Indian Institute of Technology Kanpur

National Programme on Technology Enhanced Learning (NPTEL)

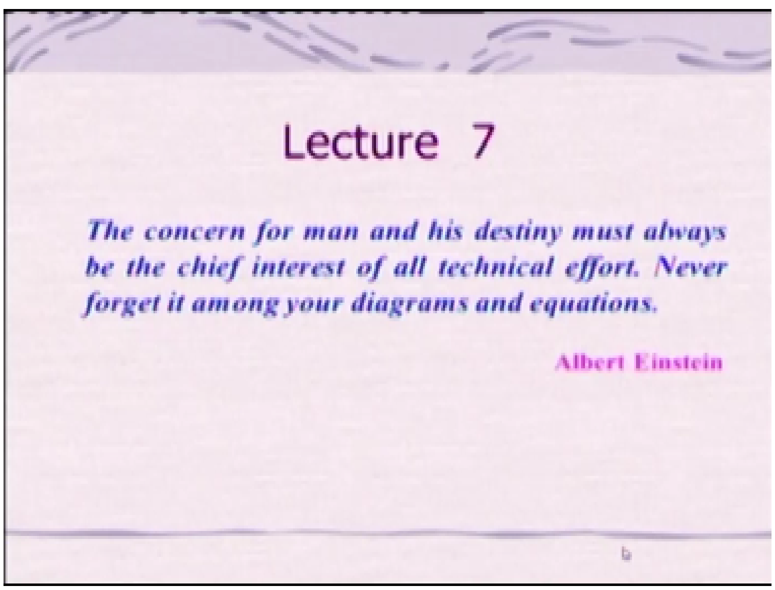
Course Title
Engineering Thermodynamics

Lecture – 07
Heat Interactions

by
Prof. D. P. Mishra
Department of Aerospace Engineering

Let us start this lecture with a thought process from Albert Einstein who happens to be one of the not only the greatest scientist of 19th century but also and in spirit ER for me so therefore I put this thing his thought process.

(Refer Slide Time: 00:35)



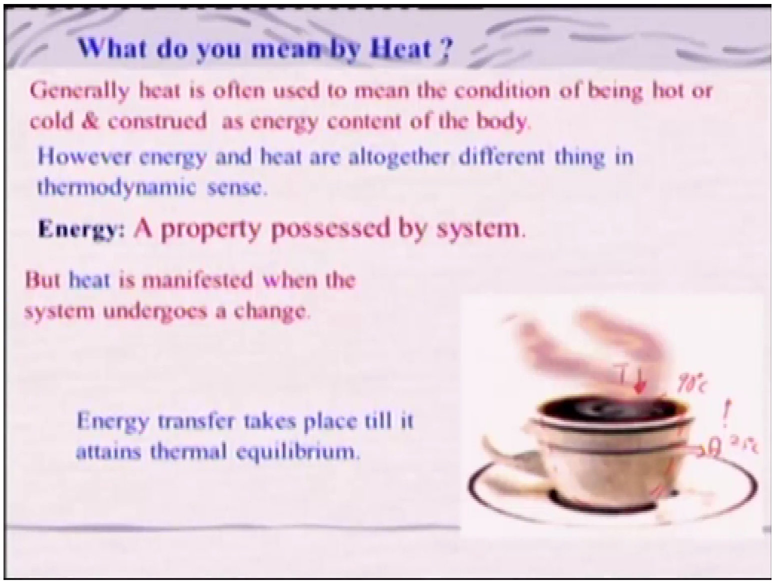
The concern for man and his destiny must always be the chief interest of all technically for I would like to put also say that it is not only the technically for any effort as a matter of fact never forget that it among your diagrams and equations that we do and then we forget about the humanity in that, so we will now be discussing about the some concepts which are very important for the thermodynamic and in the last lecture we discuss about walk and the way work is defined in thermodynamic is quite different than that of the mechanics and we demonstrated also that limitation of the definition of work given what you call in mechanics.

However we looked at the thermodynamic definition encompasses all the kinds of work not only the PD we work but also the soft work and then electrical work surface tension walk and other things and some of the examples I have not taken also like for example magnetization you know that you can also whenever they it will magnetize you some work can be done and one can also define very easily with the definition of thermodynamics or so also the dielectric material whenever there will be interaction there will be some work done.

And several other things which I not included because of paucity of time and today what we will be discussing is basically another form of interaction what we call it as basically heat interaction, so if you look at the a thermodynamic system can interact with it is surrounding in two modes one is the work other is the heat question arises what do we mean by the heat generally you can say look I mean like you know I am having a lot of energy to do the work some people say look I am very tired I do not have energy right.

And whenever you will say that you know some energy in a little qualitative manner right we can say it is hard or it is the energy content of a body right or a material, so is it really so, right we call it as a, you know a condition being hot or cold.

(Refer Slide Time: 03:18)



Or constitute as energy content of the body right or something like that but is it really, so is it the heat is same as that of the energy is 0 or it is similar to the you know work the we have discussed in the last lecture that work is basically energy in what in transient it does not depend you know on what you call point it will be dependent on the path right, so therefore it is a energy a transfer or rather in through the form of walk, so however what I as I told that energy and heat are all together different thing in thermodynamics sense it is not same as that of the what you call energy because heat is basically not a property of the system and energy is a property of a system and it will be possessed by the system.

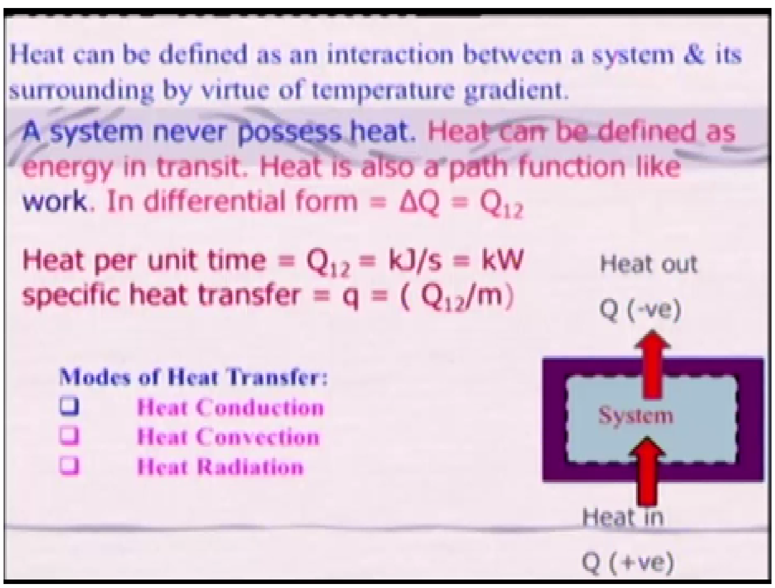
Right is it heat will be possessed by the system generally common since people say but in thermodynamic sense we do not say that, so heat is manifested when a system undergoes a change right for example I will take the example of hot what you call t right if I do that you know it is a hot tea and the ambient temperature if you look at here somewhere around this point or any other point it will be what it will below for example if I say something this temperature is something 90 degree Celsius let us say you know for example.

And here it will be maybe let us say 25 degree Celsius in this room because the AC room we might have maintained at 25 degree Celsius right, so there will be what heat transfer from the hot tea to this its surrounding right is a no I can take this as a system you know like simply a system I can say this is my system kind of thing and there will be heat transfer right, so therefore heat transfer takes place due to what due to temperature gradient right, so and then one can say basically heat transfer right that in thermodynamics sense we call it basically the you know heat.

