out. Now, if we, if it is not so which is in case of unsteady state, with that means, some it must be stored in the.

Student: (Refer Time: 17:39).

Element, so therefore, heat stored in the element per unit time is a difference in incoming minus outgoing flow, when q is a function of time and space which can it can be function of time and space. So, therefore, 1 can write, d q 1 can write like this partial derivative because now it is time and space. So, that is why I am written writing in terms of partial derivative, q is a function of time as well as space because you know it unsteady state. So, it is changing with time as well and it will, it might vary with the space also. So, therefore, that is what I write and q minus d q plus q d q because whatever is coming in is this, whatever is going out is this, whatever is because that is what I have written in that previous diagram if you have seen, into d y d z that is the area because this is flow coming in per unit area.

So, this is the flow per unit time that can be written as minus d q d y d z am I right minus d q d y d z right go back to this previous diagram that I had, what I am saying is coming here is q, here q plus d q. So, q minus whatever this must be this, so this must be stored in the system because whatever is coming in, minus whatever is going out, that is what must be stored and if it was steady then no storage would be there, whatever is coming in must be going out that is why temperature is remaining constant, but still there be flow.

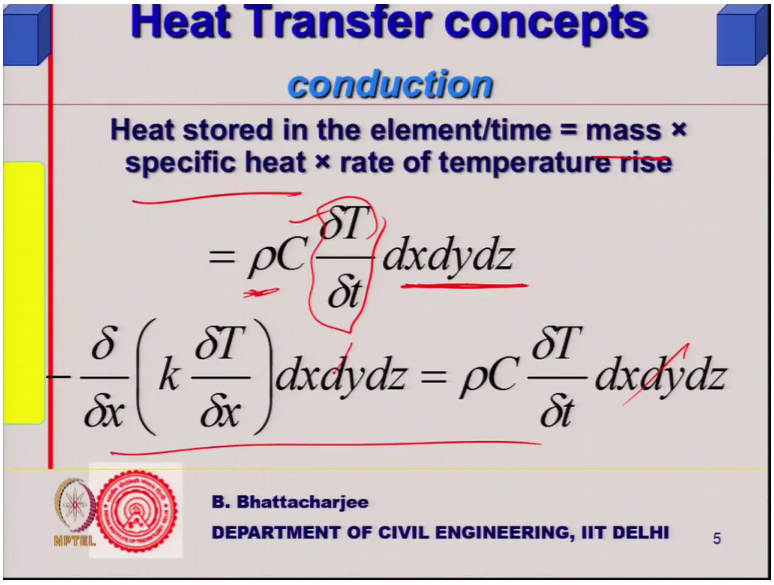
(Refer Slide Time: 19:20)



So, T is a function of time and space and therefore, d q will be written like this. Now, we said that q we just if you recollect d q. So, q was k d t d x right, so d q can be written as Del of this one, so that is what I am doing. Del x of which space if I am doing, I can write it like this k d t d x, because this the flux q, so d q can be written like this. So, d q d y d z can be written in this manner, d q is written from here like this and d x d y d z that is the volume of the element. So, how much is a stored in that element during that period of time? This per unit time and supposing this occurs in d t time's small d t time this is a amount of heat transfer that is occurring over small d t time. So, this is the amount of heat stored in the d x d y d z volume in d t time, small Del t time.

So, this is you know, this is what I have done. What I have said is, whatever is coming in minus whatever is going out is this, q can be written in this manner. So, in partial derivative form I can write it in this form; partial derivative form and d x d y d z is the volume of the element.

