Engineering Thermodynamics
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Lecture 04
Macroscopic and Microscopic Forms of Energy

Hello! We are going to now start view module chapter energy and energy transfer, but before we go into details. Let me just summarized what we have gone through quickly in last 3 lectures.

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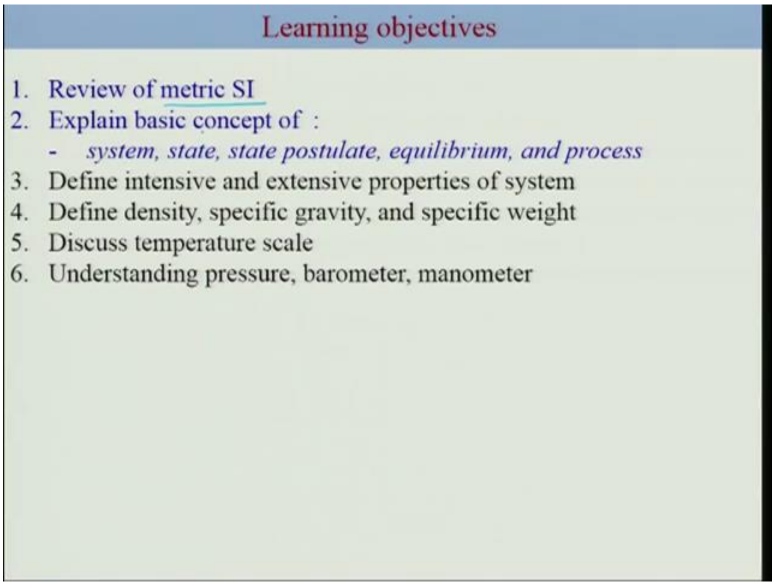

So, we will started with the importance of thermodynamics in various application areas daily life and defined SI units and importance of homogeneity of dimension, which essentially means the A is equal to B + C, if A, B, C should have all similar units.

We defined the system control volume, property of a system and something like density specific gravity and the more important thing we went through was state, definition of state and the state postulate which you lets how you define a specific state based on intensive variables. We talked about processes and cycles and what is a steady state process and then we went through the introduction of temperature pressure definition and as well as how to measure and then we ended with a importance of a problems solving techniques.

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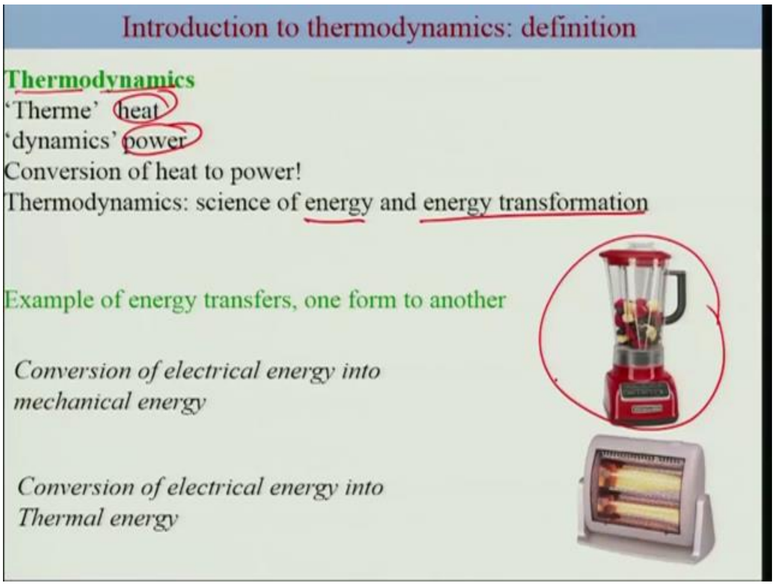

So, in this we are going to learn about the concept of energy, we will defined different forms of energy we will discuss the nature of internal energy we will define the concept of heat and the association with energy transfer by heat and then in the next lecture we will talk about work. So, let us just understand a bit of energy conversion or conservation and as well as conversion to different form.