In this case energy transfer takes place till it attains the thermal equilibrium and we know like if the heat will go if it will you know will be transfer this and then what will happen the temperature here it will be dropping down and here there are nearby this place it will be going up like 25 degree maybe you know 30 degree nearby not very far away from the cup of the hot tea and then whenever it you know both the temperature will be same both the system, so if it is my this is my system right and this is your surroundings.

Then what will happen there would not be any change of heat transfer no energy will be transferred due to temperature gradient, so therefore we can define the heat as then you know interaction energy interaction between, system is surrounding due to temperature gradient right.

(Refer Slide Time: 07:01)



So in the work whatever the things we are doing there are several gradients we talk about like you know there will be what you call surface tension there will be pressure gradient there will be you know magnetization or dipole effect or electrometric forces these are all gradient right, so but here the heat is due to the temperature gradient there will be in urgent interaction that we call it as a heat, so if you look at basically heat in thermodynamics sense right can be defined as the energy in transit it is similar to that of the work.

So what are the differences between work and heat it in case of heat it is due to temperature gradient right and whereas others will be due to other various gradient like pressure gradient and concentration gradient sorry pressure gradient and then maybe what you call electromotive forces and other forces like surface tension rising so he is also a path function like work it will be dependent on the path it takes and in the differential form we call it as Δ Q or Q12 any symbol we can use 12 will be more specific that means it is between the state 1 to the state two are.

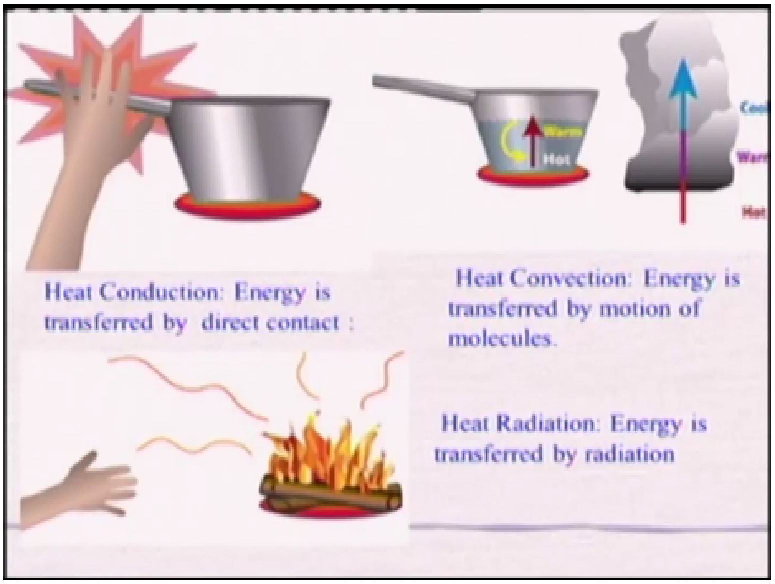
So therefore the heat per unit time we call it as a kilo watt that is kilo Joule per second in SI unit and specific heat transfer will be using you know like which is heat per unit mass and we will be also using heat per unit mode right depending on the problem is depending on situation, so as it is what you call heat is basically a is it extensive property or intensive property is it we can ease it a property of the system no right.

So but whereas energy is the property of the system so here we will be using the symbol like you know like a direction wise and that if the heat is going coming from the surrounding right to the system we call it positive and when the heat is going from the system to its surrounding or heat is transferred by the system to it is surrounding right we call it negative keep in mind that in some book people use different you know sign conventions just opposite of that.

So that really does not matter if we use a consistent or two cal sign that means if you look at the work done by the system what it would be work done by the system whether it will be positive or negative according to our sign it will be positive and work done under system will be negative but in case of heat it is just opposite heat is transferred to the system is positive and heat is transferred from the system to it is surrounding is negative just opposite in some book you may find just a positive that like you know he transferred to the system is negative.

And heat transfer from the system is positive and then work also done will be just opposite of that okay are you people getting confused what I am is trying to say that you would do this sign convention properly then it is you know it will be same, so we will be using this sign convention and let us look at the heat in thermodynamic sense whatever we have discussed till now it is equal to the heat transfer you know kind of things and heat transfer can occur by the three modes. You somehow I mean all of you will be knowing heat conduction heat convection and radiation I will just you know give some example like.

(Refer Slide Time: 11:40)



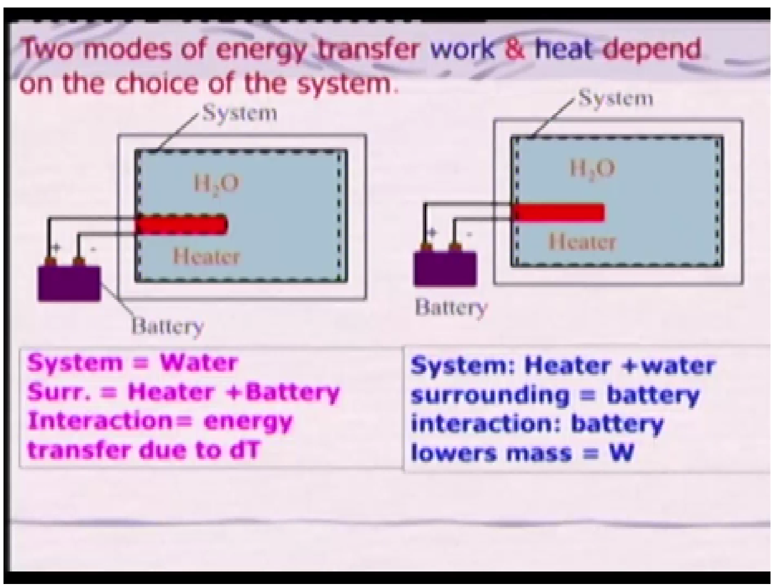
And then tell that what is that, like if you look at if you know touch a pan which is on a stall or a hotplate in this case it is a hot plate right and then what will happen you will feel are right it will get burned if it is very high temperature right and that is due to what do to contact by contacting a metal right we get the heat and that is what we call the heat conduction, in case of heat conduction energy is transferred by direct contact right.

And of course it will be you know some laws will be used and that you know laws of what you call Fourier’s law and then we will be also let us look at the what you call convective heat transfer where if you take a pan and there is a hot water here right and when this is you know come in contact the lower bottom portion of this pan with the hotplate and it will be heated and then water will be going up and then in of course it may be cooled by transferring and it sometimes it will vaporize also.

And as a result you know the energy is transformed by the motion of molecules because we know that when the molecule will be receiving the heat it will be moving at a higher velocity so it will be moving up and that we call it as a heat convection and heat radiation we know that we use you know in the winter particularly you know we will be using heating or getting heat from the fire or some other you know heaters resistance heater kind of things and then we can even though we are sitting out away from the heating source we can get heat and we get radiation in all the times.

So that is basically the heat read in you know energy transfer due to by the radiation and this contains some electromagnetic waves and then like that we call radiations, so it will be all combination of the heat conduction convection and radiation which will be taking place.

(Refer Slide Time: 14:06)



And that makes the heat to you know transfer kind of thing, so if you look at the two modes of energy transfer work and heat depend on the choice of the system what you consider right, let us take an example like because you know like whether the work transfer heat transfer you know how you will define in a system you know will be dependent on the how you are choosing your system otherwise it will be different.