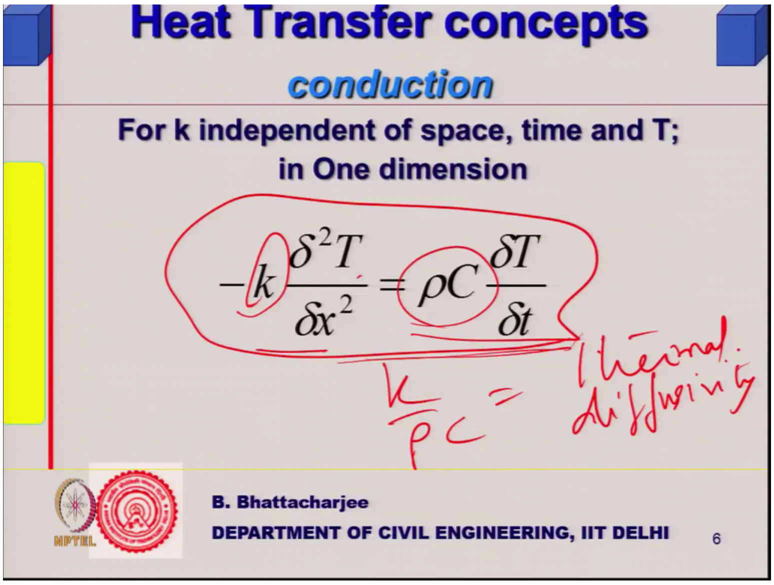
(Refer Slide Time: 20:49)



So, this must be equal to stored, heat stored in the element per unit time is a mass into specific heat into rate of temperature rise. So, therefore, I can write it like this, mass is nothing but rho into volume, that is m, m is equals to rho density into volume d x d y d z, C is the specific heat that is how we defined a little bit earlier and rate of temperature rise is del T d T because per unit time, how much is the temperature rise that must be. So, that is what I said the heat flow per unit time was d q. I did it for unit time; the flux was watt per meter square per second.

So, rate of change of temperature, temperature rise is given by this. In other words I can equate it like this and this gives me the basic 1 dimensional heat transfer. Equation, if I remove this 2, this will give you the basic heat transfer; 1 dimensional heat transfer equation and that is what it is, k Del t square like this.

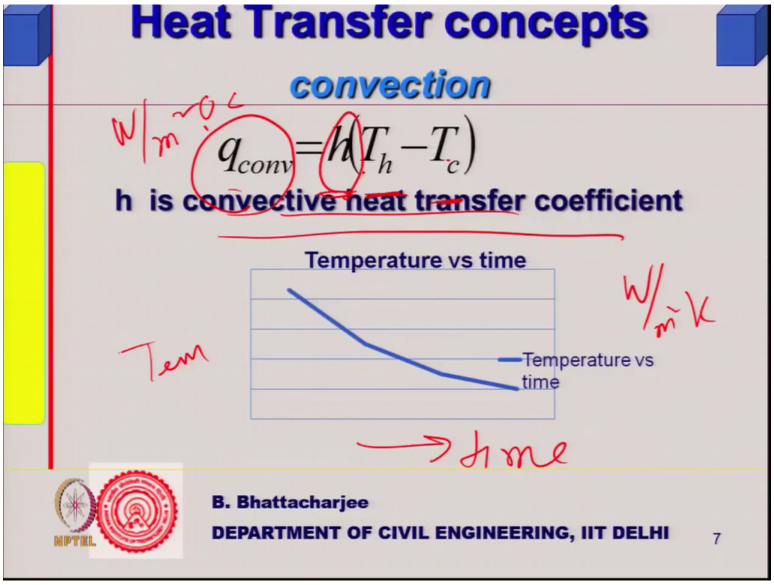
(Refer Slide Time: 21:51)



This well known equation, macro level engineering, heat transfer equation basically at that level for large bodies like wall l n n and roof and things like that we can apply this equation straight way. So, that is the basic equation of heat transfer, conduction equation and we have taken it 1 dimensional, if it was 3 dimensional homogenous isotropic material k will be same k is the thermal conductivity rho C will be same in all direction and for all of it will be same throughout for a homogenous isotropic material, homogenous material means it is same, isotropic mean in all direction it is same.

So, this property and this you can combine and we call it thermal diffusivity, k divided by rho C we call it thermal diffusivity, will come to this sometime later on, we call it thermal diffusivity again will use this sometime later. So, this basically conduction phenomenon and conduction heat transfer.

