National Programme on Technology Enhanced Learning (NPTEL)

Course Title
Engineering Thermodynamics

Lecture – 02
System and its surrounding

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So let us recapitulate what we have learnt in the last lecture we have basically looked at the meaning of the thermodynamics and later on we looked at the historical perspective of the thermodynamics how the thermodynamics was evolved as a mature subject and it is application we have looked at some of them which are quite magnanimous it in encompasses all the branches of science and engineering so therefore it is a very important subject which I urge upon you people to take it seriously and study it and apply it to your professional and personal life.

And today we will be discussing about various aspects of the thermodynamic basically the initial concepts and before starting this lecture let us look at this statement by Max Planck.

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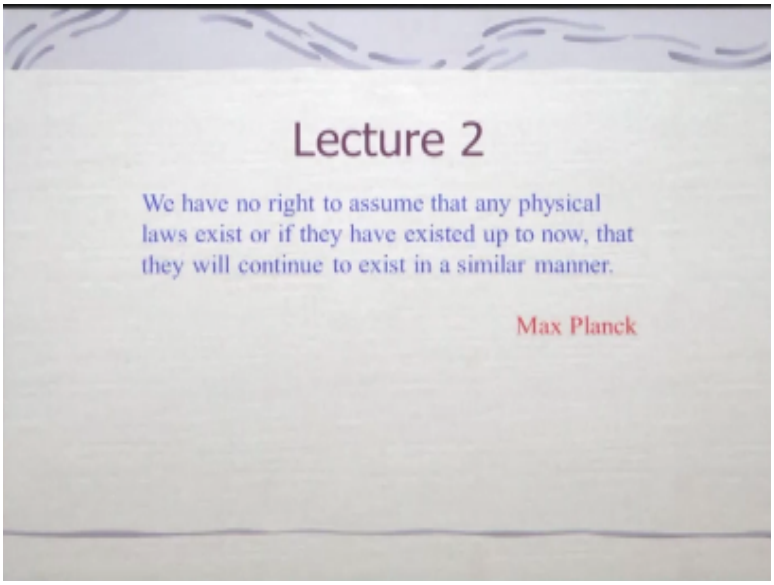

Who says that we have no right to assume that any physical laws exist or if they have existed up to now that they will continue to exist in a similar manner that means he challenging to you people to challenge the existing laws and find out what it is all you know what you call limitations, so that you can find out better laws of the nature or the physical world.

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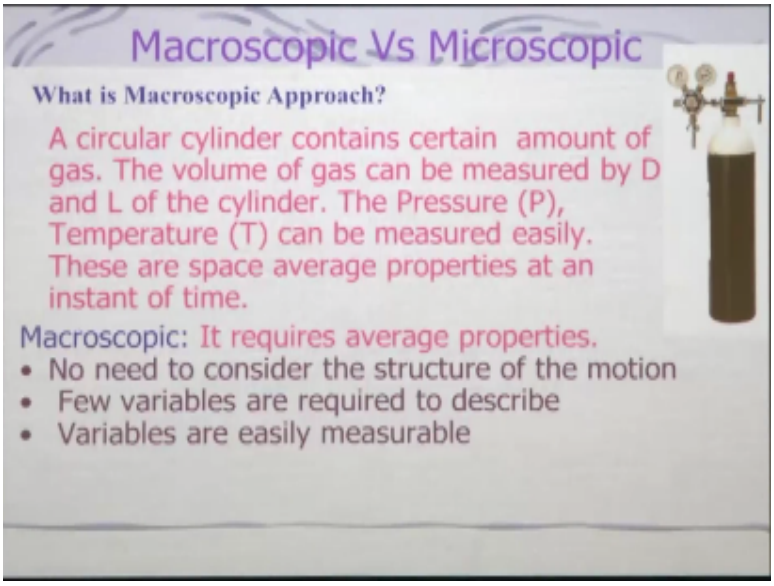

So when we talk about this thermodynamics we are basically looking at the energy and in interaction with the matter that means we will be you know looking at the matter and we use basically two approaches one is macroscopic approaches that is microscopic approaches and what is the meaning of this microscopic approach in the thermodynamic we will be using both approaches right one is microscopic approach and as it is microscopic for example like if I take a cylinder here right.

If you look at this cylinder we are taking and it will be containing certain amount of gas right if you look at this gas and if the cylinder can anybody look at this cylinder and tell whether it is you know contains oxygen whether it contains air or whether it is and then some other gas can anybody tell me actually as an engineer you should know the color code right if you look at this a lower portion is which one black color the upper portion is white color can you see right.

And from the color and if you know the code then you can say what it contains right of course that one has to look at I will ask for new people to look at the color code of the gases as an engineer you must know whatever the engineer you may be if you are in a subfloor on the plant you need to know that.

So these basically contains the air of course the color code will be different for different countries but nowadays it is what you call homogenizing and we do follow international standard and this basically is the black and white color if it is then it is having it is basically air, so when you look at this kind of a you know a circular cylinder which contains certain amount of air and

air means it will be mostly the oxygen, nitrogen of course there will be several other gases will be there which you're very less percentage you know then we are not bother about it.

And these are the two gases which will be at higher pressure because if the pressure cylinder right and when you talk about it what is happening to the molecule let us say two molecules are there oxygen and nitrogen for the simplicity we are assuming air consists of oxygen, nitrogen and they will be moving around right they will be colliding they will be you know interacting with them and then if we look at those things we call it as a basically micro scoping approach because each molecule has to be tracked out.

But in engineering sense you know we would not be looking at that we will be looking at Grassley that means if the you know what is happening to the pressure for example if you look at this cylinder is having a some gas is there this gas is are there and this is known as pressure regulating valve now what are the kinds of wall pressure regulating valve will be there right how we can regulate the pressure is a question and the cylinder one has to regulate the pressure otherwise you will be in deep trouble am I right.

If without this without pressure regulator if I use what will happen there will be some accident it will handle the high pressure gas cylinder without a pressure regulator accident will occur right so one has to be careful and if you look at the gas is basically pressure gas and by that we can measure the pressure and the pressure if you look at is manifested due to the what change of momentum by the molecules on a particular surface right and we can also the measure temperature and pressure we can also the measure the volume and these are basically properties of the space average property.

That means is average right we are not bothered about individual molecule you know interaction with that and these properties when you look at in a macroscopic way or in a vertical grass way we call it as a microscopic properties and it basically talked about the average properties you know it is not changing with respect to you know time of course one can measure the pressure and temperature with respect to time but in this example we are saying what it would be right and this is the average species.

Now why you will be looking at microscope properties in our this course will be mostly dealing with the microscopic approach to analyze the problems because they are easier and no need to

consider the structure of motion there will be molecules you know what is the structure whether the biomolecule or diewmolecular or termolecular whether it is interacting right what is the extent of molecular activity we are not bothered we are bothered the grass effect what is the effect right for example if I look at your face and you are looking good you know or your you are will be satisfied or you are attentive but in your mind there might be several things which are going on which I am not aware right.

So when I am looking at grass then it is basically grass properties I am trying to observe and your face or your activities right but in your mind what is happening that is the basically microscopy approach. So now if you look at few variables are required to describe the you know system if you look at the system or whatever it is so you can very few properties you can use it and variables are easily measurable these are you can measure pressure temperature volume these are the things or other properties you can measure.