For example I will take this system right if you look at this is a heater right resistance heater you can say and it is connected to a battery and then you are heating the water right and this is our system right, now system which one I will take so whether I will take the water I can take water as a system exclude the heater okay exclude the heat heater then what will happen, I can choose just the water which include you know sorry I can take the water along with the heater there is a system I can think of, am I right or wrong?

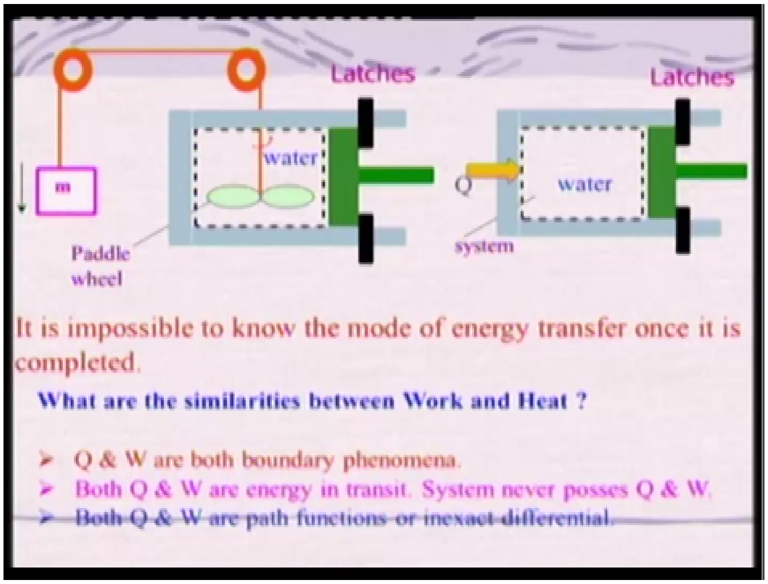
For example if I take this as my system that is the water only water in this case I have taken I have excluded this as my heater from this what it will be, will it be work or will it be heat interaction with what it would be I told you I can take two system in this case one is one is water only water in this case only what I have taken I have excluded the heater from the system, right and I can take another system which include not only the water but also the heater.

So which case it will be work which case it will be heat that is the question are you getting, so in this case the as I told the system is basically water and the surrounding will be heater and battery right the interaction will be energy transfer and due to temperature gradient if there is a temperature gradient because the surface temperature here if you look at it will be very high and then there will be heat transferred to the water and then you call it as a heat interaction right but if I take the other kind of things where only the water as my system not only the only water but also the heater as a part of the system then what it will be?

That will be work because you can think of that you know heater and being replaced by a mortar and then you know it is with a pulley it is raising a mass and then going through the gravitational force field moving and then you can call it as it work done, am I right? According to the thermodynamic definition so therefore that will be the, what you call work interaction, in this case eater and water is your system and surrounding is your battery because that is the giving the what you call electricity right and that will be converted into mechanical.

Kind of thing one can conceive that and one can say it is a work done right so what I am trying to emphasize here in this case by taking this example that it is important to choose proper you know system boundary and also do the proper analysis identify whether it is heat or water otherwise suppose you have chosen the heat vertical water as your boundary system boundary like water only you have considered as a system and then you are saying it is work done so naturally you will be wrong. So therefore one has to be one has to be careful about that.

(Refer Slide Time: 18:37)



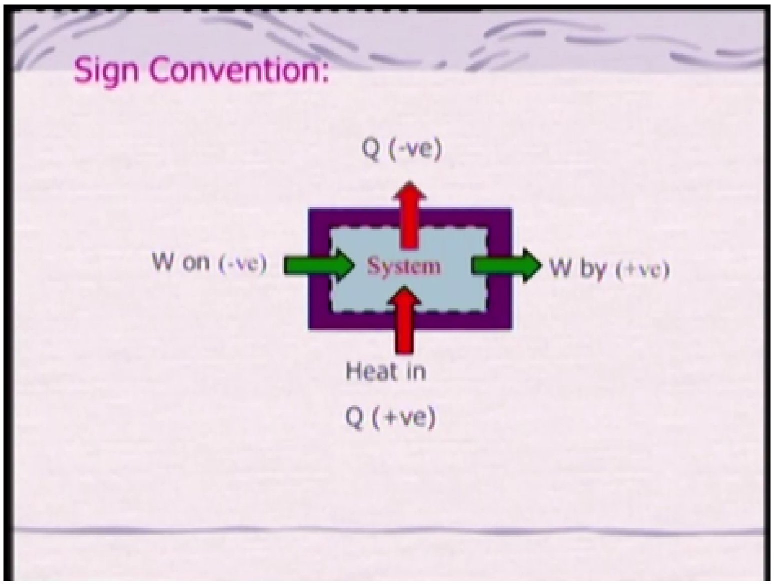
Let us look at another example like what you call there is a there is a paddle wheel which is rotating right and then it is connected to a what you call pulleys and to a mass which is moving against the gravitational therefore what will happen, it will be rotated and some work is being done right and when this work is being done what happened to its temperature will it be remaining same or it will be different will it be lowered down or it will be decreasing or sorry where it will be low decreasing or whether it will be increasing?

It will be definitely increasing rain so let us say instead of that I will take a system where it you are putting some kind of a you know heat and then whatever temperature let us say it will be started to 25 degree Celsius here in it is gone to 30 degree Celsius and here it has gone also 25 degree Celsius to 30 degree Celsius and then I will what to call you know I need to identify whether it is a work done or whether is a heat done heat being transferred is it possible, actually it is impossible to know the mode of energy transfer once it is completed right.

Once it is completed you do not know really whether it is a work done or a heat transfer or whether the energy transfer has taken place through the mode of heat or the work so that thing you should keep in mind so what are the similarities between the work and heat let us summarize it, what are the similarities what are those both are energy transfer in transient right, yes or no both are path function right or inexact differential.

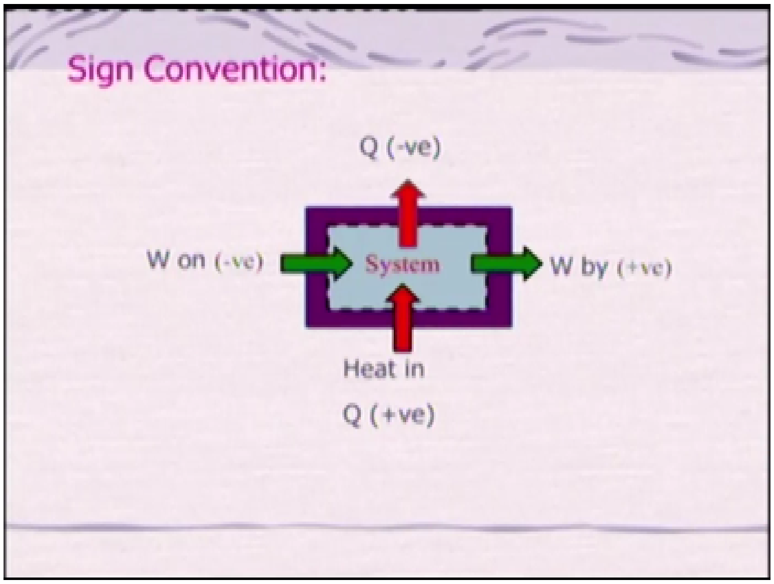
And both heat and work are boundary phenomena it means it is takes place all this transfer takes place through the boundary of the system right and system neighbor poses either the heat or the work it then what does it possess it poses the energy and which is the property of the system so these are the similarities between the work and heat okay.

