Engineering Thermodynamics
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Lecture 05
Different Forms of Work, Energy Transfer, Sign Convention

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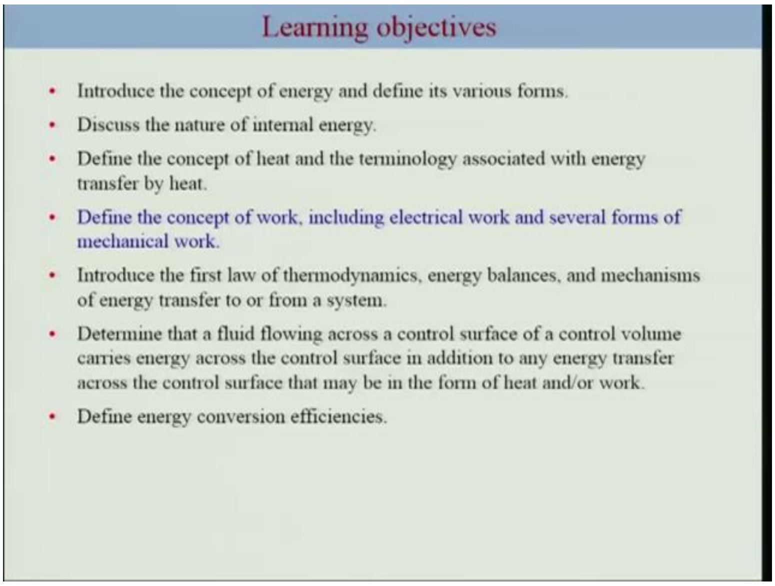

Hello! Welcome back we are going through the energy and energy analysis and this is a second part of the lecture of that series or that particular a topic. So, what we have done until now within this topic is to understand the concept of energy and different forms and nature of internal energy the concept of heat and the terminology associated with energy transfer by heat. In this lecture we are going to look at work and work related aspects that are different kind of works.

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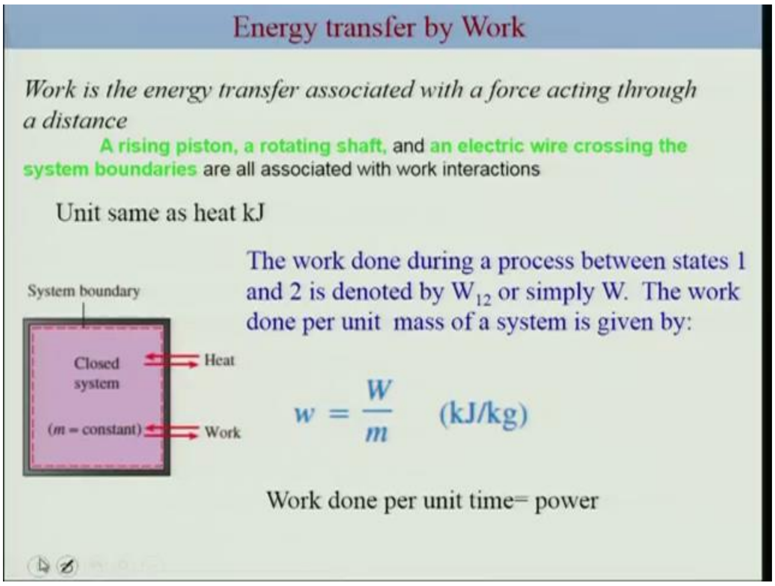

So, work like heat is an interaction at the boundary between the systems and surrounding. If you consider a closed systems and in this energy transfers is there and if it is not due to the heat then the it will has to due to work. So, energy transfer due to the heat is due to the difference in the temperature. So, if there is no temperature difference and if there is energy transfer it has to be due to the work. And that is what we talks so we have this heat and work for a closed system and if there is no temperature difference, then energy transfer has to be due to work.