So therefore you know we will be dealing with this macroscopic approach to analyze the thermodynamic problems and these thermodynamics is known as classical thermodynamics, so in this course will be basically dealing with classical thermodynamics where we will be looking at microscopic you know properties or the macroscopic approach will be utilized to analyze the problem just to give you a glimpses of what is the meaning of microscopic you know approach let me just.

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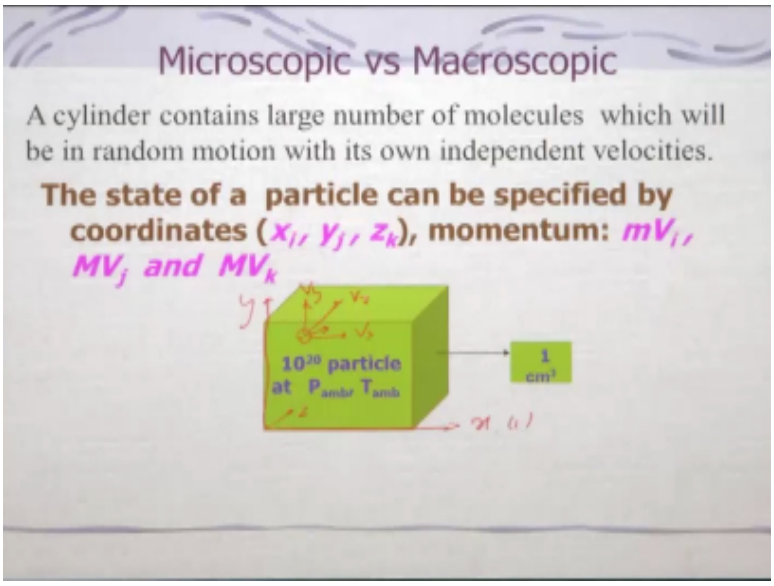

That we can take this same cylinder contains large number of molecules as I told like it can be you know in case of air it is oxygen, nitrogen but it can be several other molecules you know kinds of molecules and which will be random motion right it will be all the time moving and it will be have their own velocities because it will be collating and then velocities may be you know changing of the each individual molecule not all molecule will be having same velocities right it will be changing and as a result what will happen like we need to look at for example if I take a small slice from the cylinder 1 centimeter cube.

So if you look at how much particle it will be there it will be having something 10^{20} particles means molecules you can say right particles means you know we can think of molecules and these are very big numbers right now I want to look at each individual particle how they are doing so what will happen this state of particle can be specified by the coordinate system if you look at the coordinate system right if I take this as if it is this is your what you call x and it is having i, I can say right and this is your y and perpendicular to this you know is your z so now the coordinate system has to be and each molecule this is fixed and then your each molecule will be moving around.

Right if it is having a molecule let us say here right it is have velocities in the x-direction right Vx or it can be we Vy and it can be Vz direction right and when it is having then you will have to look at the also momentum how it is right the momentum can be MVi MVj and MVk right unit vectors ijk and it can be change in the momentum you will be talking about another thing , so if

you look at number of you know variables will be enormous and if you want to solve this equation of motion and then finding out interaction all those things it will be enormous even the best computer cannot solve these and finding out it is a fact right.

Now how to deal with it even if even if I will take a one centimeter cube as a this thing and look at in if it is a cylinder if it is a you know let us say Sun if I look at the Sun lot of molecules will be there you know like lot of nuclear what you call fuse and reaction will be going on and then other things how will analyze are you getting, so therefore even small systems it is very difficult to look at take care of each one track of all those things and then look at what will be its effect for example India is a populous country under 30 crores people.

if I look at each individual what is doing how it is doing what are the moving how it is interacting with each other you know one will go mad similarly when you talk about these molecules are moving with a you know a certain velocity is interacting with each other and then keep track of them and what is happening what are the changes occurring it is quite difficult and enormous even the best computer cannot really compute within the a enormous computational power.

Now how to deal with that is there any other way of looking at in a molecular level interactions and extend of molecular activities is it possible there comes to the picture here what you call the tool what we call statistical tool right so you know we being used and such an approach where you will have to look at the microscopic effects like each individual particle or the molecules when sometimes if it is you know other things like atoms then he will be basically known as the microscopic approach.

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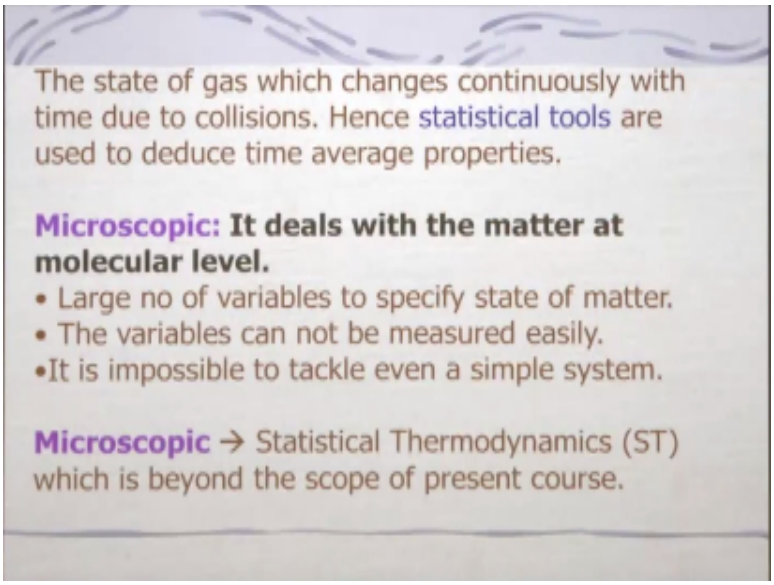

As I told that state of gas which changes continuously because all the time with the time you know it will be changing each molecule will be interacting with other molecules and then we use you know tools known as statistical tools to deduce this average properties which will be more interested in right, so therefore statistics comes into picture and this thermodynamics is known as the statistical thermodynamics and microscopic means it will be dealing with you know with the matter at a molecular level.

So in this case large number of variable to specify state of the matter and the variables cannot be measured easily if you look at if I want to look at a molecule and it is interacting what is mass and what is the velocity is very difficult to measure you know it is not really and it is impossible to tackle even a simple system and therefore you know we use the statistical tool and the thermodynamic related to you know that thermodynamic that uses the statistical tool which is known as the statistical thermodynamics which is the beyond the scope of present course will be not dealing with maybe you people are interested in that you can take in other courses in our Institute maybe in the Department of Physics and Chemical Engineer do offer.

