Heat Transfer
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Lecture – 43
Radiation: Introduction

Moving to the next topic of the course.

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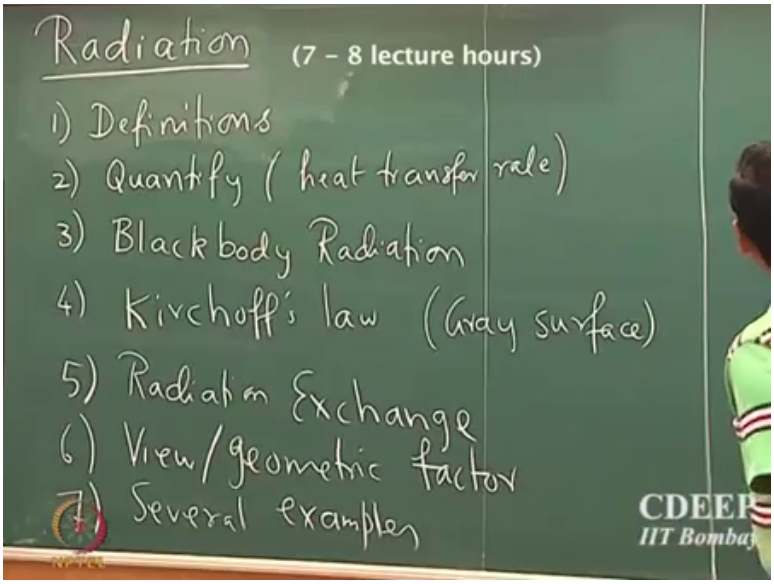

So, most of you would have heard this term. So, it is not a new topic except that the flavour in which you would see things, the flavour in which we would quantify them will be completely different from what you would have leaned earlier and for simplicity purposes they are several aspects of quantification which we will cover them in this class. We look at several things one is we will start looking at definitions of radiations.

We Look at various definitions associated with radiation, we look at what is the, how to quantify that is how to find the heat transfer rate for radius cases, radiation could be emission and absorption and transmission etcetera. So, we look at how to quantify it for various process is various radiation process is and then we will look at black body radiation, we look at what happen when there is a black body and how to quantify emission absorption etcetera from a black body and then we will look at.

So, this is special law for radiation which captures the relationship between certain properties of radiations and that is what called Kirchhoff's law and we will actually look at that and then. So, while doing this we will also cover what is called the gray surfaces what is the definition of gray surface and how to quantify them we will look at that and then the fifth aspect is we look at radiation exchange. So, supposing if there are multiple objects then how would you exchange, how does how do these objects exchange radiation between themselves etcetera and while doing that we will also look at.

So, we will look at something called view slash geometric factor those the radiation is now going to depend upon the orientation of these objects. So, one needs to find out what is the effect of the orientation or that is what is generally called as view factor or geometric factor. So, we look at how to calculate the view factor and geometric factor for various kinds for systems. So, that is what we will sort of do in next 8 lectures, after we finish this there will be several examples several examples that we will go through and somewhere around anywhere between 7 to 8 lectures what I would estimate, for this topic alright.

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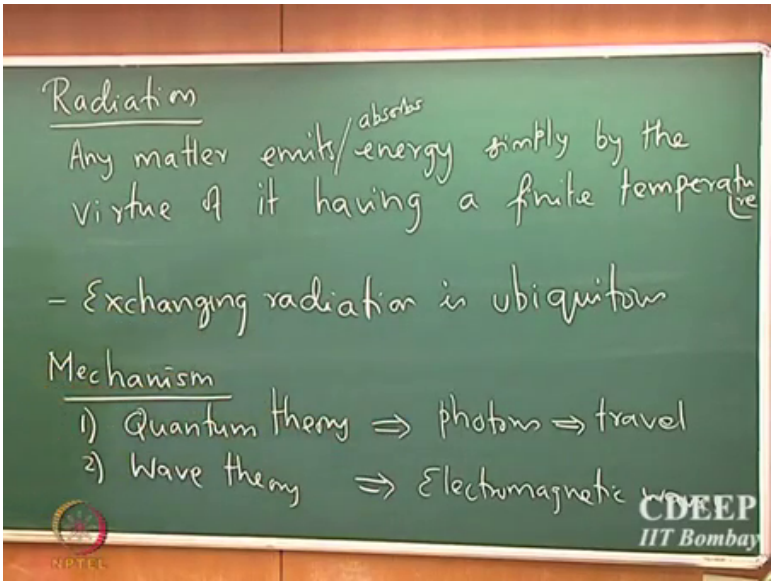

