Introduction to Atmospheric Science
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Lecture - 20
Lifting Condensation Level (LCL)

Okay, good morning. So in yesterday's class we looked at the an important thermodynamic quantity namely dew point temperature okay.

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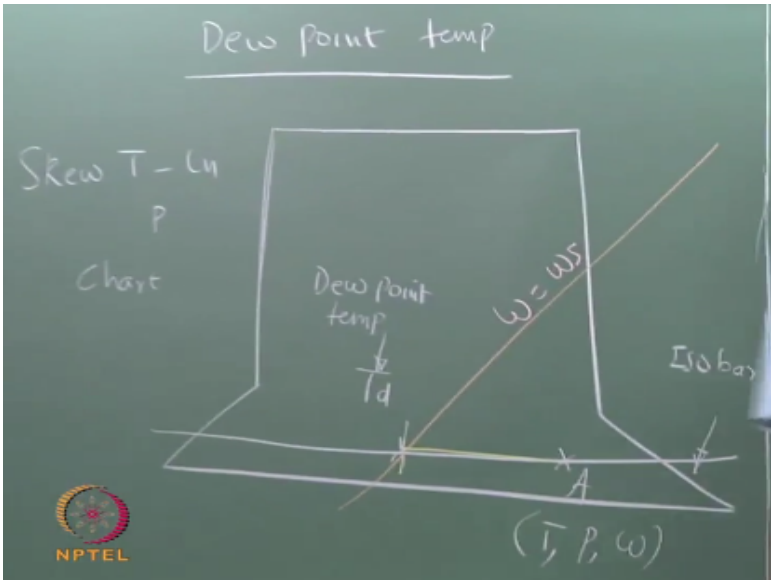

So if we look at the okay point A, point A is qualified or described by temperature T, pressure P, and mixing ratio omega alright. Then we go horizontally like this and reach a point where okay. So this point okay is T d okay dew point. What was the problem number yesterday? 30.

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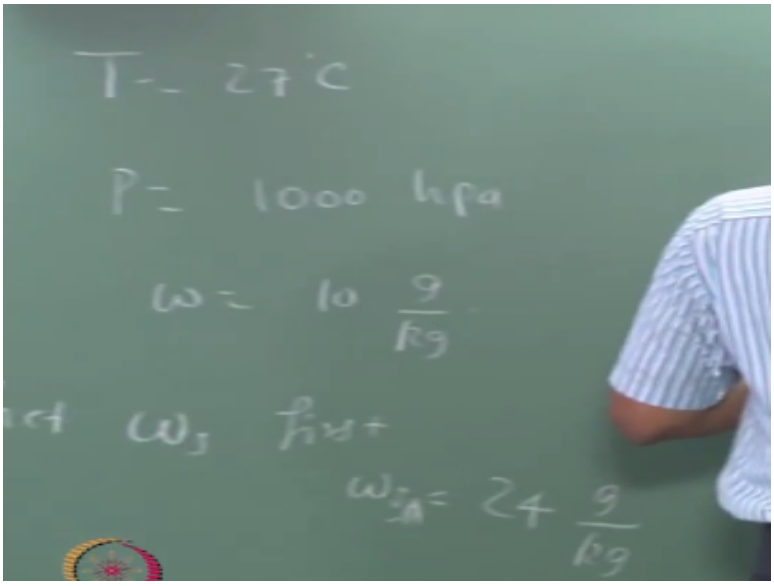

So yesterday we solved this problem using the chart T equal to 27, P equal to 1000 hPa, and omega is equal to okay. So we got omega s first. It was some 24 g/kg That omega s we will find out that this place what is the omega right. There will be omega s corresponding to this point okay. So this is like omega s at A okay.

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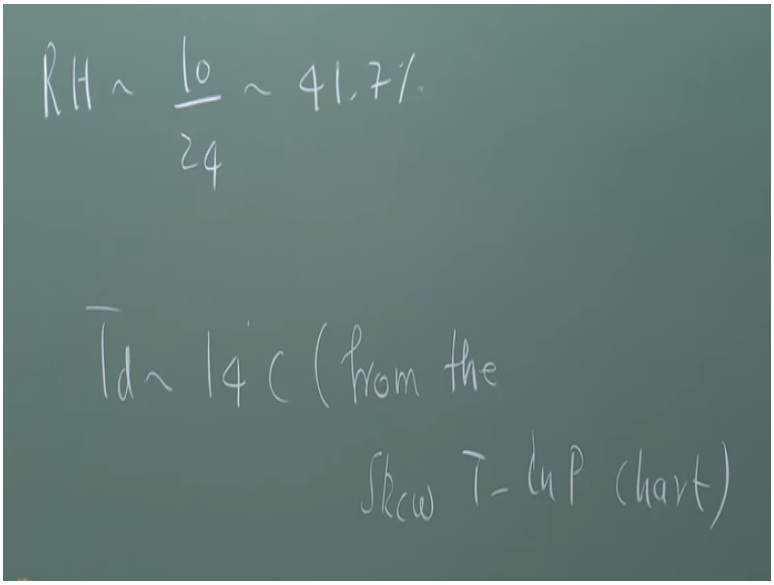

So the RH, T d was 14. Sounds good okay. Now let us discuss this dew point temperature a little further.