The work is the energy transfer associated with force acting through a distance and so the examples are raising piston, a rotating shaft and electrical wire crossing the system boundary these are all different kind of work and this is a related to some form of force which act to a distance. The unit is same as that of heat and that is kilojoules and the typical work doing a process between 1 and 2 is refer to as 1 or W12. So, it is not preferred as delta W and we will know we will discuss this part and in subsequent slides, we will simply refer this work between the process between the state 1 and 2 as simply W. The work done per unit mass is given by the simple division of W with mass and will be written as small w okay. And the work done per unit time is nothing but power.

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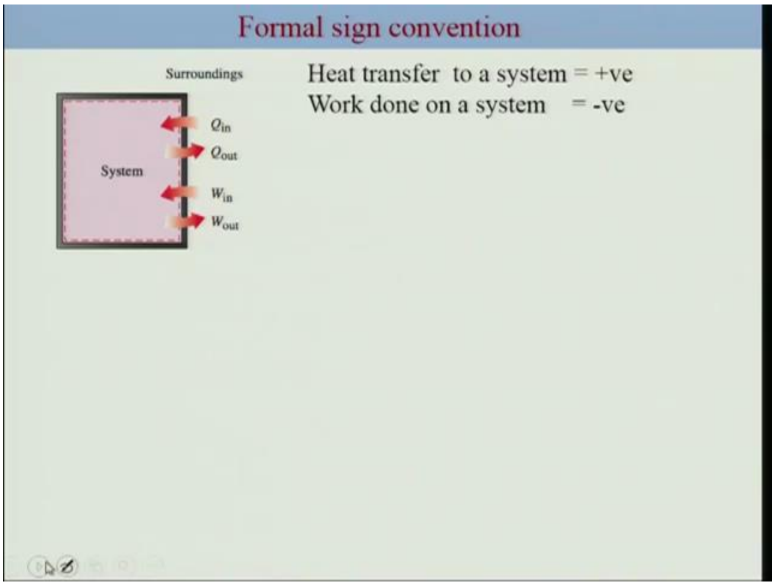

So, the work or heat has a direction and we need to provide the magnitude as well as direction to provide complete description. So, this is whether we discuss now formal sign of convection. So, heat transfer to the system or to a system is positive and work done on a system is negative or in other word, we can write in this form where we are going to define is Q in, Q out, W in, W out specific direction is already provided here. So, if you are not aware of the direction you can assume the direction and you can do the calculation. Where the value is positive that means your assumptions are right otherwise you have to change the direction.

Now heat and work both have similarities, that both are recognized at the boundary of the system as they caused the boundaries that is both heat and water are boundary phenomena okay, this we have emphasized how many times. Systems possess energy but it does not contain heat or work, both are associated with a process not a state okay. And unlike properties which is point function heat or work has no meaning at a state. It is only relevant when this there is change in the heat or change in the states both are path functions that is something which we are going to discuss a bit now okay.

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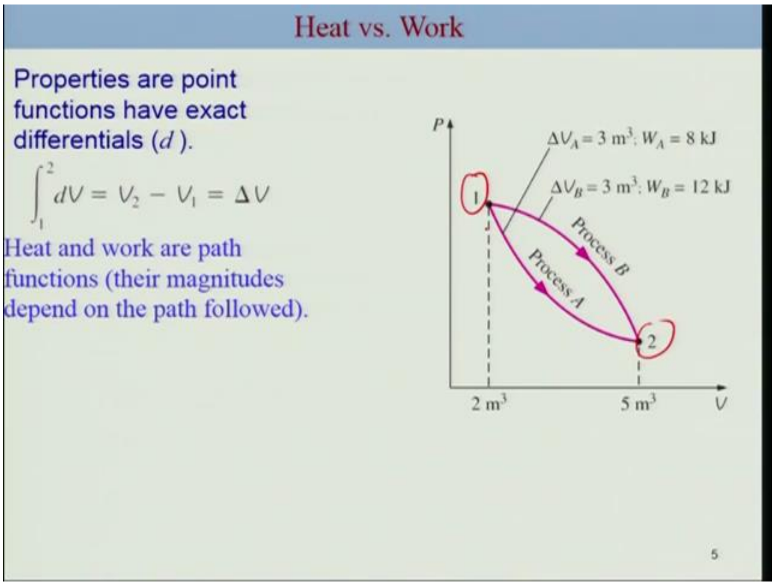

So, in essentially means that a both work and heat are path functions, their magnitude depends on the path fallowed during the process as well as that the end state it is not only the process but as well as the ends it depend on it. So, let us for the look into this let us take a case where you have a change in the volume as you change the pressure there are two processes which are considered here this is a PV diagram. You have a state one and state two or you have you are changing the volume from 2 meter cube to 5 meter cube.