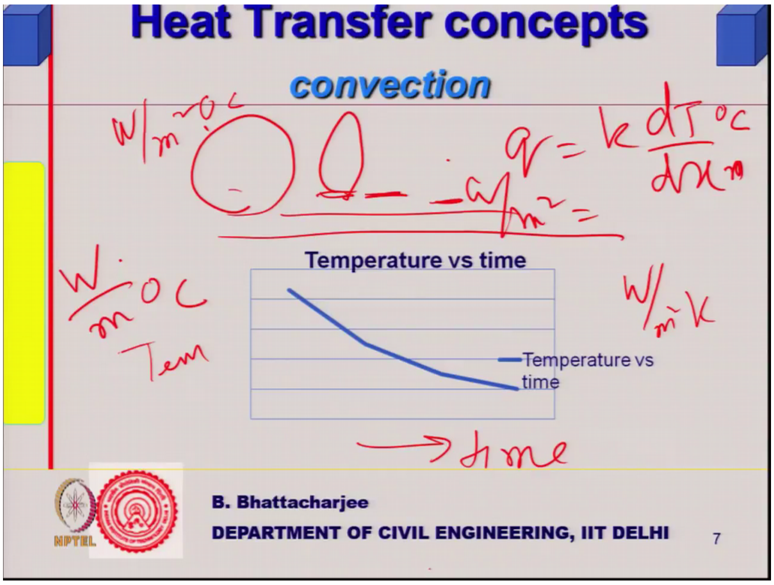
(Refer Slide Time: 22:58)



Let us look at convection, so convection you know Newton's law of cooling. Now, solid bodies they are not isolated, they are always in some surrounded by fluid. If it is my human body I am look at thermal comfort or the wall, there will be fluid around. Therefore, heat transfer takes from the solid to the surrounding fluid. So, Newton's law of cooling is temperature versus time if you plot, this is time of a body and this temperature, then you find if something like this.

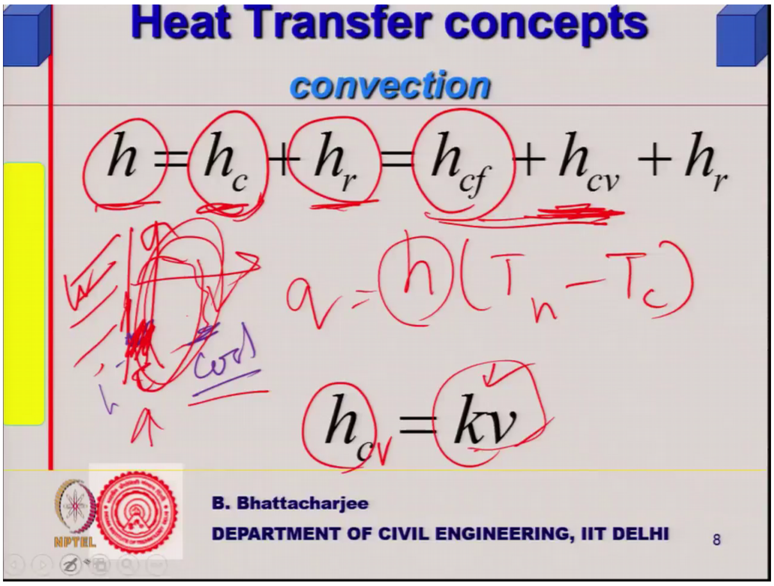
In fact, 1 can show that convection heat transfer it is proportional to hot body minus temperature difference between hot body and cold body and this is called coefficient of convective heat transfer, coefficient of convective heat transfer coefficient. I have something similar I talked about earlier, when I was talking of relative humidity. So, h is the convective heat transfer coefficient. So, this is the 1 dimensional again convective heat transfer. So, h is convective heat transfer coefficient, we use this sometime earlier, sometime you know and what will be it is unit this is watt per meter square, this would be degree centigrade or Kelvin whatever you call it. So, watt meter square that is what you know h unit of this will be something of this kind.