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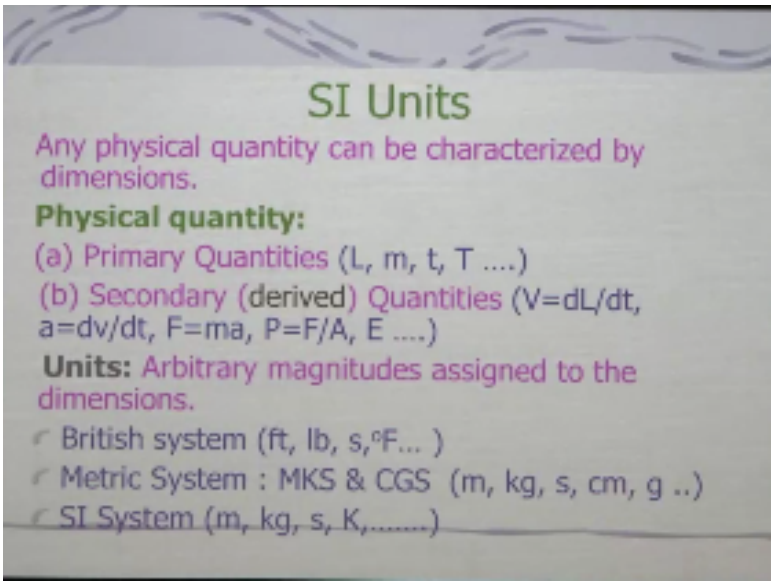

So however sometimes I will be you know looking at lately give you a flavor of the you know microscopic approach whatever we are discussing about that not may be in on some occasion now whenever we are looking at this physical properties right we need to look at the you know it is dimension because the physical quantities right will be characterized by the dimensions what do you mean by these dimensions any idea any idea what do you mean by dimensions because if there is a physical quantity then we will have to assign something like to the main.

For example you say the you know length but the length will have to say it is a meter right or a time for the second like that and if you look at this physical quantity can be you know into two categories one is primary quantities like a length, mass, time, temperatures and similarly like you can have a certain derived quantities like your velocity, acceleration right like velocity is basically change in displacement with respect to time and then a is your acceleration change in velocity with respect to time and force and then pressure force per unit area and other things like energy another thing.

So whenever this arbitrary magnitude you know being assigned to these dimension we get the units so for example earlier days people are using this British system that is the feet right pound and second degree Fahrenheit which are quite clunky you know because it is not really very good for example if you look at the foot it will be something you know third one feet is equal to 30 inches and inches again you know will be little difficult to soothe and other things there is several earlier days in our country also we are using British system.

But later on we found that which is quite you know congruent with the decimal system that is the SI system or M case system so that is being used metric system in the metric system that is called you know like MKS system the meter kg and second right in CGS system we call centimeter, gram and second kind of things and this is being used very much of course if you go to our market or something people are still using the British system although it to use and international level we use the SI system basically it is the international systems and we are being will be using in this course SI system but sometimes some problem may be given in other unit.

So that you know that you need conversion kind of things so in SI system we call it is basically meter, kg, second and Kelvin kind of things.

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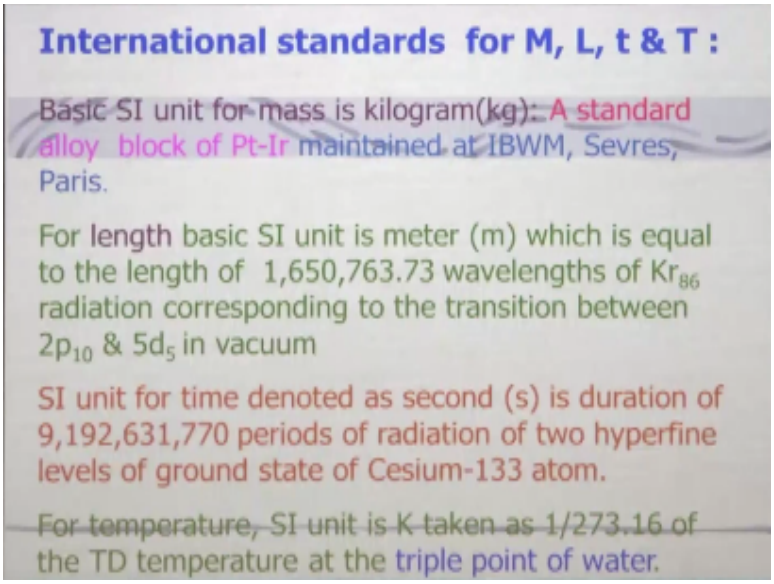

So if you look at the international standard being used for mass, length and time and temperature so these are the standard which are being used for example like basic SI units for mass is kilogram and a standard alloy block of platinum iridium maintained at IBWM this is the International Bureau of weights and measure and say various in Part II Paris it is being kept because platinum iridium Cape so that it would not change with respect to time it is a very metal like which you would not be corroded and I wrote it similarly earlier days people who are keeping the metal lengths and then they are saying this is one meter.

But nowadays it has been changed people are saying length of basic SI unit is a meter which is equal to the length of something 16 lakh 5076. 73 wavelength of Krypton 86 the radiation

corresponding to transition between $2P_{10}$ and 5d in vacuum so this is the more precisely you know one can think of because this is the standard which is being utilized for making it you know being utilized otherwise if the standard in a primary calibration or you just calibrate all the thing with that should be as accurate as possible.

Some of you who will be you know conducting experimental thing and the calibration is a very important because which is the baseline the baseline is very important and that should be as accurate as possible so similarly if you look at SI unit for the time denoted as second duration of this big number like 9192631770 periods of a radiation of two hyperfine levels of down state of cesium133 atom I am not expecting you will remember but you should aware that what is the preciseness of this because this is the baseline right so and temperature of course in the same time people are using the triple point of water in that is in Kelvin is basically expressed in Kelvin and taken as one over 273.16 of the triple point of water right.

Earlier das you know we will be discussing as we go along that people were using basically the steam point and ice point as the reference but now the triple point is being accepted always because of it is precise.

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SI System (Systeme International d'unites) in 1960

Quantity	Definition	Units	Name	Symbol
Velocity	V= dL/dt	m/s	--	--
Acceler-ation	a =dV/dt	m/s^2	--	--
Force	F = ma	kg m/s^2	Newton	N
Pressure	P = F/A	kg $/ms^2$	Pascal	Pa
Work (energy)	W = F L	kg m^2/s^2	Joule (N.m)	J
Power	p = dW/dt	kg m^2/s^3	Watt (N.m/s)	W

So if you look at will be using you know various quantities system international like of course 96 they have adopted and we will be using the acceleration is as I told the velocity acceleration is basically change in the velocities for time this meter per second square and the force is the basically F = ma kg m/s^2 Newton. Newton is the name therefore we will be using is as a capital N not a small n right any name you know whatever we use we use always capital right that is a unit symbol we will be using and the pressure if you look at the pressure by definition force per unit area and the unit of stress also is same as that of the pressure.

Because this is the normal stress one can think of and it is ascribed with the Pascal therefore we call Pa P is the capital a and small and work or the energy is basically assign with the unit kg m/s^2 because the force right and length this is a meter square by second square right and it is a you can think of using basically the Newton and meter because kg m/s^2 is nothing but your Newton right and second that is a meter and that is basically Joule is a being used and this J and power is the rate of change of walk and which is nothing but what you call the work per unit sec time and this we call it as a Newton meter that is the work per second is watt.

So you will be using this symbol basically as a capital be careful because people do you know first about it if you're not writing it properly so I will just give out small tips like how to use this thing.