(Refer Slide Time: 21:14)

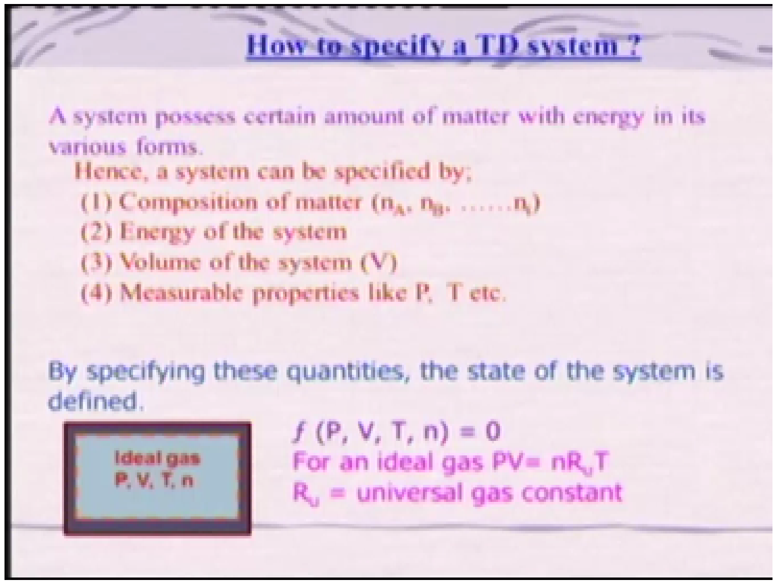


So just to summarize the sign convention I am just again repeating the work done by the system is positive and work done on the system is negative and he transferred to the system from its surrounding is positive and heat given why the system to its surrounding right is known is negative, right so these are the convention will be using but however you can make it just oppose it you know just oppose it then this does not matter you know whenever you are applying this thing the you know thermodynamic relations. It would not be really having any consequence.

(Refer Slide Time: 22:02)



(Refer Slide Time: 22:05)

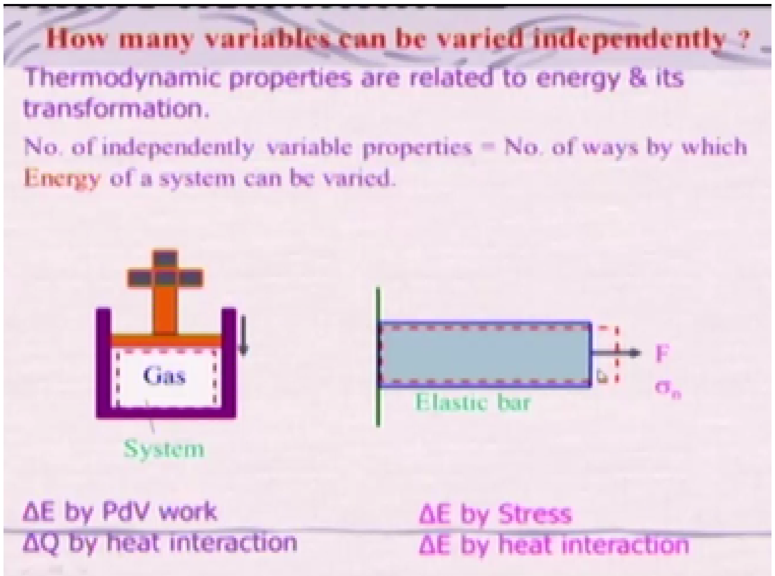


So now we will come to a point to discuss about how to specify a thermodynamic system because it is important for us to specify thermodynamic system as you know there will be interaction between the system and its surrounding as a result there will be certain amount of you no matter which will be affected by this energy transfer right and this may we need to look at the properties and hence a system can be specified by the composition of matter right for example if I consider the air right how many moles of oxygen and how many moles of nitrogen will be there we need to look at it.

Similarly we need to look at what is the energy content of that matter at a particular pressure and temperature if I take an example you know of an ideal gas which is at a particular you know volume certain amount of gas is there and at a particular temperature, so therefore I should also know the measurable properties like pressure temperature kind of things and I should know the volume I should know what is the energy content and I should know the composition of the matters right these other things are required to specify a system.

So by specifying these quantities the state of the system can be defined and for example like for an ideal gas we know that PV is equal to n ru t ru is basically gas constant that means it is basically function of pressure volume temperature and number of moles right okay. So therefore we need to look at like you know properties of this and but question arises.

(Refer Slide Time: 24:09)



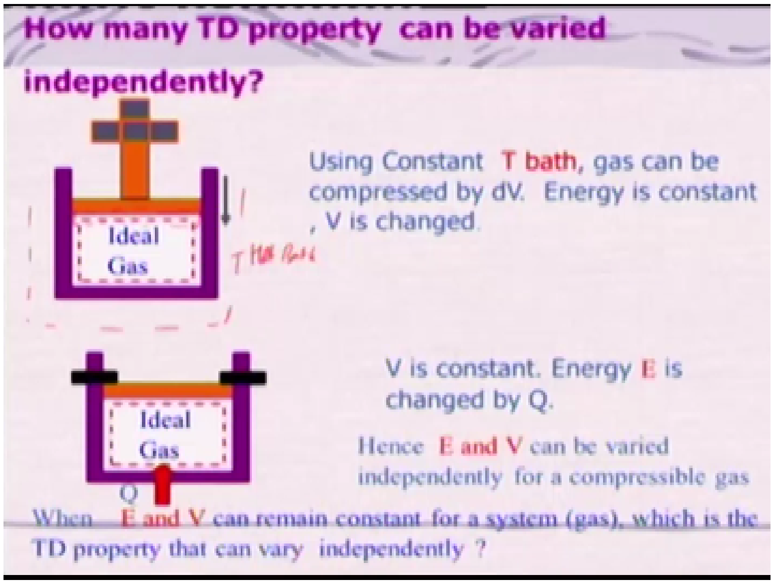
How many variables can be varied independently for example if I take an ideal gas if I increase the pressure what will happen to volume right if I increase the pressure what happens to temperature can I very it independently you know, so that we need to look at thermodynamic properties basically are related to energy and its transformation that is the crux of the thing. So we need to look at that number of independently variable properties will be basically equal to number of ways by which energy of the system can be varied right.

We can do we can you know make a case out of that means that how many ways we can vary the energy of a system right, so let us consider the gas in a piston cylinder arrangement and this we call it as a system the dashed line and we have put to identify the system boundary and it is having certain weight kind of things. So what will happen in this case the work energy transfer can be take place by what by pdu work right is in it?

So if the piston can move up or down some work will be done either by the system or by its surrounding okay and there might be also some heat interactions, so therefore in these situations what we will do we can say that you know by the two mode the you know energy sister of the system can be varied similarly if I take an elastic bar then there will be applied a force and then there will be a stress here right and if you look at if I apply a force it may be elongated if it is elastic resin it will be elongated and if you remove this force then it will become back to its original position right.

Similarly if I will heat a metal rod what will happen it can also be expanded and again it will contract provided it is a very small change in temperature or the heat you have given the heat interaction is not too strong right people might be knowing that when you are using very high temperature or the gradient kind of things it may not it my bend right or it may not come back to its original position so therefore in this case it is a basically by the stress or by the heat interaction.