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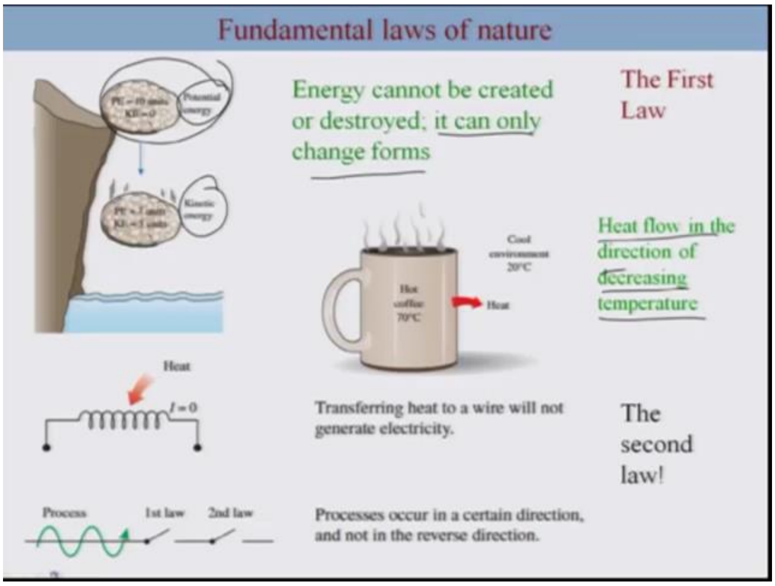

So, let us take an example of this, this is a refrigerator which you have open the door in a room okay, and then you have what you have done is you have well sealed and insulated the room. So, what you have is a system which contains air + this device which is refrigerator and the boundary of course is here walls of the room and then you have this interaction with the surrounding through this electrical part. We want to you in the first you will do that in the room get colder that is not the case even if you will later on you realized that is going to heat up and the reason being is conservation of energy. You are transferring electrical energy into thermal energy okay because the electrical energy is provided by this and then you have increasing the temperature of the room by conversion of electrical to thermal okay.

So, there are many forms of energy thermal energy I said once already is thermal is one mechanical, kinetics, potential, electrical, magnetic, chemical and nuclear. Some are microscopic in nature, which depends on the elevation of the overall system velocity, some are depends on the molecular motions which will microscopic. So, the macroscopic are kinetic and potential and microscopic once are these which are related to molecular structure which is independent of outside reference is we are going to discuss about this more in detail it is basically internal energy.

Now if you are a defining the energy of the total system, then you have to consider the macroscopic and microscopic both together. So, total sum of far sum all form of energy will comprise the total energy okay. On the other hand, sum of all microscopic form of energy will be called internal energy okay. Let me let me first go through the microscopic forms of energy first and then I will talk about the internal energy.

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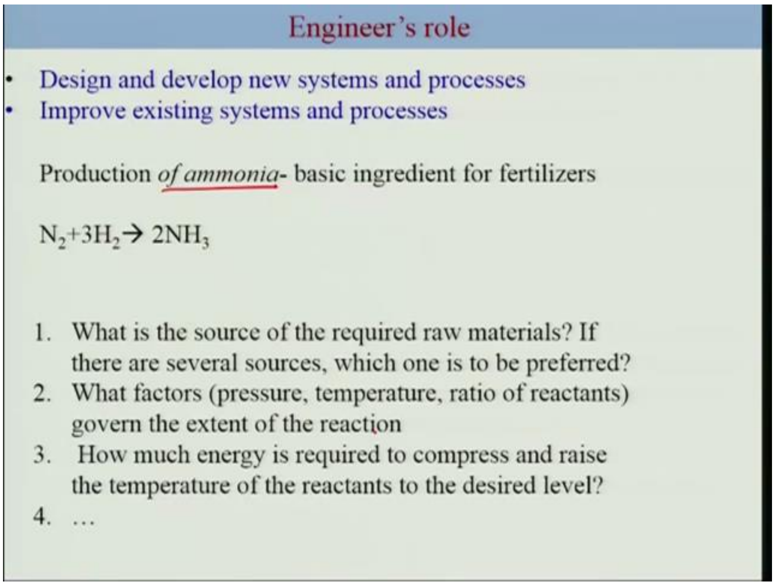

So, as we already discussed the microscopic forms of energy is depends on the elevation of the speed of the system of the object. So, this is the classic examples are kinetic energy, which is represented by this expression which is m v square by 2 and the potential energy which is represented by m g z, where z is a elevation of the object. You can define in terms of per unit mass in this form you divide by it and you get this V square by 2 okay.