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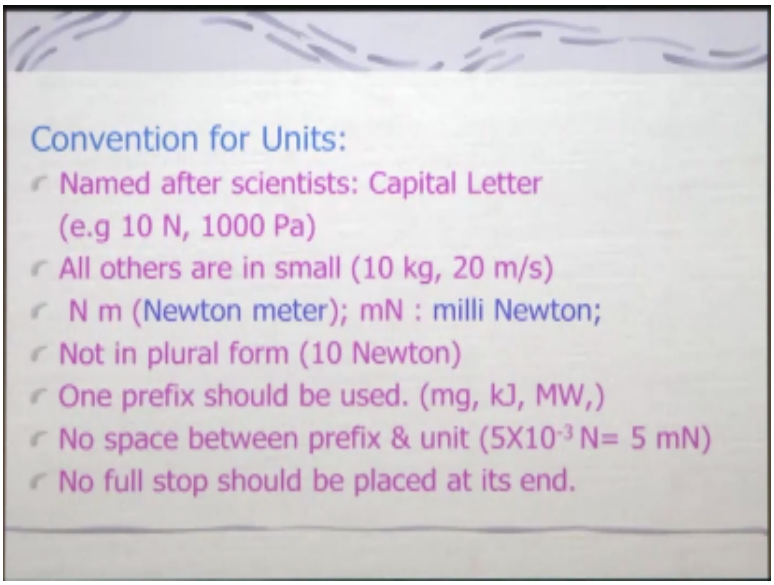

In your convention for using the unit whenever the any unit right is after the scientist named for example Jules, watt, Pascal's, Newton’s and you know other things Coulomb right this will be with capital letter okay and for example 10 Newton thousand Pascal's right it will be P will be capital Pascal and a will be small and all others are in small letters for example 10 kg and 20 meter per second right okay and if I will say this kilometer what it will be it will be also small but people go to your highways sometimes people write in capital am I right did you observe that thing.

Whenever you are moving in this looking at the sign board you will find in some places it is written in capital letter am I right particularly you can see the Lucknow and the Kanpur highway right if you did not observe you could have observe just observe that you know it is not right so and we will have to be little careful about when you say a Newton meter there should be a gap right here and if it is milli Newton’s will have say mN there is no gap so enough to distinguish between this thing and for example you right you want to write 10 Newton or 100 Newton do not write Newton's you write nu 100 Newton or 10 Newton plural one should not use and one prefix should be used.

For example milligram right mg is basically milligram right or kilo Joule k should be small and J should be capital but a lot of people I have seen their right either you know like K is capital J is capital or k is small j is small am I right I have seen and let us say MW what is a unit MW megawatt right but I can write can I write down kilo joule kkj can I write I cannot okay so only one prefix should be used so no space between in a prefix and units.

For example if I say $5x10^{-3}$ Newton is equal to 5 milli Newton you should not write 5m there is a blank and then Newton one should not write that way so one has to be careful and also develop and have it so that you would not make mistake in the writing right and no full stop should be placed at its in right and you might have seen people are writing you know120k. and m. and that means 120 kilometer and the signboard which is not right and they will be writing in capital also that is also not right so one has to be careful about assigning the units to the your this thing.

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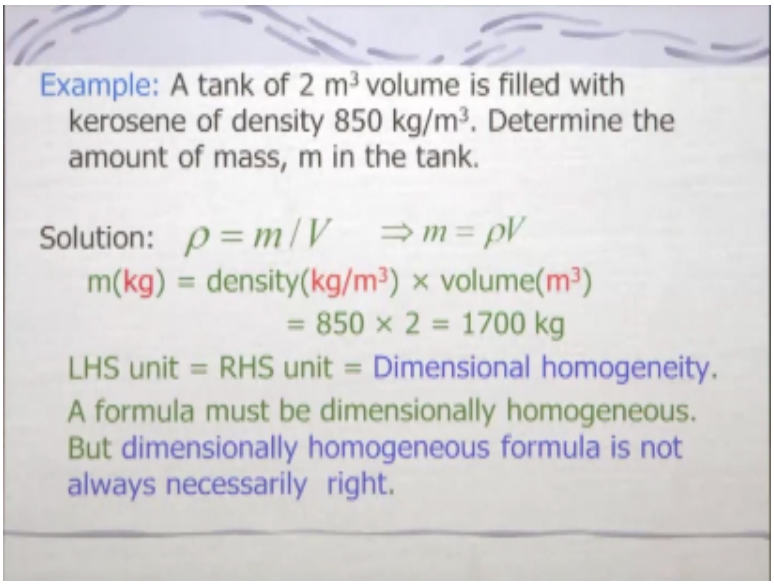

So let us take an example which I have taken a very simple example a tank of two meter cube volume is filled with kerosene of density 850 kg/ m^3 determine the amount of mass m in the tank so we will have to do that what I will have to do is very simple right you are given density you are given the volume, so basically the density is equal to m/v and you will find out mass is equal to ϱ/ V and you just plug in the numbers and you will get and if you look at unit wise that left hand side here mass is kg and density is kg/ m^3 and volume m^3.

So cancel it out is kg right and if you put these values you will get this number there is very simple one what if indicates you might be thinking why I am showing this simple example what is indicating what it is this example what do you have learned is it very simple you know like you use a formula and plug in number you will get it says that left hand side unit is same as the right hand side you need what we call dimensional homogeneity.

That means a mathematical equation should be dimensionally homogeneous am I right that is the first you know thing one has to check whether it is a right or wrong and that means if it is dimensionally homogeneous is it write the equation need not to be right okay but that is a first condition is a mathematical formula must be dimensionally homogeneous but dimensionally homogeneous mathematical relationship should you know always not necessarily right okay it may be right it may not be right.

So therefore one has to be very careful interestingly I must share with you in the last semester I gave an example to the student in the examination okay and that subject was not covered but I

just gave such that he can use the dimensional homogeneity and answered the question I will tell you that only maybe 10% people could answer that question and 95 % could answer and it was very simple is simple as simple as this question right, so therefore I would suggest that be careful in the sense it is a tricky question not tricky it is just to recognize whether you know this or not.

And you may say look it is out of my course it is not right it is the few thing what you will have to requires little presence of mind and which people did not do that I had experimented so therefore you need not to think that why is you know like giving a simple example with this is there not only a simple example it is a very profound example for illustrating the dimensional homogeneous homogeneity of the equation mathematical equation now we will be looking at the definition and concepts of the thermodynamics which is very important why we need to look at definition and concepts.

Because like every subject is having their own vocabulary you need to understand the words or the vocabularies of a particular subject properly and precisely so that misunderstanding in that subject can be avoided therefore one has to look at the you know definition and concepts and most of the things you will be aware in your plus two labels science but however we will be again redoing it.

So that it will be seep into your mind and so that you would not commit any mistake in doing that, so therefore you please listen it carefully and also try to think about it what it is. So when we talk about a thermodynamic we call it as a system so what do you mean by a system, can anybody tell me? See as in the thermodynamic which will be looking at energy and it's interaction right and means interaction with, with a you know with It is surrounding one can think of right.

Now we need to define and also we will have to take whenever there is a energy you know exchange the taking place there will be some change in the properties and that means it will be properties will be changed only through the what only through the matter then only you can think of we have already seen microscopic and macroscopic without matter can you think of you cannot think of a change in the state of you know any interaction is taking place.