(Refer Slide Time: 27:02)



So if you look at I mean we need to look at basically how many thermodynamic property has to be varied independently let us take an ideal gas again same example what we will do we will keep this thing in a hot bath let us say there is a something hot bath here right this is the hot bath hot bath means it will their temperature can be maintained at a constant you know the temperature can remain constant is a big like you can think of what will be a hot bath let us say it should be having a very large amount of mass at a particular temperature.

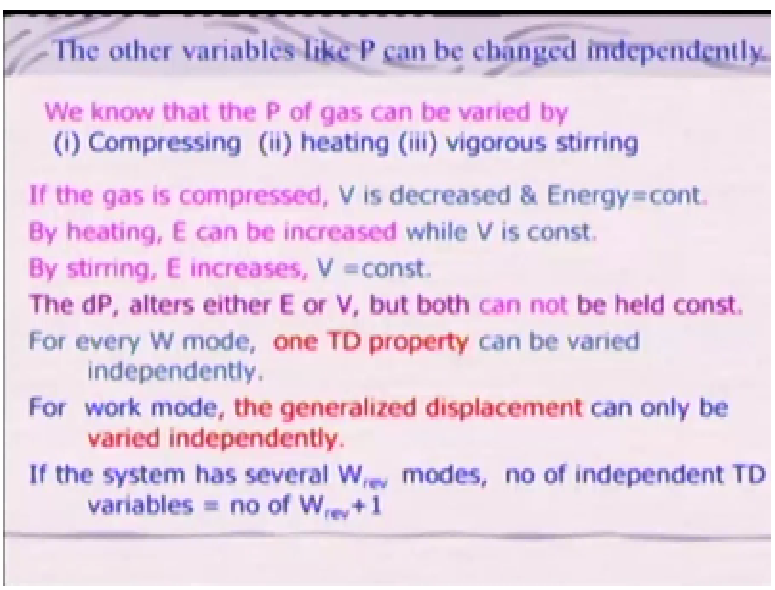
So that if any heat interaction will be taking place between the system here and its surrounding so this is my system and this is my surrounding then that temperature would not change right are you getting for example if I put you know take some kind of a let say hot rod which is at 70^{0} Celsius and put into a pool, pool means in a very big what you call water pool and then what will happen temperature would not change at are as such okay the total water.

So if you look at the at this temperature at the constant bath the gas can be compressed by changing the volume right, I can put a weight and then it can come over here right the piston can move and then the change in the volume, so that means there is the interaction between the system surrounding and in this case temperature remaining constant that means energy is constant while the volume is changing right is in it.

The energies of the system will be remaining constant because the what you call the temperature is remaining constant right energy basically I mean internal energy so let us take another situation where the we are giving the heat and latching it says that the piston own move and the volume is remaining constant. So therefore energy is changed now see in that case energy not changing in the earlier example now it is change due to the heat transfer however the volume is remaining constant.

So hence one can say that energy and volume can be varied independently for a compressible system because this is what we are discussing now a compressible system where you can compress it right or you can expand it so when energy and volume can remain constant for a system which is the thermodynamic property that can vary independently right, so then questionnaire ages you know like which is the thermodynamic that can vary independently we will have to look at it.

(Refer Slide Time: 30:15)



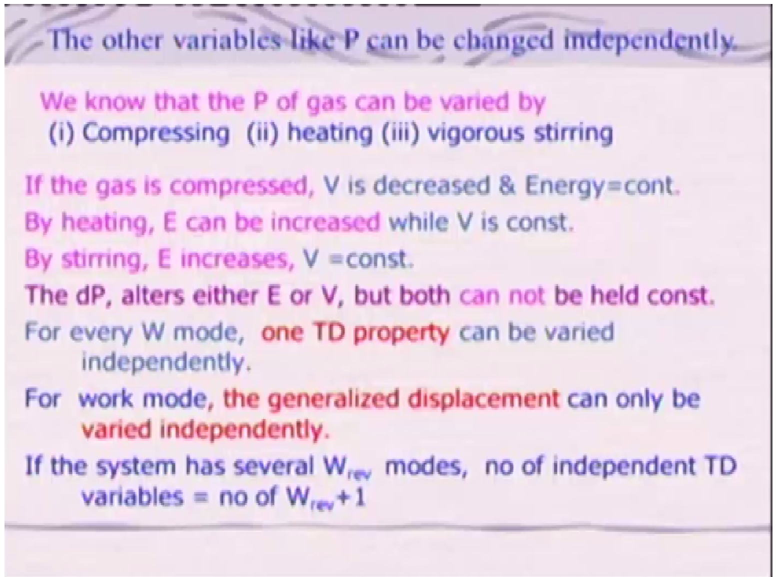
So let us other variables like pressure can be changed independently like when this is changing like you know one can think of changing the pressure we know that the pressure of the gas can be varied by three more ways I mean like one is by compressing that we know right if I compress the gas the pressure will increase or I can you know fix the volume then I will heat it in the last example where the piston is being latched that means volume not and when I am meeting it what will happen to pressure will go up am I right or wrong.

But similarly if I you know keep the volume constant and vigorously stirred and give some work what will happen that again pressure will go up, so if gas is press then volume is decreasing an energy remaining constant right and by heating what is happening energy can be increasing while volume is remaining constant right and in studying what is happening energy is increasing while volume remain constant this similar heating one is the walk you can think of studying is nothing but a what you call shaft work kind of things and in the other example it is the heating.

And if you look at the change in pressure alters what it does either energy or the volume one cannot really keep both as a constant you know I cannot really make the you know volume and energy constant right you cannot do that, so therefore we can say that every mode work mode one thermodynamic properties can be varied either heating, heating is one of the mode and other is you work in this example studying is the work and heating is the heat transfer wherever taking place and that is basically two mode.

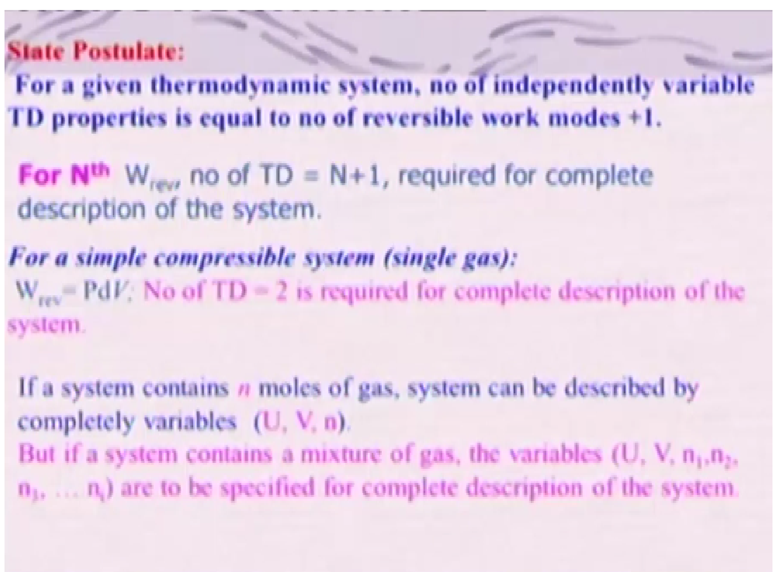
So for every work mode one thermodynamic property can be varied independently that is only valid for the compressible substance okay, what we using simple compressible substance so the work mode is basically the generalized displacement which we have discussed can only be varied independently right for the work mode the you know you can vary a the displacement generalized displacement it need not to PDV work it can be served to work it can be stretched or the substance work it can be magnetization you know that can be varied independently. So therefore we can say that if this is has several reversible work modes.