So, the microscopic form of energy is simply related to motion and influence by that external field. So, that could be not just gravity, when we talk about elevation that could be magnetic, could be electricity, and could be surface tension okay. So, if the magnetic, electrical and surface tension forces all external field are excellent, when the total energy of the system would be there, internal energy which is a microscopic + the macroscopic apply which is kinetic energy and potential energy okay. So, this is the expression which we are going to write okay.

So, let us look at internal energy, so internal energy can be divided into many forms, rather it is comprise it comprises of many expect of these energies. So, one is sensible energy so sensible energy is simply associated with the kinetic energy of the molecule, so what is the kinetic energy of the molecule. So, okay you molecule can vibrate okay can rotate okay and can translate okay. Additionally the molecule consist of nucleus, electron, electron can rotate around the nucleus, electron can spin around this own axis, nucleus nuclei can also spin around its own axis.

So, this comprise is sensible part of the internal energy and that is what it is return in this illustration, so this is all sensible part of the internal energy. In addition the energy required to change the phase of the system is also part of the internal energy, so that would be a latent energy. So, examples would be, when you change liquid water to vapor, when you melt solid ice to liquid, these are all the energy required to change the phase would be Latent energy and this is the also part of the internal energy.

In addition if the molecules during the reaction the molecules are break the break bonds and turn to different spaces that is the chemical energy because that is associated with the bonds okay. That would be chemical energy and then you have this nuclear energy where the energy is associated with the strong bond within the nucleus of the atom and this is extremely large amount of energy.

So, in this we are not going consider nuclear energy is the part of the analysis that, these all parts of your internal energy. So, typical thermal energy would be a sensible energy + Latent energy. So, we will talk about thermal energy it would be sensible energy because that is what the energy associated with the movement of the molecule plus if there is a phase change and internal energy would be sum of all these energy which we have listed okay.

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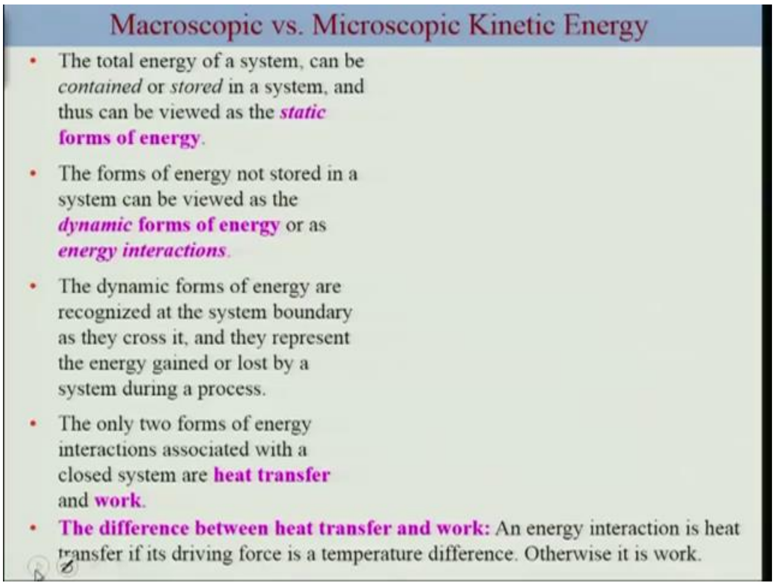

Now the system, when you put in the place in the container let say water in a container, there is the energy stored in the system that is called a static because there is the movement with their boundary. And but there are other energy which is associated with the transfer for energy from that boundary to the system and these are called dynamical form. So, the one is a static form and the other is dynamical form. So, the dynamical forms are the one which are associated with energy gain and loss by the system during a process. It is only recognized only when it gets out the system or comes to a system from this surrounding and heat transfer is one example okay.