(Refer Slide Time: 24:38)



What was the unit of thermal conductivity, unit of thermal conductivity will be because we said q is equals to k d t d x right. So, this is watt per meter square and this is degree centigrade meter. So, it will be actually watt meter degree centigrade unit of k will be watt meter degree centigrade and unit of convective heat transfer is watt per meter square degree centigrade.

(Refer Slide Time: 25:05)



Let us look at radiation now, convection there are 2 parts of course, what I said was it is the part of temperature difference only, but supposing I have a wall from the wall to the surrounding, this is the wall part of it, let us say this is my wall surrounding, heat transfer will actually occur not by convection alone, but also by some radiation also because there is a temperature difference existing, we will define the radiation part later on. So, some radiation component I can equivalent h when I write or surface coefficient of heat transfer at the surface of a wall or a ceiling or something of that kind or outside roof. So, I will have 2 component h C and h r, this is the related to convection suns portion will be related to.

Student: radiation.

Radiation and we approximate them linear take them as linear and sum it up, you can sum it up, but this 1 will have again 2 component, what was the 2 component? We wrote that it was T h minus T C, q was equals to T h minus T C. Now, supposing this, if I have a air stream moving at the surface, temperature difference will cause. Actually, convection is what? It is movement of the molecule; conduction is essentially solid crystal to crystal.

So, you have 1 molecule to another molecule, there in contact or 1 grain and another grain, there in contact and heat transfer occur from through contact in case of solid, that is what is conduction, it is conduction. Like the school days they use to give us a good analogy, that supposing I have a huge quantity of brick; pieces of brick kept on 1 door and we want to heat transfer it to another corner, some 10 of us, so 20 of us stand up in line, take 1 heat pass to the next person and pass to the next person and pass to the next person that is kind of conduction, the molecules are not moving.

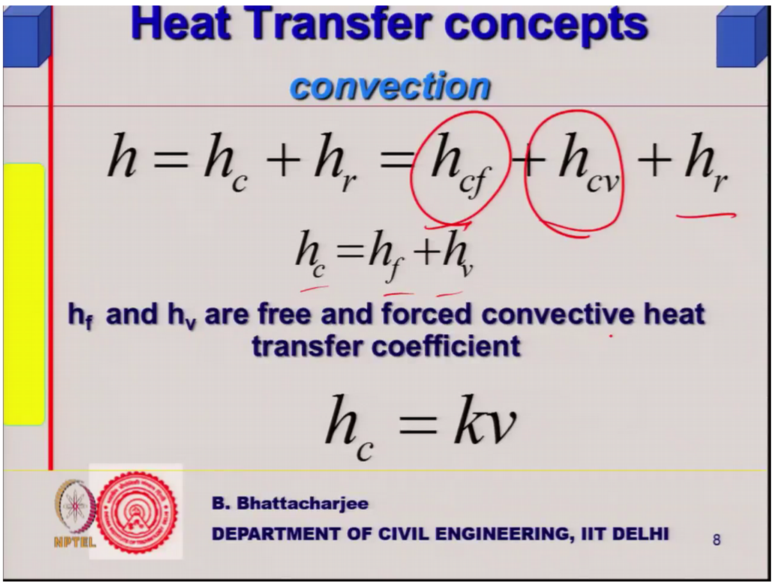
But if you take the same number of molecules, take 1 brick, run to the corner drop it and come back and take it that is convection. So, actually in convection molecules move, for example, you have a beaker you are heating the water, the water molecule will what will happen, they gets the density reduces there is a buoyancy effect because once they starts, once you heat it up, there mobility increases, all theories kinetic theories and all so there mobility will increase, the molecule Brownian motion will increase and there density reduces. So, higher density one tends to go down, lower density one. So, hot once will go up, cold once will come down, so there is a circulation.

So, in case of a wall, similar thing would happen, hot if the air here is hot there air it is cool let us say, air here it is you know cool let us say, say cool air here, cool. Hot air is hot, actually it is hot. So, this is hot here, cool here. Now, what will happen hot air will have a tendency to go up and cool air from this side will go and fill it in. In other words, there will be a circulation pattern, so that is convection.