(Refer Slide Time: 33:27)



Then number of independent thermodynamic variables is basically number of the reversible work mode plus 1 right 1 will be basically the heat you know one can think of.

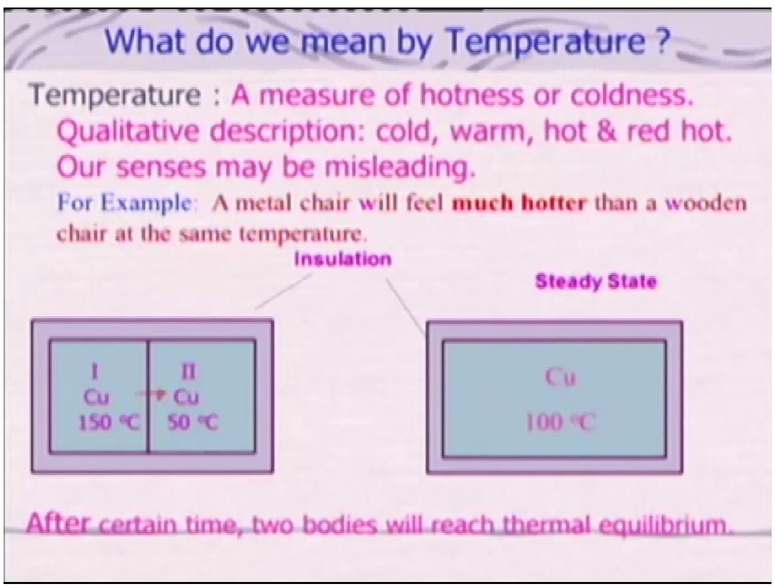
(Refer Slide Time: 33:46)



So and that is nothing but the state postulate which will help us to say that how many variables can be changed independently that is for a given thermodynamic system the number of independent variables that can be change variable means i mean the thermo properties = number of reversible work mode + one. So let us consider that if NH reversible work mode is there then number of independent thermodynamic properties are basically =N+1 for complete description of the system

If you consider a simple compressible system with a single gas one can think of is basically number of thermodynamic properties that can be varied independently is equal to two because one is the reversible work and other is one reversible work plus one but if system contains n moles of gas and system can be described by completely internal energy volume number of moles but if system contains mixture of gases the variable will be more depending upon the number of kind of gases will be there and which will be required for specifying a system completely.

(Refer Slide Time: 35:56)



So what we will do we have talked about basically how many variables and other things will just quickly look at what do we mean by temperature because whatever the heat you know transfer or the heat the interaction is taking place between the system and surrounding it is due to the temperature gradient therefore we need to understand what do mean by the temperature right. So generally we use temperature very often in our vocabulary you say that temperature is increasing decreasing but what do you mean?

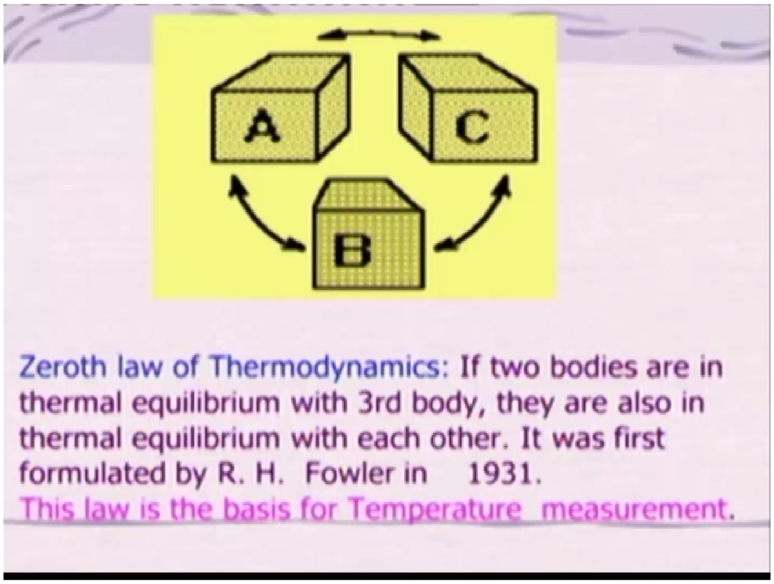
Like we can say it is a basically hotness or a coldness kind of thing is a measure of hotness or coldness. Some people can say look you know warm or hot or the red hot right and that is with our senses right and our senses may be misleading. For example if now let us say it is hot quite and summer you know hot summer now you are sitting now on a wooden chair let us say there is a wooden chair in the hot summer outside not in the ac room.

Right and you will sit down there what do you feel it will be hot or not? There is another chair in the same place it is being placed one is made of metal one is made of wood right so if you sit down there the same person and what do you feel which will be you know hotter at least according to your sense and which one? Metal will be utter why because both are at same temperature right.

So therefore the it is misleading because your sense the same sensor you are using and then it will be misleading kind of things so you know like but however we need to take about the temperature like what we will be doing we will be looking at this example with the copper block at 150^0 Celsius and there is another copper block at 50 degree Celsius and it is having a partition. Right which is separating and that partition is being removed and this both the block will be coming in contact with each other

So what will happen if this block is removed right and then the you know the heat from the higher temperature will be passing through the copper block which is at the lower temperature right and if you allow a large amount of time or the sufficient amount of time what will happen? It will reach a steady state temperature and of course it will be changing with respect to time but have people give enough time then you know it will reach a temperature and is already insulated so we can call it basically it has reached a thermal equilibrium right.

(Refer Slide Time: 38:59)

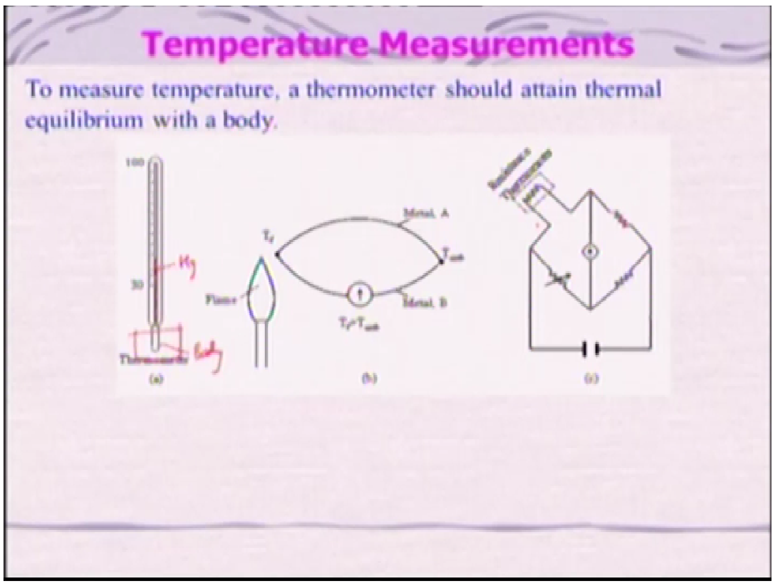


So and that is you know we can state in a very different way we do use this thermal equilibrium and our day to day life also. Let us say that this block A is in thermal equilibrium with block B right and we can also conduct experiment and also do that like in the third the Block C is in thermal equilibrium with block B. Then we can say that the block a is in thermal equilibrium with the Block C and that is nothing but you zero law of thermodynamics which was given by R. H. Fowler in 1931 and much later than the first and second law of dynamics.