So, what is radiation? So, radiation is any matter emits energy simply by the virtue of having a finite temperature. So, it is a most general temperature. So, any matter in fact, we can even qualify better by seeing emits slash absorbs etcetera. So, worry about transmission later. So, in general emits slash absorbs energy simply by the virtue of it

having a finite temperature ok, the fact that which has a certain temperature it has certain energies stored in it and therefore, it is exchanging radiation. In fact, every object in this room is a is emitting radiation black board, this bench, etcetera everything is emitting radiation it is not just as emitting radiation it is actually exchanging radiation with itself with all the object which is present here. So, therefore, exchanging emission, exchanging radiation it is a ubiquitous process, exchanging radiation is ubiquitous it is found everywhere it is found in all objects our hand everything is radiating. So, out of curiosity. So, there was a place where a I had an access to infrared camera.

How many of you heard about infrared camera oh not bad ok. So, if you place your hand in front of the infrared camera and you measure the profile that you will get, measure the image. So, the image that you get from an infrared camera reflects the local temperature of that surface that you are looking at. So, if you keep your hand in front of the infrared camera you will be surprise to see that all location they have different temperature.

So, you do not have a uniform temperature profile even in your palm there is a definite temperature profile. In fact, if you get an access to infrared camera to some of the lab there are infrared cameras in this institute. So, if you get an access to problem it is not a bad idea to just sort of a get an idea of how the temperature profile looks in your palm or in hand etcetera. So, really the temperature profile is quite different than and it is uniform and.

So, if I am actually putting my hand there is a heat exchange between different part of my hand, one hand to the other hand because the temperature is different. So, exchanging radiation is actually quite a ubiquitous process it occurs across all matters all objects etcetera ok.

So, incidentally there is a I do not know how many of you read the newspaper yesterday. So, this is new type of blub that is going to come out it is called a liquid cooled LED how many of you read the newspaper yesterday and today it came out yesterday in newspaper nobody, no body, it is called the liquid cooled LED.

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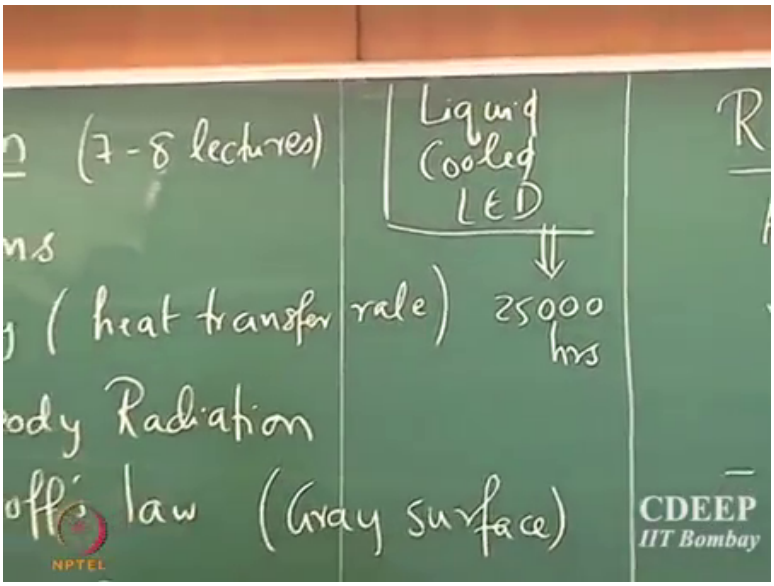

If you not seen you should go and see it today, actually one of the direct applications of what we are actually studying in this course.

You know what LEd lights most of this incandescent lamps and LED lights the problem is the emits the lot of heat, particular in LED lights the LED itself does not emit heat, but there is a an a panel which supplies electricity and etcetera and controls the glowing of LED, so that emits the lot of heat. So, the life of an LED lamp is actually dictated by how one can control heat transfer how one can keep the ship which is present below the LED under normal temperature.

So, one is able to keep for at a normal temperature then actually you can have a longer life for LED. So, these apparently these liquid cooled is going to be next generation bulb, it can glow for 25000 hours what is a remarkable we have never seen any blub which can actually go glow for that long none of the blub that we know. So, it is really remarkable.