So, the two forms of the energy associated with a closed system, which means the mass is not flowing will be heat transfer and work. If there is a temperature difference, let say in surrounding in system, it will be a heat transfer otherwise it will be work okay. So, this is an example of dynamical form and you will be tried to illustrate this more get into more depth to that. So, you will talked about microscopic kinetic energy, what is the microscopic kinetic energy, when you have fluid let say and it moves with a, or the object which moves with a velocity.

Now and then you have a macroscopic kinetic energy which is the part of the sensible energy, where the molecules are moving. Now these molecules they move in a disordered form, now you this is illustration with tells you that the macroscopic kinetic energy is more organized and more useful, then microscopic kinetic energy. And for example you put water and this is a damp and this is a turbine wheel and if the water does not flow, the turbine will do not rotate even though the molecules be move a lot. On the other hand if it flows we have a perfect you know the energy can be generated electron.

So, essentially it tells you that you know macroscopic kinetic energy is more useful then a disorder microscopic kinetic energy okay. There are many engineering system which are designed and to transfer the fluid from one location to another at a specified velocity for velocity or certain elevation or these are these do not involved any conversion of chemical and nuclear energy to mechanical energy and but it can be analyzed by considering the mechanical form of energy,

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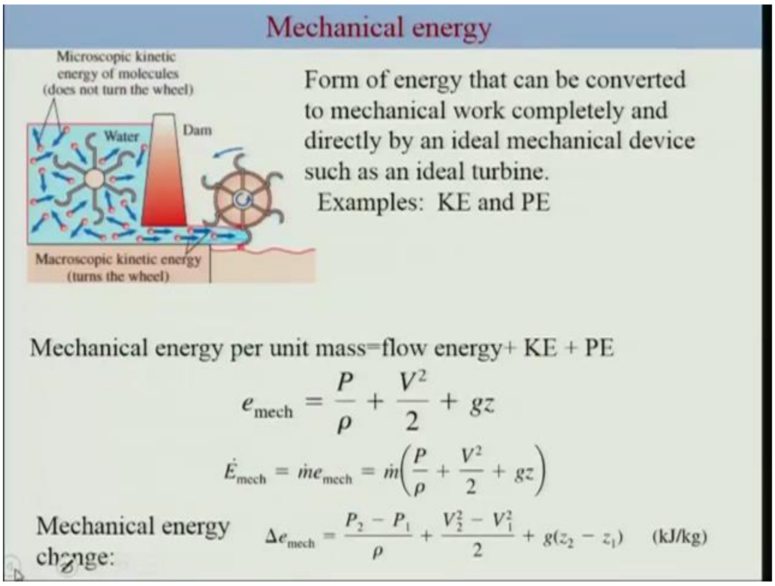

So, let us look at it what is a mechanical form of energy, this is a form of energy that can be converted to mechanical work completely and directly by in ideal mechanical device such as ideal turbine. The examples are kinetic energy and potential energy or microscopic kinetic energy in potential energy and thermal energy is not a part of a mechanical energy. The reason being the thermal energy cannot be converted directly to work completely okay and the due to a second law of thermodynamics and that something which we are going to learn later okay.

So, let us take an example of pump, pump transfer is a mechanical energy to a fluid and it raises it is pressure. Turbine extract mechanical energy from the fluid and by reducing it its pressure, thus the pressure of a flowing fluid is associated with mechanical energy okay. So, the pressure though is not on energy, but when the pressure force acting on the fluid through a distance it, it produces a certain work okay. And this work is called flow and work for the convenience and we says as flow energy and we include that as a part of the mechanical energy.

So, where all we can define the chemical energy in this form, so mechanical energy is per unit mass includes flow energy, which is nothing but a flow work and + kinetic energy + potential energy okay. So, the so this is nothing but P v which can be written at also as p by Rho and this is your kinetic energy as is that in terms of weight we can write in this form. So, you can find out the change in the mechanical energy for a incompressible fluid, it will be a simply a difference in pressure by and the difference in kinetic energy and difference in elevation.

So, in case of a system which do not have any change in the pressure or difference in the velocity or it is a particular static at elevation is not changing in such case your delta e mech is going to be 0. Now for the case where the mechanical energy is transferred to the system your delta e should increase if you further case where it is extracted from the system your delta e mech should be less than 0. So, this is the case for transfer from the surrounding or to the system that means the fluid and the mechanical energy is being transferred to the fluid hence your change in mechanical energy should be greater than 0 okay. And this would be the case where you have extracted mechanical energy from the system such as your turbine okay.