Now considering the volume itself is a state property or is at the point function thus for both the process with delta V will remain same. Since properties of point function there are exact differential that means the integration of d V is simply delta V. But that is not true for work, for work we have different values can be seen for different processes because that depend on the path.

So, the path functions as we have already discussed they are in exact differential. So, if you integrate the work along a path it should not be delta W, it should be written in the form of let say W12. And the reason being that the delta W means that you have saying the system contains work, but this is not true the system do not contain as we have already discussed that the work is recognized only at the boundary thus we cannot write the integral of delta W in the form of delta W. So, in order to avoid all this confusion you can simply write any change as simply delta W 1 to 2 or you can write as process A or process B as depicted in this particular example okay.

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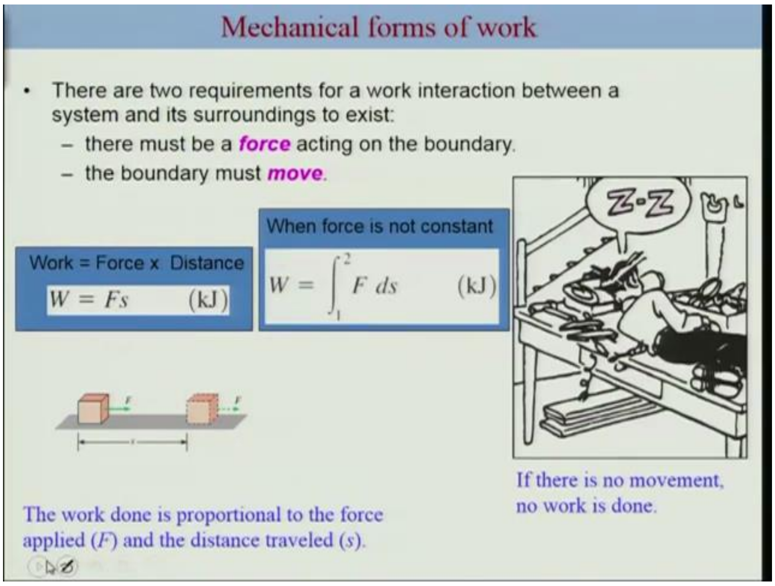

So, there may be forms of work they are mechanical forms or they are non-mechanical forms. So, let me first describe the mechanical forms of work, the two requirements for work interaction. Between the system and surrounding there must be a force which acts on a boundary and the boundary must move. So, this is an example where the force is constant where in that case you are just going to use the expression force into distance, then force is not constant then you can integrate F over ds from his point 1 to point 2 as in this case okay. So, the work done is proportional to the force applied and the distance travelled, if you are not doing any movement as in the case of this gentlemen sleeping on the bed, then there is no work done for the particular time frame.

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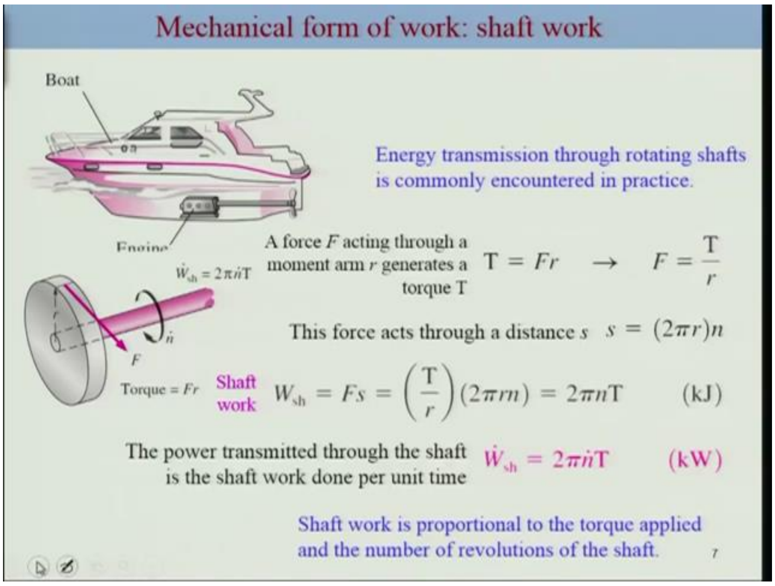