That means before this law being put forward by the Fowler you know the first law and second law we are being you know put forward rate by the jewels and other people right. So if you look at what is that zero law of thermodynamics if two bodies are in thermal equilibrium with the third body then they are also in thermal equilibrium with each other and this law is basis you know for the temperature measurement? We know that you must have must be having experience in your day in your life that is you know if you place the thermometer right on your armpit whenever you are having a fever to measure the temperature right.

So you will take a more time am I right is it instead of if you put in that thing in your mouth where the liquid will be there right and it will take less time to reach the equilibrium temperature is not it. Suppose be beforetime if you remove then you will show so it will not show you the body temperature it will be showing the lower than that right so that we use for the temperature measurements.

(Refer Slide Time: 41:22)



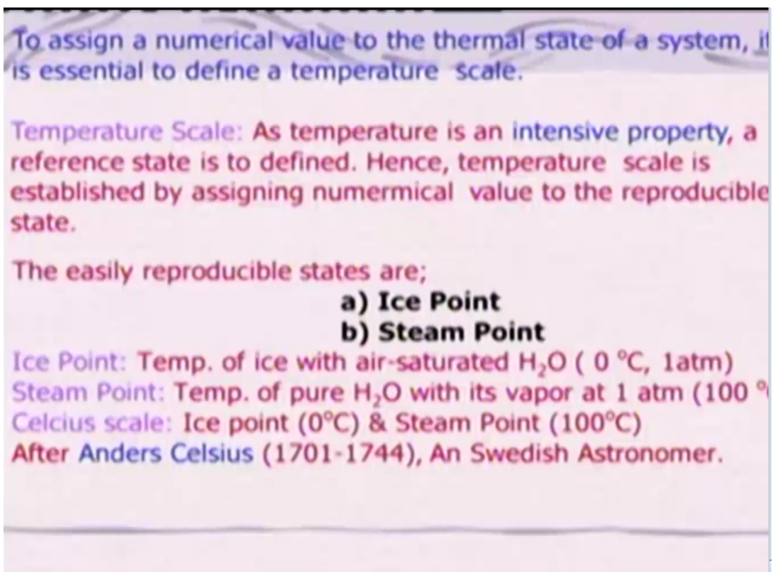
If you look at the various ways of measuring temperature and right there are three ways I am just trying to discuss over here and in each three cases right that we will have to you know satisfy the thermal equilibrium governed by the zero law of thermodynamics if you look at if this thermo meter which what you use is a mercury in a glass tube and you can use also some other kind of things.

Like if you look at this a temperature here which will be shown let us say the mercury will go up and then you know that label because of expansion our curry whenever it will become in contact with the body right. What it means in the matter anything you can also use this thermometer but this is having limitation of the thermometer this is a glass tube thermometers and you can also go for a call thermocouple where to two dissimilar metal.

When it joined together and there are two junction one is we can call it as a heart junction right because you can put into a flame or some other I temperature and then you can make it as a cold junctions and then maybe ambient temperature then there will be what you call See beck effect and that gives you EMF and that if you measure that EMF.

You can relate that thing to the temperature provided you know this cold temperature and generally people use ambient or the when zero degree Celsius or the ice point being used and there is a change in the resistance if due to the temperature you can use a what you call Western breeze and then change these variables and then you can measure the temperature and that. So if you look at basically one can measure and there are several various other ways of measuring the temperatures. But all the time it has to be you know satisfy the thermal equilibrium condition then only one can

(Refer Slide Time: 43:36)

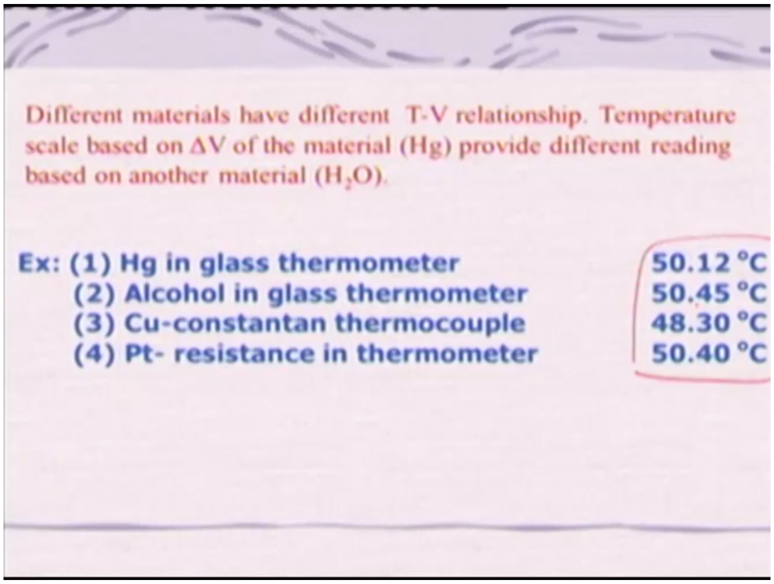


But if you look at we may measure because these are all variables like if you look at temperature is an intensive property or an extensive property intensive property. So in intensive property we need to assign a numerical value to the thermal state of the system to define the temperature scale right otherwise we cannot. Like for example like if you take a mass right or a volume so which are extensive property you can this thing so therefore we need to look at temperature scale and temperature scale is established by assigning numerical value.

To reproducible States this has been dome like you know you and two reproducible state which are being used very much ones the ice point other is the steam point and ice point if you look at the temperature of ice with air situated you know water at zero degree Celsius.

Being considered and the steam point is the temperature pure water with its vapor at1d one atmosphere corresponding to 100degree Celsius kind of things and Celsius sir we use these two points ice point and the steam point and then found out a Celsius scale you know what we call degree Celsius and nowadays also we do use and similarly the Fahrenheit you know he assigns some value to the ice point to 30 degree Fahrenheit and the steam point to 212 degrees Fahrenheit and made a scale so that is known as Fahrenheit scale however these scales will be having the problems because the different materials have different you know temperature volume relations right .

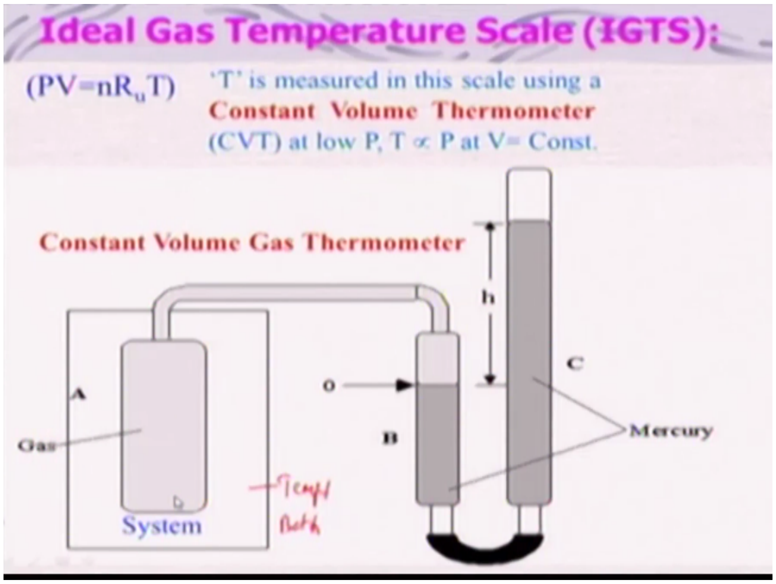
(Refer Slide Time: 45:25)



And temperature scale based on the change in volume of material of mercury what we use in our day-to-day thermometers it will be different then when we are using water or some other things right so therefore if we use the mercury in glass thermometer and alcoholic glass thermometer or copper constantan thermocouple or a platinum résistance thermometers then you will find the temperatures you know will be different.