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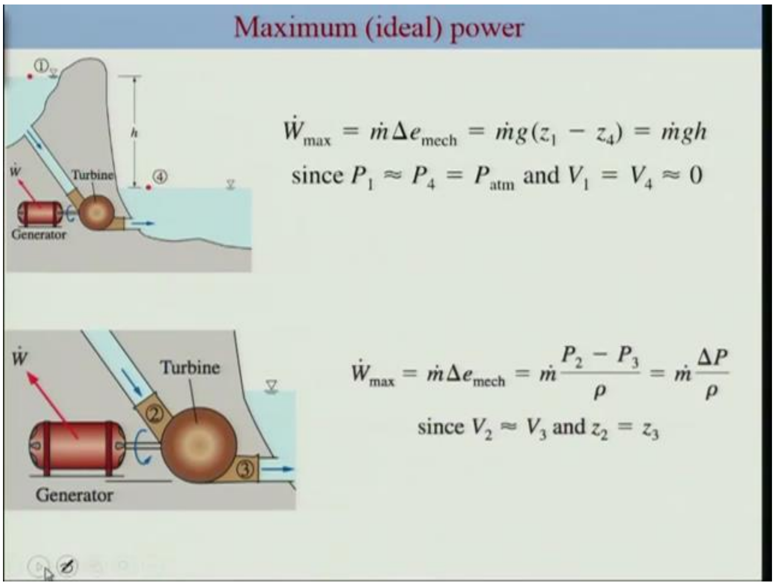

So, we can take an example and apply this aspect, now in cases of an ideal hydraulic turbine, what would be the maximum power. So, assuming that this is the case where you have ideal hydraulic turbine connected with the ideal generator and it means there is no loss of energy had we having here. So, whatever the mechanic energy of the fluid is transferred to the work done by the generator, so this the maximum power okay will be simply m dot e delta e mech.

Now what we are assuming that, so this are the two cases we are going to consider, one is here were we considering this 1 or 4 point, which are this is upstream and this is downstream okay. So, the pressure here we are going to come assumed to be same, that the elevations are not so the difference is not so much there will be change in the pressure. So, it is how much closed to atmospheric pressure. Now what about the velocity both the reservoir which we are going to be use will be not flowing, so will going to consider them to be at stationary, which means the V 1 is should be same as V 4.

So, in that case your delta e mech should be simply the change in the elevation and that change delta e mech okay. And hence it is simply change in the elevation of the two reservoirs. Now you can zoom this and you can also express this maximum ideal power in terms of the pressure drop across the device that is turbine and this is in second case here you apply the same expression but now you considering these two points 2 and 3 okay.

Now here the velocity we are going to consider almost closed to same that is the velocity base not changing much elevation we are considering to be almost similar. This is because the scale if you recount the scale the change in this Z is called a small compare to what you have shown here in the difference between the reservoir heights. So, this will the simply written as the change in the pressure across the turbine because the rest of the component is going to be 0 so this is application of fuel mechanical energy.

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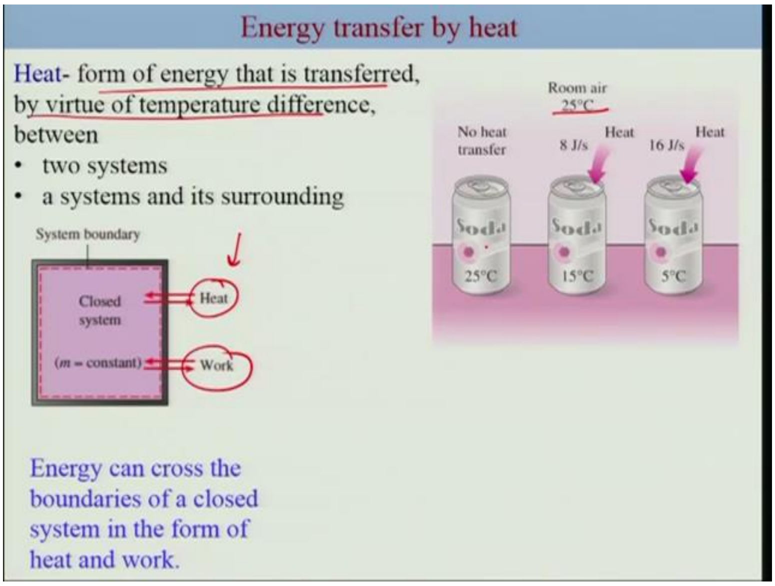