So, there are other forms of work, one is a shaft work which is extremely relevant for many engineering applications since such boat where the energy is transferred through rotating shaft okay. So, let us consider the shaft here the rotating shaft here where you applying a force on a moment of arm r. So, in that case you generate Torque and the Torque is given by T equal to F multiplied by r and which essentially means that F is nothing but T divided by r. And the distance you also can calculate by knowing the number of rotation done. So, for example for case of a n number of rotation the total distance which the force as act acted on it is the circumference multiplied by n. So, the work shaft work would be simply F multiplied by s in that case and you can replace this expression by these values and in the such case you can get this expression which is 2 pie n multiplied by the Torque okay.

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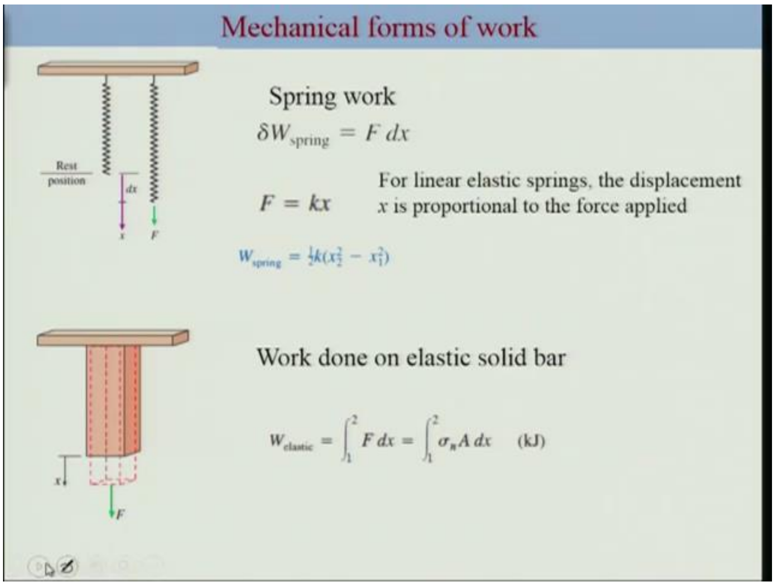

So, in case a per unit (())(7:35) this will the power transmitted through the shaft would be given by this expression, where the weight of rotation is considered. So, it is proportional to the Torque as well as the number of rotation per unit time. The other forms of work in mechanical work such as spring okay here, for example your spring is resting and then when we apply a force, the displacement caused can be given as dx is in the force then the work would be given in this farm where simply you multiply F and the displacement.

Now this first if it a linear elastic spring we know that this force is proportional to the displacement and hence F is equal to k x can be replaced here you can integrate it in order to get the work of spring for two position x 1 and x 2. Now you can also analyze the work done on a elastic solid bar which can be considered an elastic spring and you can apply a force and force should be in elastic ring where the force should not be so large that it stop the solid bar permanently in such case you can express the work elastic done on the solid bar and this from there this is in the normal stress.

The other example of a mechanical form is surface tension work. So, this is a rigid wire frame which contains the film this is a simply let say a water film. Now the air is outside, so there are two interfaces so there are two water air interface okay. As we know surface tension acts on the interface, so you have 2 lines of a interfaces which essentially is associated here. So, what is the force which is require to overcome the microscopic force between the air and water that would be the first that would the surface tension multiplied by the interfacial length here okay.