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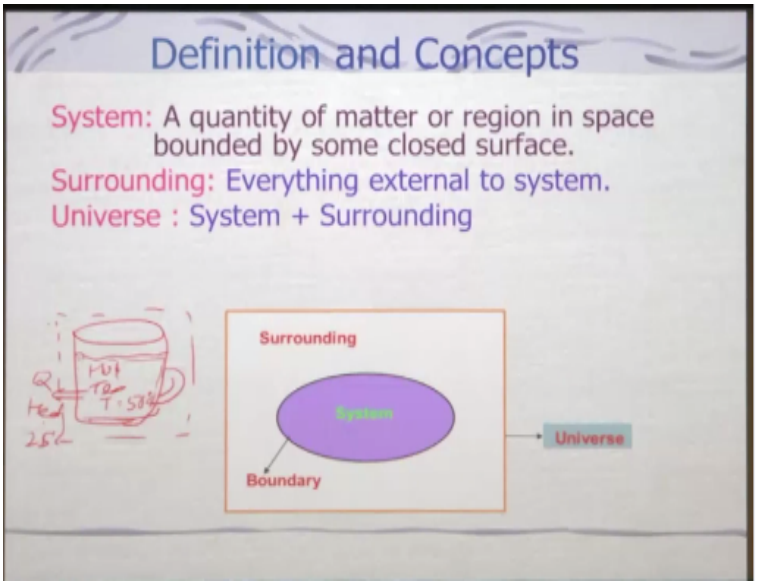

So therefore so we can define a system as a quantity of matter or a region in space bounded by the closed surface for example if I take this room I want to find out the how much energy we are utilizing right and we will have to look at how many light points are there whether it is coming let us say Sun is falling on this room and some energy is entering into here and maybe there is a AC which will be you know on and how much cooling air it is giving.

So I need to find out for that what I will have to look at I will have to make this you know in this room and then as a system and then we will have to say that it will be reacting with the or interacting with the surrounding, so if you look at everything external to the system is known as surrounding and system and surrounding together we call it as a what universe, so if I look at a system here right and it is having a boundary and the rest of the things will be surrounding and this total we call it as a universe.

Let me you know take another example I am having a cup of coffee here right and now this temperature is higher cup of coffee when I say the temperature will be let us say higher hardcopy and it will be interacting with the surrounding, so what will be the is surrounding, what it will be

for example if I take this let us consider this is the cup and it contains some amount of hot tea let us say right.

And now it will be interacting with the what you come with it surrounding what will be surrounding, suppose the temperature is there let us say I will keep this cup here on this what will be it surrounding the system I can take the whatever the hot tea is there let us say I am saying this you know I can take this as a system my right or I can take the full cup as my system right I can I am having liberty to choose that.

Now I am interested to find out like it will be interacting with surrounding that means some heat will be transferred right some heat will be transfer to surrounding what will be it is surrounding suppose I am keep placing a you know what you call a cup tea cup here can I say that a surrounding will be there where you are sitting let us say maybe 10 meter from this or can I talk about 1 meter can I talk about 1meter is possible 1 meter from the cup it cannot be you as some of you are saying yes no why?

Because you cannot have any change if I put a thermocouple sorry thermo meter 1meter from the hot tea can it sells any temperature it cannot, am I right or wrong? So it will be closer to that where there is a change there is a heat transfer is taking place and if heat transfers that where that temperature let us say this is something maybe 50 degree Celsius and this is something 25 degree Celsius right if the change is occurring and then because of heat transfer nearby places then only we will take it surrounding.

So if you look at my surrounding will be very closer to mine hot cup where the physical properties are changing due to the interaction of this system what we call it as a hot tea with its surrounding, is that clear to you people? So generally people say look this is my system and this is my surrounding know where ever interaction taking place then only we call it as a system.

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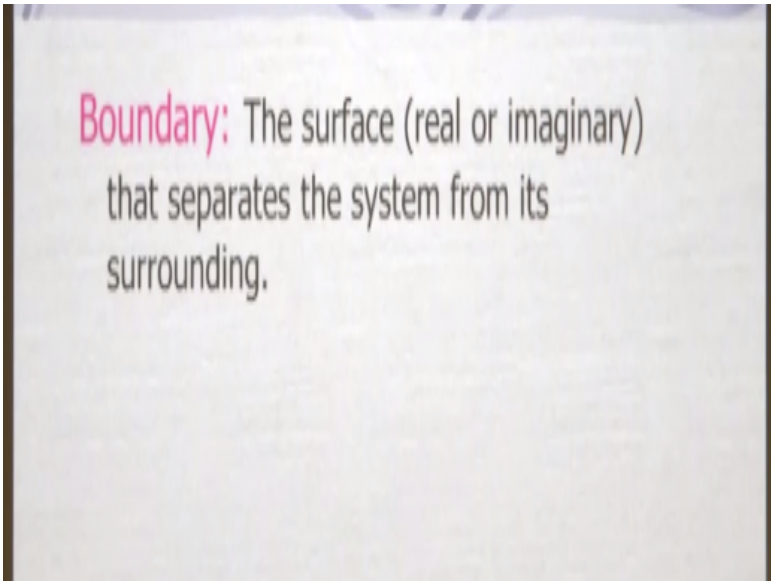

So as I told that boundary you know is a very important because that separates the system and surrounding, now how to choose the boundary is very important it can be real it can be imaginary right in nature and but how to choose which is the right boundary is very important point one has to look at because that will that boundary will be defining the system, so as I told it can be fixed boundary it can be rigid boundary movable boundary right and it can be di-thermal that means heat transfer can take place between the system and surrounding through the boundary right.

For example I took that example of hard copy through the wall of the what you call through the wall of this tea cup then heat has to transfer right and this boundary can I take that whatever the thickness of the tea cup can I take it as a boundary, mathematically it is not right mathematically we take a this thin boundary right and if this heat will transfer through the boundary then we call it Diet thermal and there will be some boundary which would not allow the heat to transfer we call it as a adiabatic right?

Most of the cases say air-conditioned room like this where the wall should act as an adiabatic wall so that heat will be not transferred through that otherwise you will have to pay penalty that they know alike because a lot of heat will be entering into the room and then the cooling load on the your air condition will be higher so therefore one has to insulate it properly and if you look at just to summarize.

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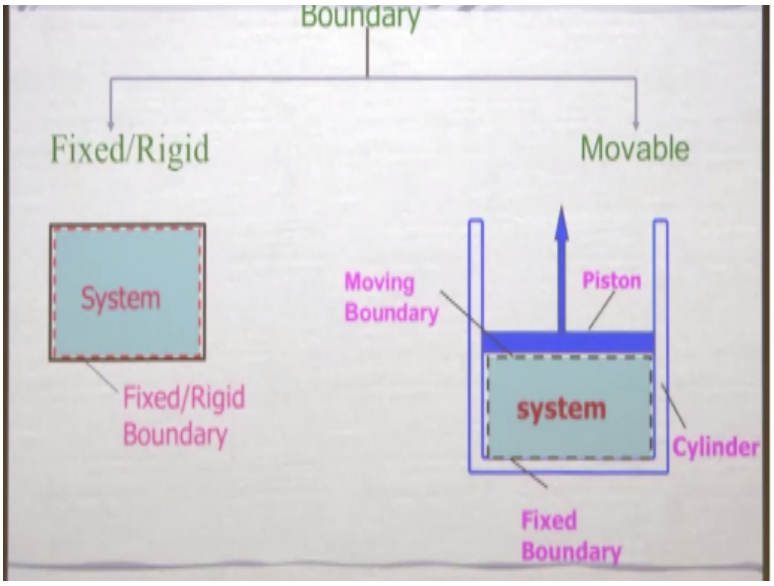

The boundary can be fixed it can be visit right it can be moveable for example I have already given you this example like in a system I can take this as a thing as a wall of this room if I take this room I can take this room as that it means wherever you are having interaction right that you will take as a system and boundary and in the moveable systems for example there is a piston cylinder which you use very often like can you tell me where you use your piston cylinder right.