Now as I mentioned already that their two form of dynamical energy. So, system contain the static energy and system has can undergo dynamical change, but these those would be recognized only at the inter interface. So, for a closed system you have two possibilities that is heat, when there is a change in the temperature and thus the work and heat is a one which is the form of energy that is transferred by the virtual temperature difference okay. Between the two systems or could be system and surrounding.

So, so will talk about heat first and then we will discuss is about work later. So, let us take a example here, so you have a room temperature at 25 degree Celsius you put soda a Can of soda which is also 25 degree Celsius, what is a heat transfer, it will be 0 because this will be at equilibrium with the surrounding. You take this same Can from refrigerator at 15 degree Celsius, the temperature difference has increased which increases which allows the heat to transfer it is a 8 kilo 8 joules per seconds. You decrease this temperature this Can or increase the temperature the temperature difference, you increase the heat transfer.

So, this tells you that the temperature difference is the driving force for heat transfer. The larger that the temperature difference, the higher is the rate of heat transfer. So, we will consider the couple more examples here, so let us take an example of a big potato, so a big potato if it is isolated is not going to transfer any heat to the surrounding that if you take out from the oven, we will going to noticed that it slowly cool down.

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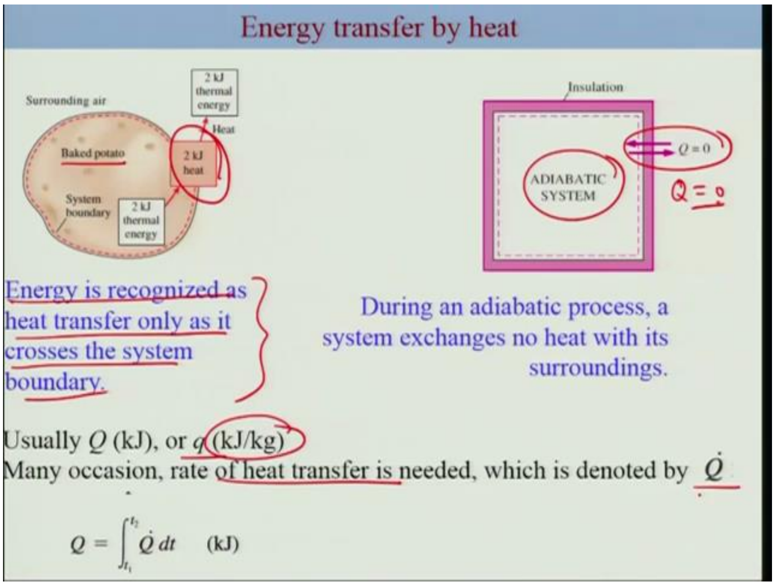

But it does not cool down directly like it has a step because it contains when you take out, it contains the thermal energy of very high heat temperature the thermal energy. And then it transfer to the surrounding in the form of heat, but this heat which you see here is only at that point, once it transfers to the air, the amount of energy is gets a part of transfer to the part of the air.

So, the air thermal energy increases okay. You do not feel the temperature rise because of it a wide room and so forth, but you can always see the differential change, when you take out the potato close to a body. So, energy is recognized as a heat transfer only at as it crosses the system boundary. So, I have said this many times just emphasize, if you put a insulation around the system you will make system to be adiabatic, which essentially means there is no transfer the heat that is we are going to be used Q as a representation of heat so the Q is going to be 0 here okay.

So it also uses a small Cube, but that is only on the basis of unit mass, so that to the unit is going to be kilo joules per kg. And if it is a weight of heat transfer, then we are going to use Q dot and such case you can integrate the amount of heat. So, if you want to find out the total heat transfer between t 1 and t 2 you will have to integrate Q dot over the time okay. All right, so let me end this lecture with this background of heat.