Now, supposing have a air motion here, on the horizontal there is a air you know air is moving, velocity is there, wind you know or air movement is there; air flow is there, what will happen? The rate of movement of the molecule will increase, so it will actually carry the heat more, so that is called force convection. For example, you have a fan, fan causes more cooling, so that is force convection. So, there is 1 component related to the velocity, force component and there is a, other is a free component. So, 1 is free is because of the temperature difference, force is because of the air movement air velocity present.

So, you can actually divided into 2 parts and h c is some constant in to v velocity, this 1 is a function of h c v actually, is some k dash in to v function of velocity, but you do not look into that details, we are just trying to understand them that is all.

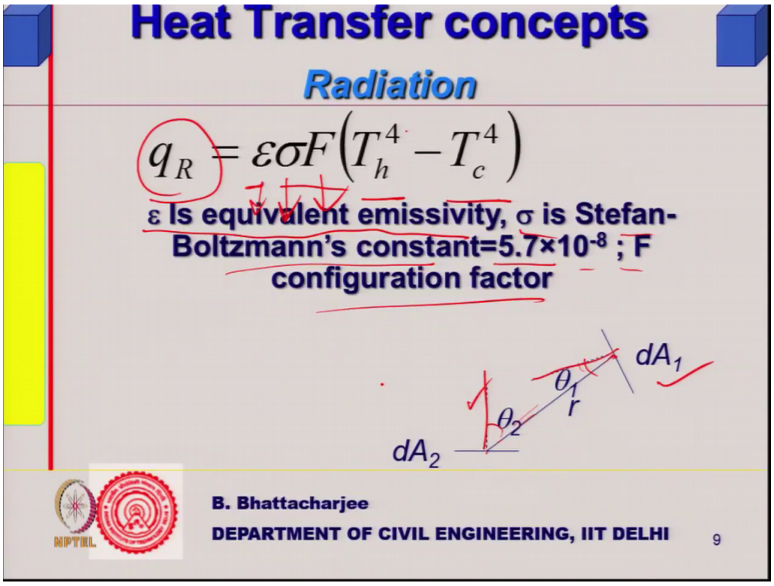
(Refer Slide Time: 29:21)



So, this is related to velocity, this is related to temperature difference; there is a radiation component also. So, h c is equal to h f plus h v one can write. So, h n are free and forced convection heat transfer coefficient and we sum them all up together and we call it surface conductance for wall or coefficient surface coefficient, heat transfer coefficient for wall as well as ceiling roof or anything solid surface in contact with the fluid.

Now, then we can look into radiation heat transfer.

(Refer Slide Time: 30:00)



Now, radiation heat transfer the same analogy, if all of us stand there and that corner we have to transfer the break, what you do throw it? No movement of the molecule, no contact with the molecule, you do not require even, you know I mean even a medium in electromagnetic radiation you do not need a medium, while of course, mechanical waves there will be a particle to particle transferred local vibration of particle about the mean position of equilibrium, but heat transfer can occur, for example, suns radiation comes from that far and it does not require, it is not necessarily there is a medium there.