Wherever you use you will be using in your day-to-day life am i right yes or no right for example nowadays water crisis across the country you do know you are aware we use the hand pump in the hand pump right it will be piston and cylinder you do give you know inflate your tire in your cycle by hand or by compressed air if you are giving by hand definitely it will be used you will be using a air pump where the piston cylinder will be there am I right.

You must be riding your bike in bike piston cylinder arrangement will be there or not and yes or no where in your bike by means automobiles right auto bike or your car your truck buses everywhere piston and cylinder arrangement will be there yes or no but you people are not saying anything right you will be using piston cylinder arrangement where the system you know we can consider this gas which is there in the piston cylinder let us say for example and piston will be moving.

And as a result this boundary is moving right and there might be some heat interaction between this system and its surrounding, surrounding will be nearby so we will be handling this kind of problems very often.

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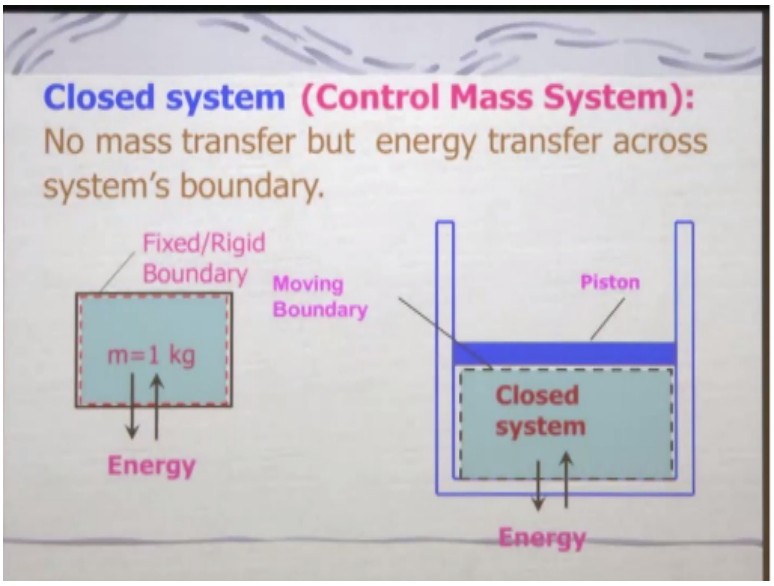

And there is a we call it as a closed system where no mass transfer will be taking place that means if I look at this boundary what is happening we take you know a 1 kilo of mass and then we can give heat here right what will happen to this mass, mass will not change right okay but however there is a energy interaction for example now you are having let us say 6070 students are there all of you are having if I consider 70 students 70 mass you know like in this system if I look at you know like you people as a system I am interacting with you I am basically transferring certain kind of information to you.

That means there is interaction if I take this as a system as a student as they all together a system that means you are remaining here the mass is the number of students are remain same so it is not changing but the some of you will walk down then it is changing right this cannot be a closed system and there is a interaction for example you imagine the student will be coming and going out and the teacher is like you know it happens in your public speech or the wherever the you know politician or some other things will be coming then you know people will be coming and going that is it what do you come open system.

So where you know you can free can think of a what you call fixed boundary and there might be a closed system right where it is the in this case it is a fixed boundary but in this case it is a moving boundary is the piston cylinder and piston will be going up and it can be come down

whereas the interaction taking place and this is also known as a closed system because there is it energy interaction but there is no mass change or the mass you know no mass transfer is taking place mass is remaining same so therefore we call it as a closed system.

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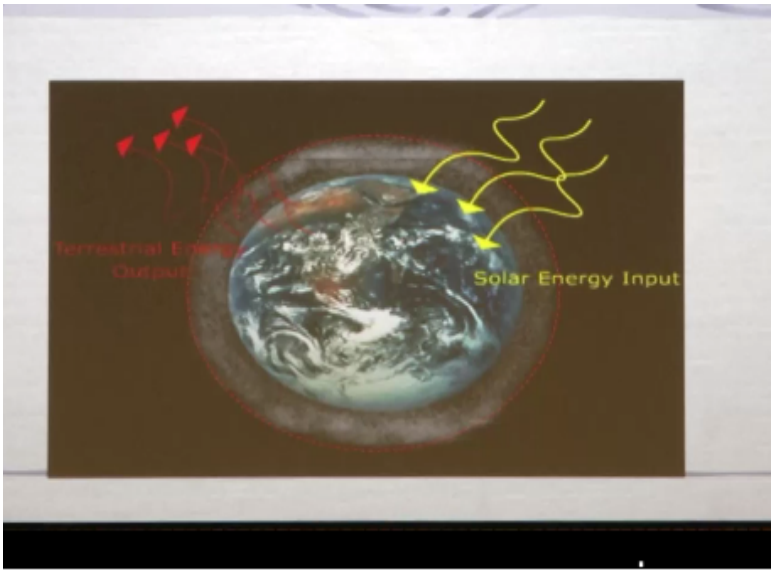

Similarly let us look at an example here right if you look at this is your beautiful art where we leave could you see how beautiful it is it is quite beautiful, am I right? And now the heat is coming in from the solar we are getting lot of wheat particularly now there summer you know we are getting lot of heat from the Sun and it will be observed by this earth surface and so also by yes by the trees and other things you know like and lot of heat also going out now I want to analyze this thing what I will use, can I use a control mass system or not yes or no?

See what happen these whites are what this white thing these are the atmosphere right around that where you know if it is a sea there will be some kind of a precipitation will be going on vaporization of water again condensation will be there cloud is coming and pouring water I am like a rain and there is a dust particulates it is moving out settling down right now I want to analyze right.

Depending on what you want to analyze we can choose the system because choosing a system is very important otherwise it will be very cumbersome it will very difficult to analyze the problem how to fix the boundary where to boundary suppose I want to analyze only the what only the

energy interaction or the solar energy whatever is coming out and mean then what I will do, I can use as a control mass system.

So where I will put my boundary, should I put here or should I put in this place, where should I put my, what you call the system boundary says that I can use the control mass system where can anybody tell me, is it atmosphere right, okay. So if I put it here that means whatever changes is occurring here right I am not bothered it is coming and going so that but if I put it here then it cannot be a closed system if I put my system boundary around the art surface itself I cannot consider it rather than a closed mass system or a closed system or a control mass system I cannot.

It will be difficult because the mass is going and out and it will be interacting so therefore one has to very carefully choose the system boundary identify the system what kind of analysis you will be doing you know based on the analysis being carried out.