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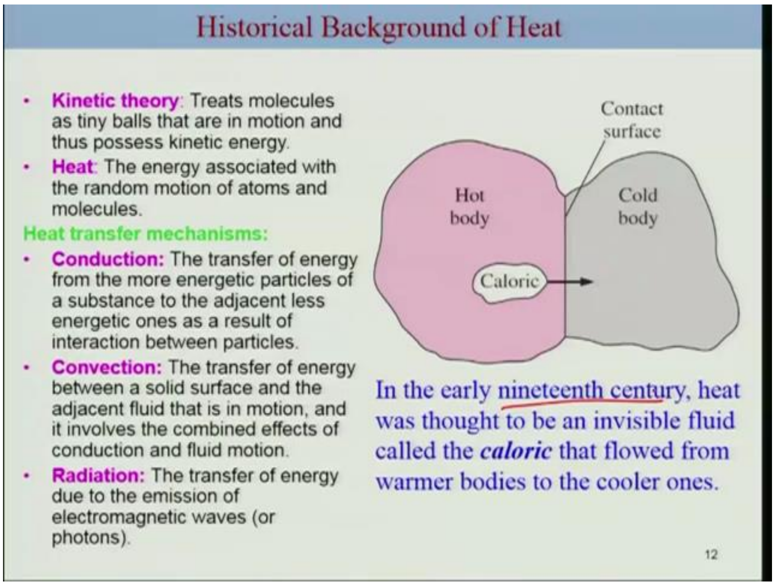

Now in early nineteenth century if the heat was considered a massless, Odorless, tasteless object or some material or object substance which transfer from the high a hot body to a cold body. It was a until the theory or kinetic theory was developed this was the notion okay of course it was wrong it was incorrect but that caloric theory brought lot of you know understanding of the heat for us.

So, what kinetic theory tells us is that this heat is nothing but is is the motion of the molecules and kinetic theory relates the kinetic energy through the temperature okay. What does it mean that a hot body like hot water as steam should have higher kinetic energy or the molecules compare to something which is at room temperature okay. So, heat is nothing but the energy association with the random motion of atoms and molecules okay.

So, heat is typical then through conduction, convection and radiation okay. Conductions are between two objects like substances which are adjacent okay to each other. Convection involves some part of conduction on fluids motions, radiations is the transfer of energy due to emission of electromagnetic waves and the more details you can go through the text it is not going to be a part of the course.

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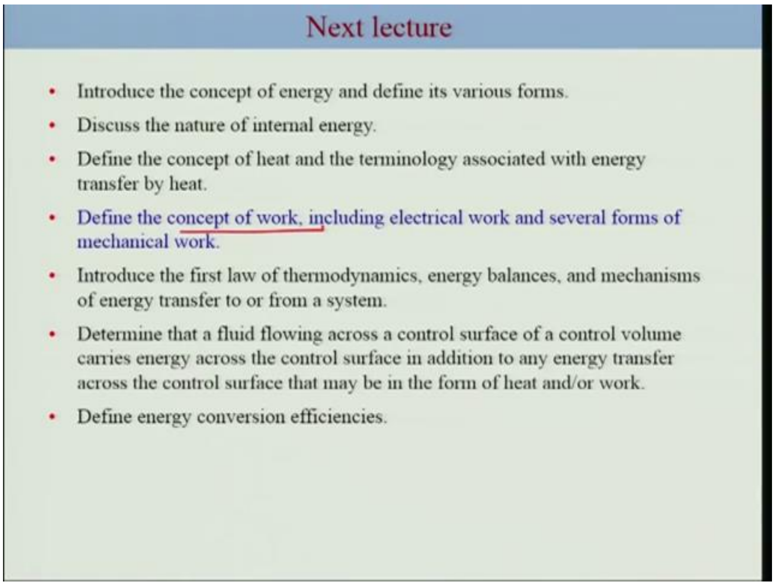

Okay so with that I am go to end the lecture and next lecture we are going to talk about the work okay the including electrical work and several forms of work.