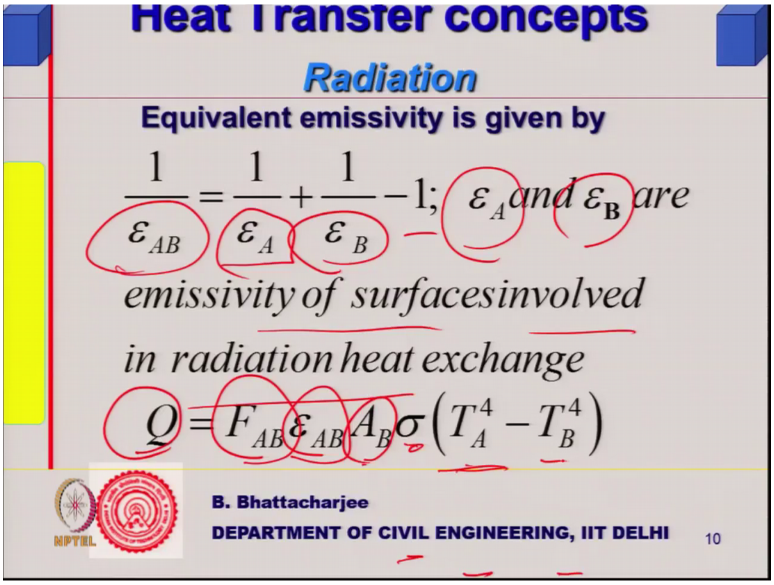
So, the equation is given by, radiation heat flux is given by this equation T h to the power 4 minus T c to the power 4, T h hot, hot temperature, hot surface temperature to the power 4, to the cold body temperature which is T c to the power 4 multiplied by Stefan Boltzmann constant, this is called a factor, brewing factor, will have configuration factor and these are equivalent emissivity. Now, let us define each one of them, epsilon is equivalent emissivity, sigma is Stefan's Boltzmann constant 5.7 into 10 to the power minus 8, F is called configuration factor, what is f?

For example, if 2 bodies are facing each other then they are seeing the complete thing right it is 1, but it is something like this, then projection of this 1 over you know there is a common projection that is what would be seen. So, the amount of radiation heat exchange between this condition and this condition will be different, this will be lower.

So, there is a factor geometry related to the geometry of those 2 spaces, that F is a factor related to that for example, I have a surface d A 2 and d A 1, these are the angles theta 1 and theta 2 normal to them, direction of that direction you know that joining there center parts or something like this, normal to this surface is this, normal to this surface is this, this angle is theta 1, this angle is theta 2 then the F will depend upon this.

Supposing, this was theta 1 and theta 2 both 0, there will be maximum. So, this is related to those, we will not look into that details actually, but this is radiation heat transfer.

(Refer Slide Time: 32:45)



What is equivalent emissivity? F you know, it is a combination of emissivity of the hot surface and cold surface. Now, what is the emissivity? A perfect black body absorbs all.

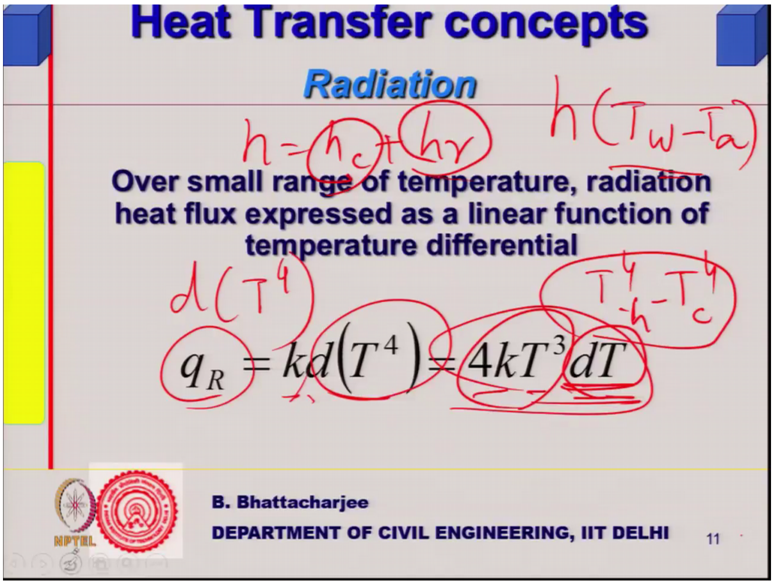
Student: (Refer Time: 33:03).

All radiation, right it absorbs all radiation and at the same wavelength it will emit that radiation also, because it will get heated up, so it will, if it absorbs all radiation will get heated up and it will become too hot, then it will give you a those radiations also. So, emissivity of a body is defined with respect to a perfect black body, it is a relative in a given wavelength, relative fraction of energy it will emit compared to that of a black body, that is why I define emissivity was surface involved radiation heat exchange. So, 2 surface is will have different emissivity's and the equivalent emissivity epsilon A B is given by this formula minus 1.