So, in this case the interfacial length is 2 b, so this is the surface tension this 2 b is the is the interfacial length which essentially is nothing but the length of this wire here this is b and the other side of it. So that become b + b is equal to 2 b okay. So, you can you can write there calculate the force and calculate the work done completely, when you change from this position to this position and that means from 1 to 2 by this expression here, where this this surface tension and this is the area which you are changing which is nothing but 2 b multiplied by the displacement which you are causing by moving the wire okay from position one to position two okay.

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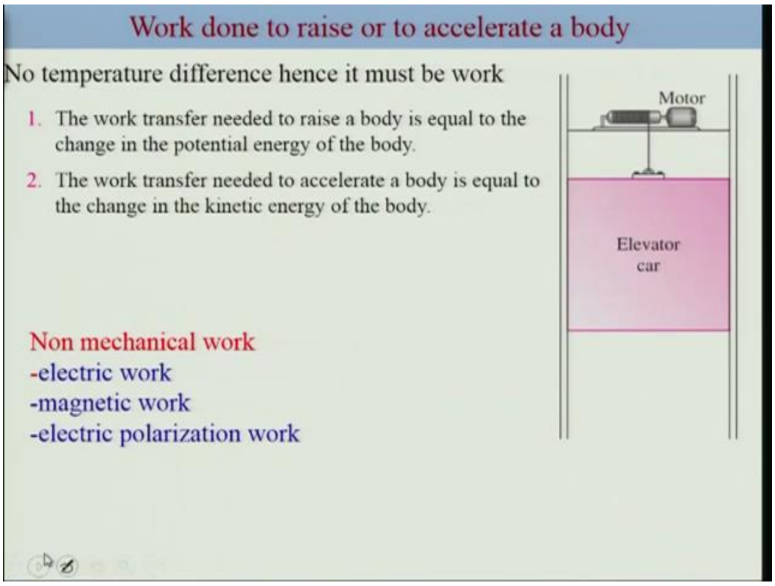

So, there other form of work you take an expression of let say elevator car and here you know that the body is rest and as you using the elevator or lift, in such case there is no temperature difference thus the work done should be thus the whole change in energy is due to the work done by the elevator. So, in such case the work transfer needed to rise about is equal to the potential energy of the body or if you want to accelerate a body, the work transfer would be to equivalent to the change in the kinetic energy of the body okay.

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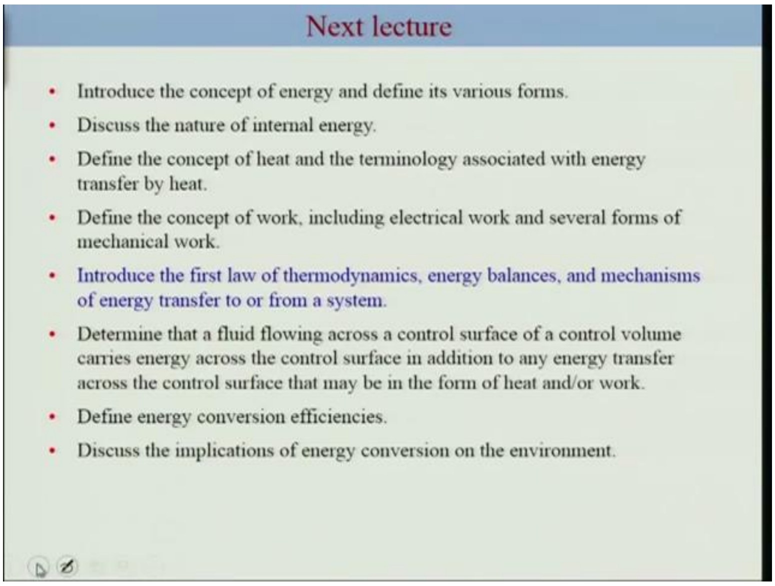

The other non-mechanical ways such as electrical polarization work which we will not going to discuss in details. So, that would be the end of this lecture we are going to introduce the first law of thermodynamics and other expects of that in the next lecture.