And if it really works it is going to completely change the paradigm of conservation of electricity and. In fact, you suppose to have it is suppose to be very efficient and it takes about 80 present lesser energy than the normal incandescent lamp that we have here. So, if this works it is really a great technology any way. So, it had a lot of implications and it is a direct application of some of the things that your studying in the class they have worked out what should be the optimum amount of heat transfer that should occur between the LED panel and the liquid there is a small amount of viscous liquid, which is

actually circulating inside and they have made a precise calculation of how much should be the exact heat transfer and what should be the volume of the viscous fluid etcetera. So, it is an interesting property and. In fact, it is one of the direct applications of what we are actually going to in this course any way after this (Refer Time: 09:55). So, let us go back to the what we are looking at so the mechanism of radiation.

So, let us look at what is the mechanism of radiation. So, as we directly pointed out what happens is because the there is a certain object which is at certain temperature. So, there are these electrons which are actually emitted from the surface and. So, there are 2 theories which are actually available to explain the mechanism of radiation. So, 1 is called the quantum theory and other 1 called the wave theory. So, the quantum theory again it is a postulation, it is believed that the object because of its certain temperature it emits quanta and photons and These photons will travel.

I mean they hit the other object they leave the energy that is how the energy is being transmitted from one object to another. The other theory is that is a electromagnetic waves because of the temperature of the object it emits electromagnetic waves and these electromagnetic waves are intercepted by the receiving object and that causes exchange of energy between 2 objects. So, these are the 2 theories that are actually existing. So, we are going to debate about which is right and which is wrong that is the problem of the physics, but it would not matter to us because as long as we know either of these theory is right we should be able to quantify the process we are going to see that in short while, alright when we looked at conduction.

We said that heat transfer we are conduction it occurs through a cross sectional area right. So, similarly we need to know what is the what is the geometry at which the radiation is going to occurs. So, the first question is it a surface area or a volumetric phenomena.

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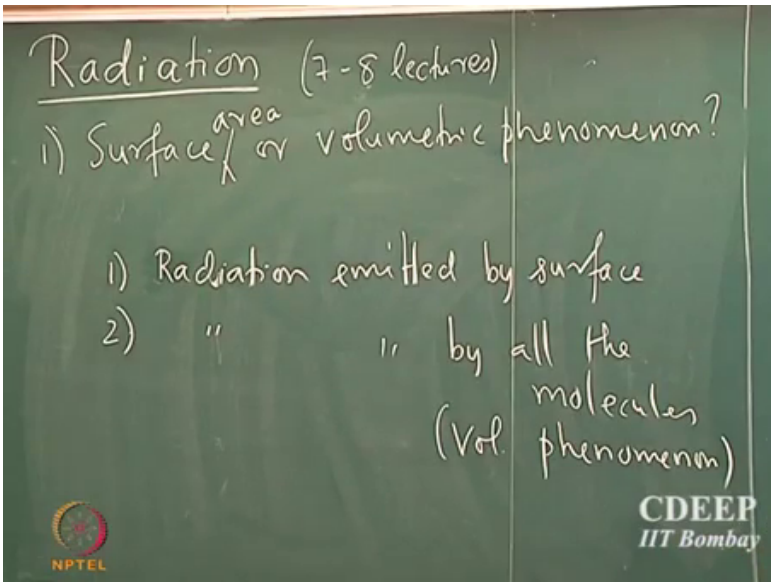

So, first question we need to answer is it a surface area or a volumetric phenomena. So, remember when we discuss conduction we said that the thermal diffusion occurs across the cross section while the capacity to store heat is a volumetric process.

So, what about the radiation it is a surface area or a volumetric process. So, he says that radiation can occurs only from surfaces. So, it is a surface area process what is your (Refer Time: 13:11) you said it is a volume process (Refer Time: 13:17) ok. So, in the class we have got two thoughts one is that radiation emitted by surface. So, it has to be a surface area process and the second part we have got is radiation emitted by all the molecules. So, it has to be a volumetric process. So, which one is right?

So, the correct answer is both are right. So, you would not intuit as to why both are right. So, that is what we are going to explain in a next few minutes so. In fact, any material you take. So, this second suggestion is always right, the radiation is emitted by all the molecules which is present in the matter that you are considering ok.