So, epsilon A and epsilon B are emissivity of surfaces involved in radiation heat exchange, again we do not have to really get into that, calculate that those ones because epsilon we will simplified this for our purpose, will actually simplify most of them, but this is a principle. So, F A B, so radiation heat exchange between 2 bodies will be given by F A B, F A B is configuration factor, epsilon A B, A B is a area of 1 of the bodies sigma, Stefan Boltzmann constant T A minus T B to the power 4, so that is what it is.

Now, which means that, radiation heat transfer is non-linear, is T to the power 4, right, but if temperature difference is small, T A minus T B is not very large, then we can approximate it in linear manner, let us see how you do it.

(Refer Slide Time: 34:57)

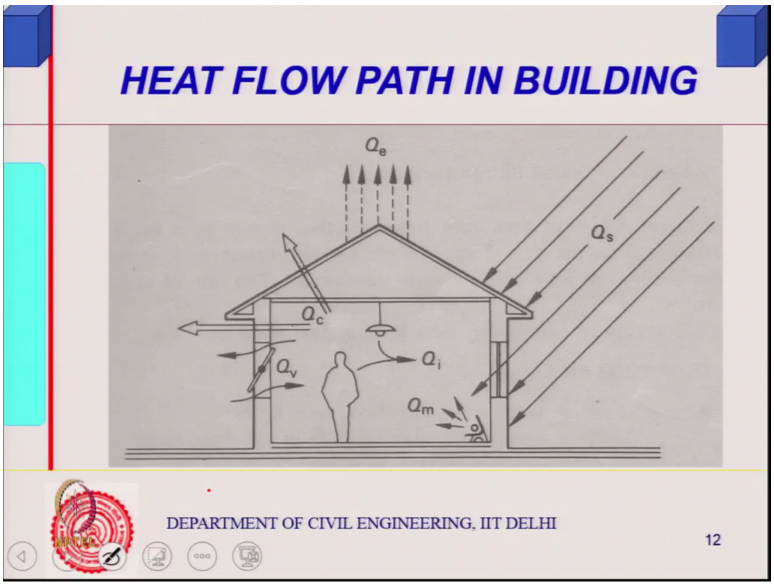


Over small range of temperature, radiation heat flux express as a linear function of temperature differential because instead of writing T to the power 4, I can write q R is equal to sum those constants, d T to the power 4, T to the power 4 T 1 minus T h minus T c to the power 4, this is nothing but I can write it as d T to the power 4, temperature you know difference in T to the power 4, small difference in t to the power 4.

If this, this temperature differences are not too large, which can be written as 4 T cube d T. So, when this T h and minus T c, T h is not too different from T c, you can approximate it as 4 k T to T cube d T. In other words, you have actually converted into a function of difference in temperature rather than temperature to the power 4. So, for our condition of building heat transfer in normal condition of from environment to inside we do not consider it to be T to the power 4 non-linear manner, but if you are dealing with fire, where temperature can go up to 1000 to 1200 degree centigrade, you cannot take it in this linear manner.

So, here it will be 50 degree, 25 degree order difference of you know, difference is not very large, we take it as simply something up this kind, so you linearize it. So, our h r, that is why you could write that h r if you remember, we talked of h r, we did talk of h r. So, h r which he said was h is equals to h c plus h r and these are 2 component, this h r is now some constant in to temperature difference because this we are saying the heat transfer will be proportional to h, let us say wall minus the T air. So, this wall to the air the temperature difference is not very large. So, we combine and write in a linear manner and approximate values are available with us and that is how we handle. So, there is a basic equations of heat transfer.

(Refer Slide Time: 37:17)



We can little bit look into heat flow path in building, yeah we can little bit look into heat flow of path in the building, but maybe just after a small break, we will do that.