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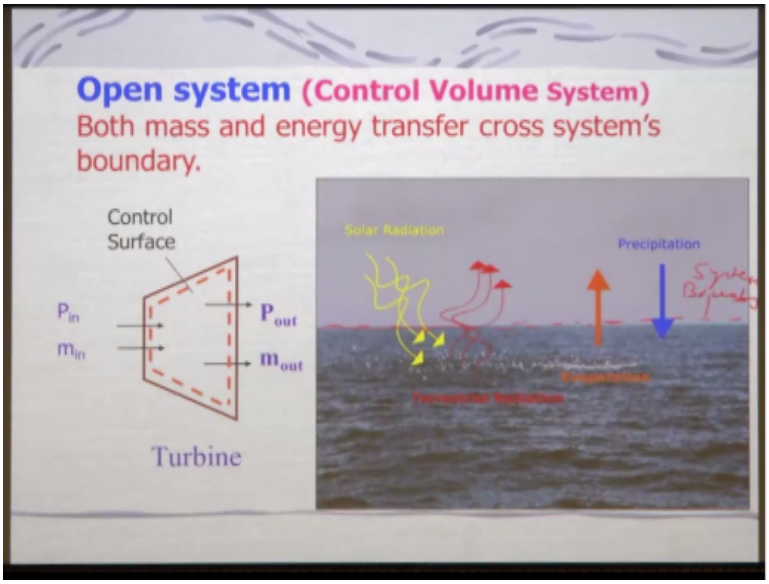

So let us now look at the open system, open system both the energy and the mass will be what you call crossing the system boundary right I let us say you people in the winter might be using the Geezer right forgetting hot water in your hostels am I right, so there will be heating and then water will be flowing out and in and throwing out so then we can consider this as a flow system

as a gave an example of this room that if the you know like a students will come and ingoing out then it will be like kind of a open system.

So if I look at that what is happening, the solar radiation coming and is going out there is a precipitation you know then we will be consider this as a what you call a system an open system right for that I can take this as a system boundary this as my system boundary, so that what will happen like it can be basically what you call an open system because there is a precipitation going on and it is coming going up and coming down kind of thing I can think of a turbine you know which I have done in schematically that means some mass is entering and some mass is going out and pressure you know with a certain pressure.

And it is expanded and you will get the work output and then you know we can consider it as a open system and this we can take it as a system boundary which is I mean basically the outer casing of the turbine, so let us consider a example because this is you know like.

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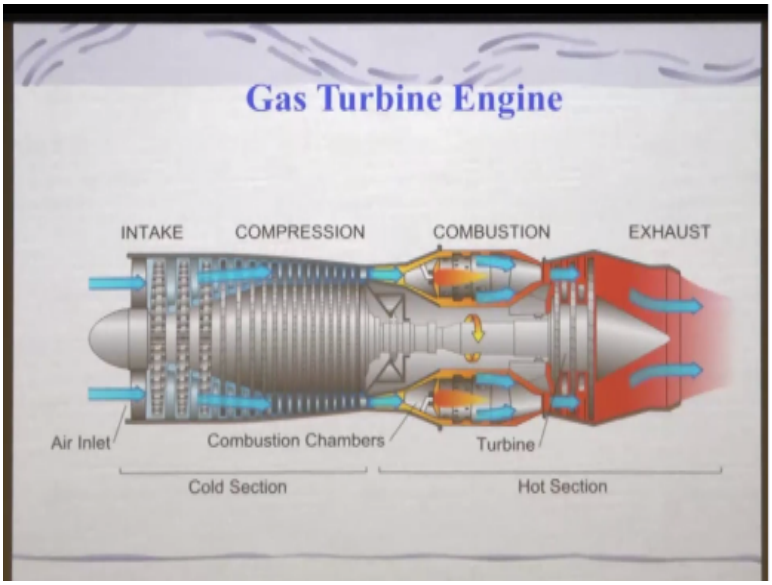

If I consider this a gas turbine engine which is quite complex in nature you know like what we use for power generation we use further also for like your jet engine applications kind of things to provide that thrust to the aircraft and other vehicles, so if you look at these are basically a compressor and there is a air intake and then what will happening the flow will be entering here and when it is entering you know like it will be pressure will be increasing and you will be giving some work through the SAP.

So I want to analyze this thing what I will have to do I will take a system boundary which is corresponding to this place right and then we will have to look at how much work is coming in and what is the change in the mass and changing the you know like your velocities and pressure and other things will have to change look at it and then find out how it is interacting similarly combustion chamber will have to burn some well and we can take if this as a system boundary and look at how much change in the temperature is occurring and it will have to look at.

So these complex systems can be you know looked at in a total or you can take in individual components like in this case compressor air intake and combustion chamber or a turbine or a nozzle right which is right and each individual component you can take analyze or you can take the whole system and also analyze what is happening so depending on the things you can take and this is an example for the open system.

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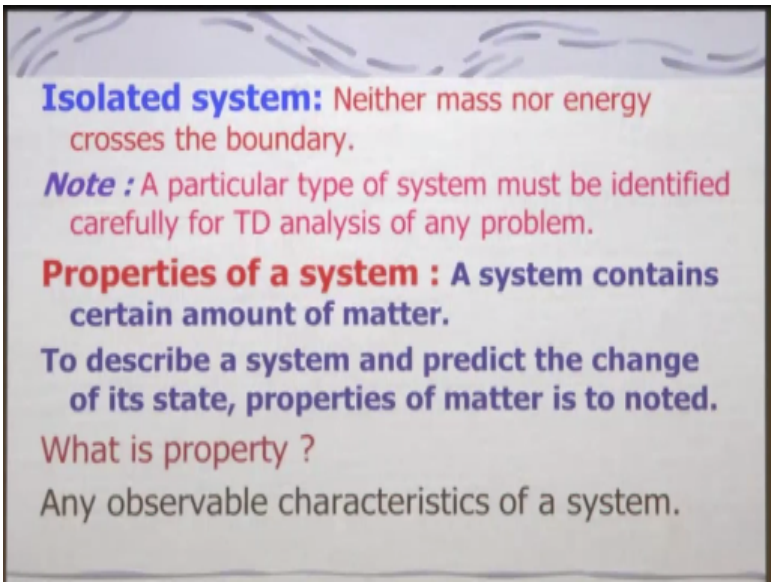

So when neither the mass nor the energy are crossing the system boundary we call it an isolated system right that means what will be happening in isolated system, is it I having any applications you know there is no energy interaction there is no mass also you know a changing or it is not coming in anything that means there is no mass interaction as such right then we call it as an isolated system we will be using it sometime but under what condition we will use it, any idea you know like people are isolated how?

Suppose you will do some nuisance in the society you will be isolated put into a gel am I right or wrong so you are being isolated so it is alike isolated system where the interaction will be low and you will be and we will be using this whenever we will be talking about entropic calculation then we will be using that okay so and as I told earlier I am also harping it again that particular type of system must be identified carefully for carrying out thermodynamic analysis otherwise you know your life will be miserable for analyzing.

That does not mean that I cannot use you know a system for to analyze for example if I take a problem and whether I will be taking control mass or whether I will be taking control volume the open system is known as the control volume system also right whether it is possible or not in other words for example I have taken the art and its interaction with the solar energy right as a system I told that look you will have to take the control mass system you know till the atmosphere exists Earth's atmosphere exists right as a system boundary.

But suppose I will say that I am interested to have an open system can analyze it I can analyze the same problem with an open system instead of control mass provided I know how to do it okay and it may be little bit cumbersome that means in other words that you can use any of them for the urinalysis sometimes it will be cumbersome to handle but however it is one can convert you know both the control mass and control volume system for the same problem that we will be doing when we will be deriving the first law of thermodynamics for a control volume system or open system will be using the control mass concept and then derive that.