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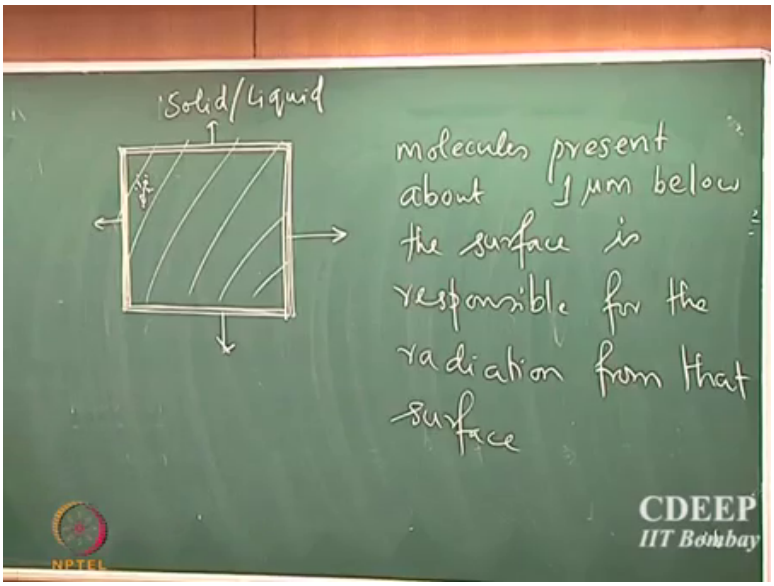

So, now, supposing, supposing we have solid or liquid matter let us say it is a solid all the particles which is present in solid in principle they are going to emit radiation.

Because they are all maintained at a certain temperature that, what happen is the molecules which are present at the interior location any where inside every radiation that is emitted by one molecules is also going to be observed by the molecules which are surrounding them, right. So, therefore, there is whatever emitted by the molecules which are present inside they are going to be constantly emitting and observing radiation. So, therefore, all the radiation that actually comes out of this object are essentially from the molecules which are located close to the surface while give u in a short while what is length scale for all the molecules which are located close to the surface are the ones which are resulting in the radiation which is emitted out of this object.

And in principle what is believed is that the molecules present about one micrometer below the surface is responsible from that surface. Now, note that this is true for solids and liquid it is not true for gaseous system remember that gas is also emit radiation. So, the radiation is emitted by all the system.

So, observe that radiation is emitted by all forms of matter. So, when it comes to gases it is slightly different.

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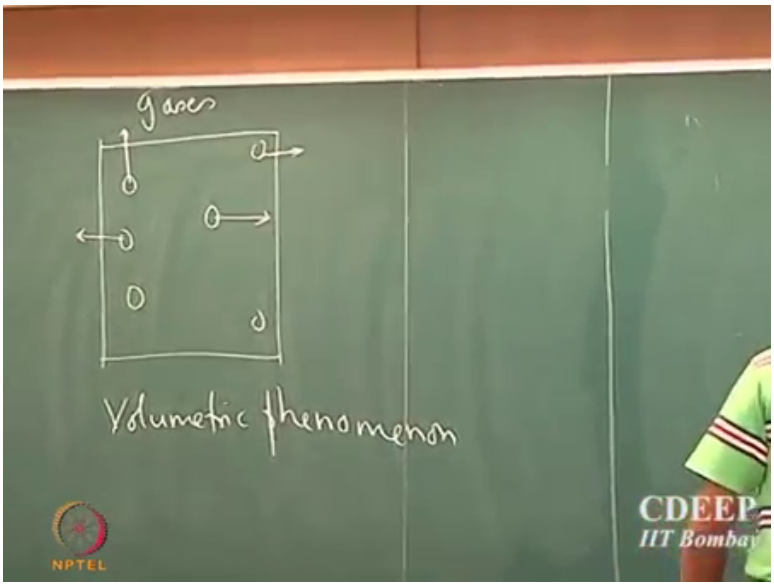

Because the density is very small right density of gas is very slow and. So, supposing there is a gas which is place in a container, now you have molecules which are actually dispersed in this medium and as we observed every molecule in principle can emit radiation and because the density is not sufficiently tough, the radiation emitted by one molecule is not necessarily completely absorbed by the molecules which are present around them therefore, in gases it is a it is volumetric process, it is a volumetric phenomenon.

While in a solids or liquid it is a surface phenomena. So, most part of the discussion were actually going to look at the surface area phenomenon we are going to characterize radiation quantify etcetera and then apply some the principles to the volumetric phenomenon towards the end of the radiation topic ok. So, whether we believe in the quantum theory or the wave theory we can always characterize radiation.