So if you look at these temperatures are different of course you may say look it is not really much but however preciseness is very important when you do conduct measurements so therefore it is important to devise thermometer scale which is independent of the material .That is very important right so either is possible or not we will see that we can think of a constant volume you know gasps thermometers.

(Refer Slide Time: 46:29)

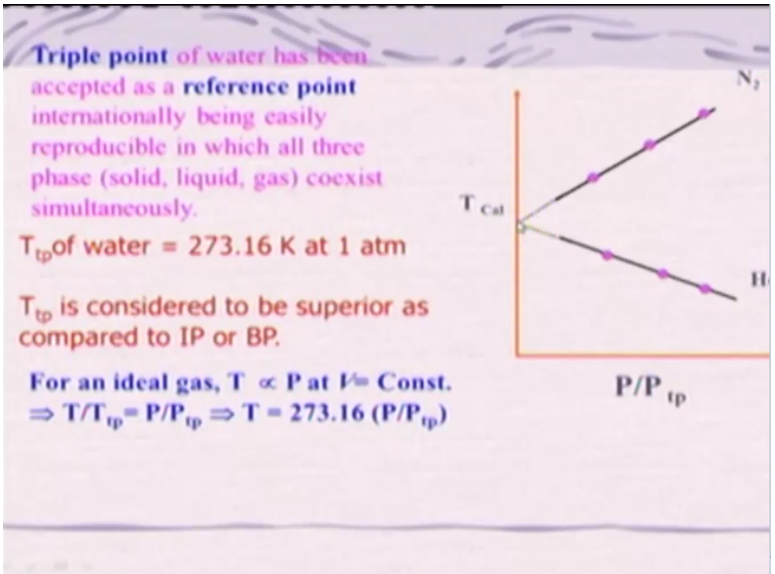


Which will be this is your continuing gas which will be in a system I mean like you can say this is your temperature bath which you will be and whenever the temperature will go up this person you know what will happen this is having flexible mercury which will go up and it will go.

That distance I can connect it with the temperature over here whatever it is having provided this system will be in thermal equilibrium with the water bar or the temperature bath right and so if it is so then what we will call that if I say this volumes constant because if i will keep in such a way that the volume of this gas of this you know system what we are saying the bulb of the thermometer inconstant that means this pressure you know is proportional as a temperature is proportional to the pressure is it and that head which can give me the temperature .

Whatever you know which changes will be occurring with this thermometer so triple point of the water has been accepted as a reference point internationally because of fact that all three phases solid liquid and gas coexist simultaneously if there is a small change in any of either pressure or temperature then there will be change the 23 pages won't be there that maybe two phase or maybe a single phase depending on situation so therefore thetas very precise definition and triple point of water is considered as a 2703.16 Kelvin at one atmosphere pressure and it is considered to be the superiors compared to the vertical ice point or the boiling point .

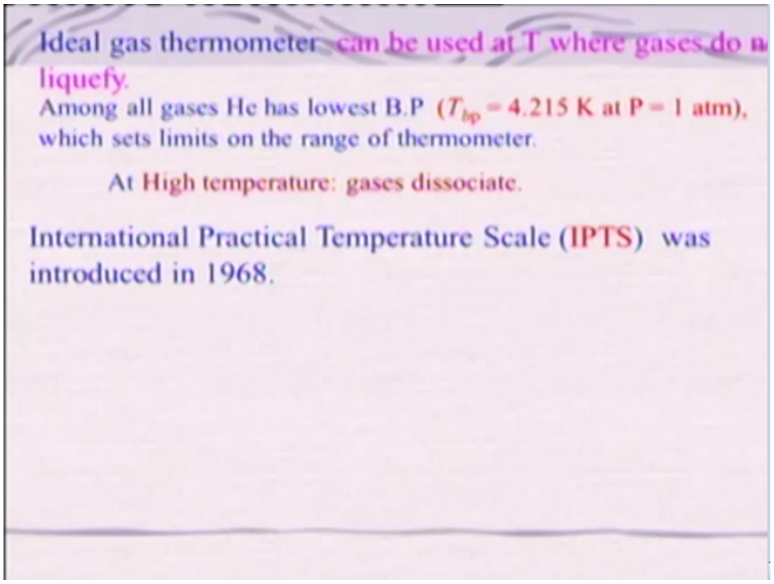
(Refer Slide Time: 48:27)



And if I will use the ideal gas law and t is proportional to Pat a constant volume then T by T TP thetas corresponding to the triple point is equal to P by the PTP and I know this temperature is known that is 27 2.16 Calvin so therefore the temperature you know I can really relate to the pressure provided know the PTP which is also very precise so you can think of by conducting experiment and plot this calculated temperature p by PTP and weather is helium gas or the nitrogen gas if you look at a lower pressure.

Now it will be coming to the same you know temperature kind of things all gases I have taken a nitrogen or helium at a low-pressure it will act like a and though what I say you can extrapolate and put their temperature and that is being considered you know as a vertical ideal gas thermometer and of course it is having limitation that that you cannot go beyond the temperature or the below that temperature where the gas is you know can liquefy you would liquefy you cannot use that that is the limitation of ideal gas you know thermometer so above that one can use so among all these gases helium has the lowest boiling point that is 4.2 15 Kelvin 81 attain spacer we set the limit on the range of thermometer.

(Refer Slide Time: 50:11)



Of course at the high temperature gases can be sausage and if you look at International practical temperature scale was introduced in 1968 and they use a Kelvin thermodynamics a temperature scale which will be valid overall temperature ranges which is independent of property of the thermometric fluids light means whether you are using mercury or water or another things so it will be not and that is basically temperature you know Kelvin can be related to the degree Celsius we just add 270-degree point 15 Kelvin.

So if you look at will be discussing about this ideal gas you know temperature scale little bit whenever we are talking about second law of thermodynamics which will be discussing later on and we will basically you know looked at the how heat is a one form of energy interaction it is a basically path function and then you look at various way of temperature measurements and then we looked at how we need to have practical temperature scales that wended to use it and that will be using basically the Kelvin in our case so with this also oh thank you.

Acknowledgement
Ministry of Human Resource & Development

Prof. Satyaki Roy
Coordinator, NPTEL IIT Kanpur

NPTEL Team
Sanjay Pal
Ashish Singh
Badal Pradhan
Tapobrata Das

Ram Chandra
Dilip Tripathi
Manoj Shrivastava
Padam Shukla
Sanjay Mishra
Shubham Rawat
Shikha Gupta
K. K. Mishra
Aradhana Singh
Sweta
Ashutosh Gairola
Dilip Katiyar
Sharwan
Hari Ram
Bhadra Rao
Puneet Kumar Bajpai
Lalty Dutta
Ajay Kanaujia
Shivendra Kumar Tiwari

an IIT Kanpur Production