So we will do that later on so whenever we are a system is interacting with the surrounding right there will be change in the properties of the system and also, also the surrounding and therefore we need to look at a properties of a system right and as I told earlier a system contains certain amount of matter and to describe the system and predict the change of state right we need to look at properties of the matter is to be noted down right.

For example if I am giving some heat to a piston cylinder arrangement the pressure you know will be changing so also the temperature and then we will be looking at those properties so what is the property then, property is basically an observable characteristics of a system that means what you can observe grossly right pressure temperature you know like all those things.

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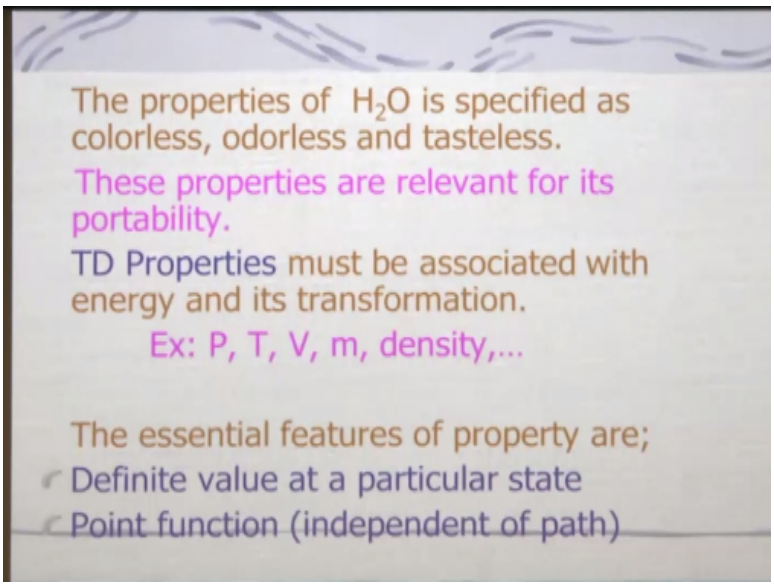

For example properties of a water can be specified as what as a colorless, odorless, tasteless right am I right? Now can these properties these properties of water considered as thermodynamic properties is it possible that we can say look at these are the thermodynamics, no it is basically related to the portable condition of the water but nowadays it is not see these properties are not good enough to say whether water is portable or not now we are bothered about whether it is a you know like TDS that is the total dissolved salt or how much and then what it is biological this thing like bacteria other things are not there.

All those things will have to considered now to make a water portable attack but these properties you know are not enough good enough for us for us the thermal must be associated with the energy and it is transformation or energy and it is interaction with the surrounding so what are those properties so those properties are pressure temperature volume mass density and several other things right, so the essential feature of properties are basically definite value at a particular state that means you should have particular values.

And also the it is must be a point function that means it must be independent of the path taken by the system during its interaction with its surrounding it should not really right so therefore one has to be considered that.

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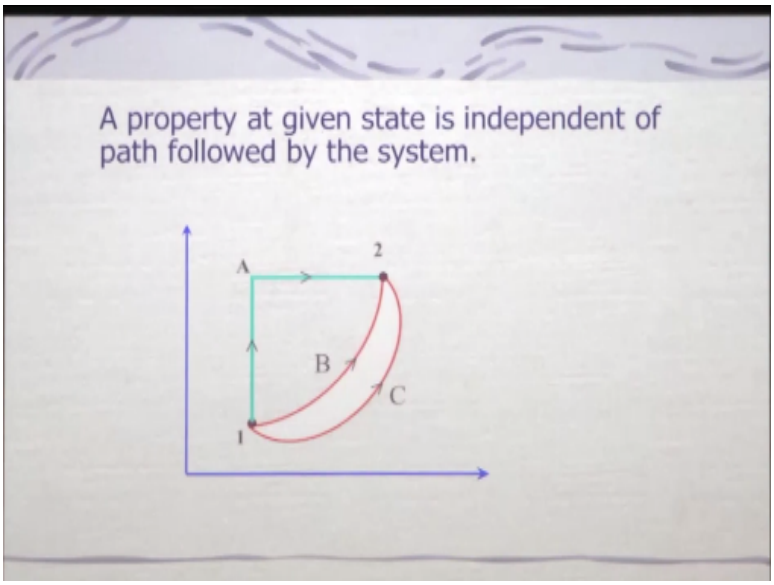

So a property at a given state is independent of path followed by the system right, if I consider this as a path you know like for example a system is here and it can go to a another point in this right can go through this path 1 to A or it can go to A to 2, right it can go through A to B, A from 1B2 it can go to A23 path C but the properties at Station one will be you know not affected by the path take and so also the properties that the two it is you know does not depend upon what path it has taken. So then only it will be the property of a system right.

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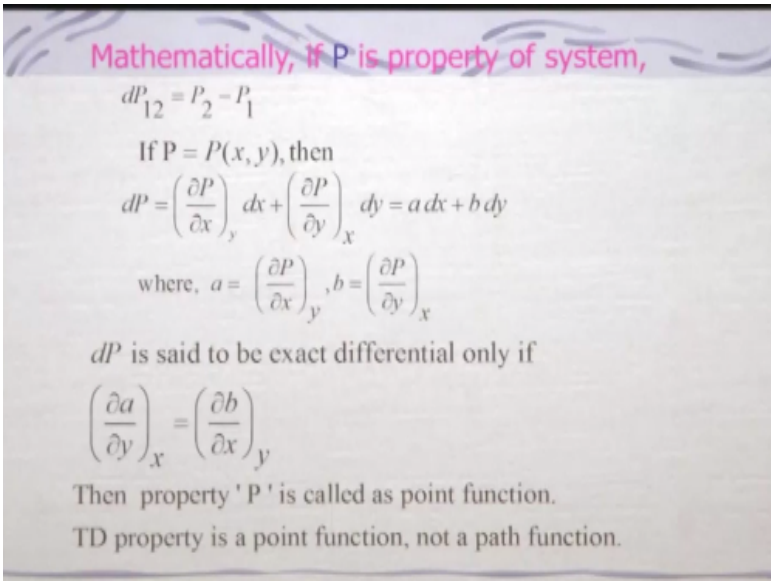

And in order to do that mathematically we can say properties P I am just saying symbol using P it can be pressure it can be temperature it can be anything and let us say there is a system is interacting with surrounding and there will be change in properties right let us say the pressure is changing right if I take a closed chamber and then started heating the gas then naturally pressure will increase okay.

So if I say that the change in pressure will be p2 - p1and if I say the pressure is a function of x and y I can write it down as that DP is equal to ∂ p/∂x when y is constant into DX + ∂p/∂y when x is constant into dy = adx + bdy what is A then here, A is nothing but your ∂p/∂x when y is equal to constant right and b = ∂p/∂y when x is constant right. So now I want to find out P as a property whether it is exact differential or not what I will have to do.

I will have to use this condition that DP is said to be exact differential only ∂a/∂y when X is constant and equal to ∂b/∂x when y is constant right. So then property is called as a point function and thermodynamic property is a point function not a path function right it does not depend on the path so if you look at we will see in the next lecture right how it is it is a mathematically we have told physically we will look at it and we will stop over here, thank you.

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