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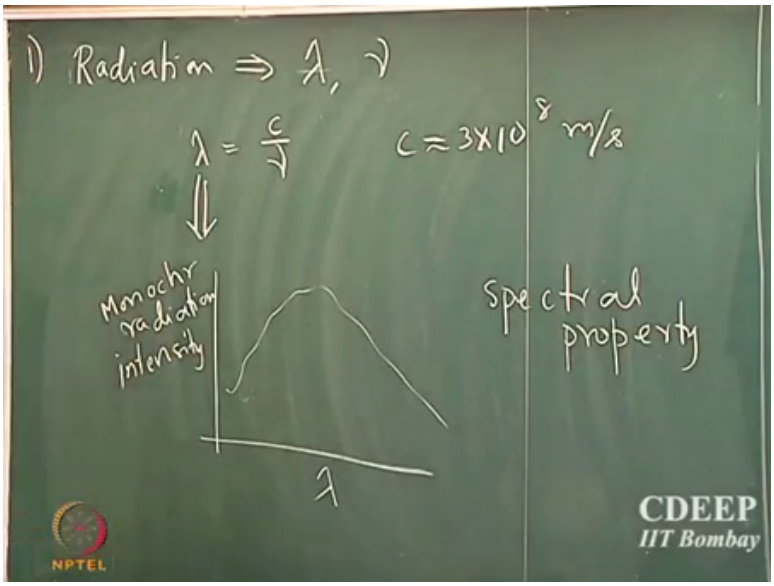

Radiation is always associated with the a certain wave length and frequency ok, never matter whichever theory we believe it is always associated with a certain wave length and certain frequency. So, we can always say that lambda is equal to c by mu where c is the speed of light and the vacuum conditions.

Proximately 3 into 10 power 8 meters per second. So, that is the speed of light about it is 2.998 something, approximately it is about three into 10 power 8 meters per second. So, any radiation is always associated with the wave length and its frequency. So, if we know the wave length we know what the frequency is going to be so. So, therefore, we are going to talk a lot about the wave length of the emission.

So, suppose if I take a monochromatic radiation ok, when I say monochromatic which means that the radiation is emitted at a fixed wave length right at single color which means is it is a single color. So, if I look at the monochromatic radiation intensity, radiation intensity verses lambda at a fixed wave length what is the intensity of the radiation emitted by a certain object in that wave length ok.

So, then the typical profile is something like this does not matter what these numbers are we will see that later. So, this property of radiation of an object to be dependent upon the wave length is what is called as spectral, here is a waves come from the word comes from the idea that there is a spectrum for radiation and. So, this is called the spectral property. So, fact that it depends on the wave length of the emission is called the spectral

property. So, this is the first important dependent and the second one is the directional dependence.

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The radiation is also dependence on the direction at which the emission is occurring. So, in principle as a cartoon suppose I have a point object here emitting radiation. So, the emission in this direction could be. So, the as length of the arrow as if I say that indicates or denotes the intensity of radiation. So, the radiation intensity is different in different direction. So, that is what it means by saying it has directional in dependence and theta is counted from this angle going from 0 to pi, now when it is a surface phenomenal the emission is only in the one direction and if there is a object here.

If I want to characterize the emission from that surface it is really emission occurring only in the upper plan of the surface that is the upper hemisphere of that surface note that is a 3 dimensional process. So, it is going to depend on the theta it also going to be dependent on the 5 angle fine. So, if you will if you imagine a sphere 3 angle, 2 angles to the sphere, one is the generally called as theta.

So, any sphere you have 3 coordinates 0 sorry r theta pie. So, in principle the radiation if I put a hemisphere on top of this. So, the radiation that is emitted by that surface insensible dependent on both theta and pie. So, theta is suppose if I say this is the theta direction then pie is in the direction outside the board and inside the board. So, note that

the it is going inside the board it is circle inside the board ok. So, so the radiation is now going to be a function of both theta and pi.

So, these are 2 important properties of radiation which it needs to be a accounted for if you want to quantify amount of heat transport because of radiation. So, if it is black body with a fixed radiation it will be at a single pick. So, if it is a gray surface there will be flat, flat peak. So, we are looking at solids we will look at gases later. So, note that gases can in principle made in all the direction.

So, the question is whether it is continuous or discrete now the discrete nature we are going to see that a sometime down the lecture one of the lecture we will see when you have grace surfaces particular hydrogen is actually a grace surfaces a grace molecule it is not black board radiation. So, when you have gray surfaces it is not that the spectrum is continues you will have discontinues spectrum, we will see that we will see that shortly, mostly 3, 4 lecturers down the line we will see yes.

Student: (Refer Time: 23:54).

Sure because.

See supposing, supposing my object is here supposing my object is present here now the emission from this surface is the strong function of the roughness of the surface. So, you will never get a smooth surface, even at the microscopic level you cannot have a smooth surface. So, there will be small (Refer Time: 24:19) around and therefore, the emission in different direction is going to be different.