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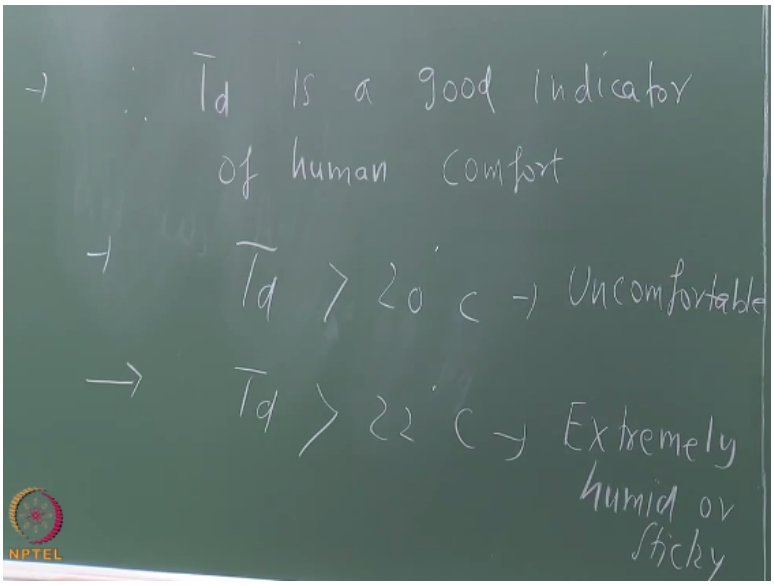

At the earth's surface, at the earth's surface P varies only by a few percent from place to place. Therefore, what we can say is therefore the dew point temperature is a good indicator of human comfort. So therefore T d is a good indicator of human comfort. So T d so for a particular condition we will calculate the T d. The T d is greater than 20 degree C is uncomfortable alright. T d greater than 22 is extremely humid or sticky okay. Okay let us now work out a problem 31 okay. So to understand this concept of dew point temperature little further.

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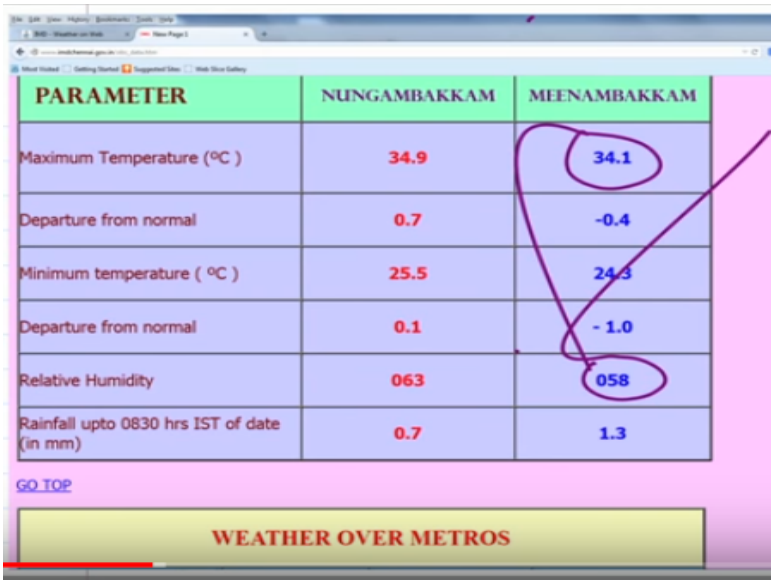

PARAMETER	NUNGAMBAKKAM	MEENAMBAKKAM
Maximum Temperature (ºC)	34.9	34.1
Departure from normal	0.7	-0.4
Minimum temperature (ºC)	25.5	24.3
Departure from normal	0.1	- 1.0
Relative Humidity	063	058
Rainfall upto 0830 hrs IST of date (in mm)	0.7	1.3

GO TOP

WEATHER OVER METROS

Okay so this is what I got from the India meteorological department website okay. So which is like imd dot imdchennai.gov.in okay. So this Chennai weather, observations recorded at 5:30. Yesterday was 17th September Marius very good. So there are two stations Nungambakkam and

Meenambakkam. Meenambakkam station is just outside the airport. Nungambakkam is in the heart of the city Mount Road or close to the Mount Road.

So we will take some condition, Meenambakkam which is closer to IIT okay. So let us say the temperature is 34.1 okay, pressure will be like 1000, you can take it as 1000. It will be more than 1000 hPa no in Chennai. Let us say 1010 or something okay. So problem 31. Problem, based on the data given for Chennai, Meenambakkam determine the dew point, determine the dew point temperature at 5:30 pm on 17th September 2014.Can you get the dew point temperature? RH is also given right? Okay, I will give you the values okay.

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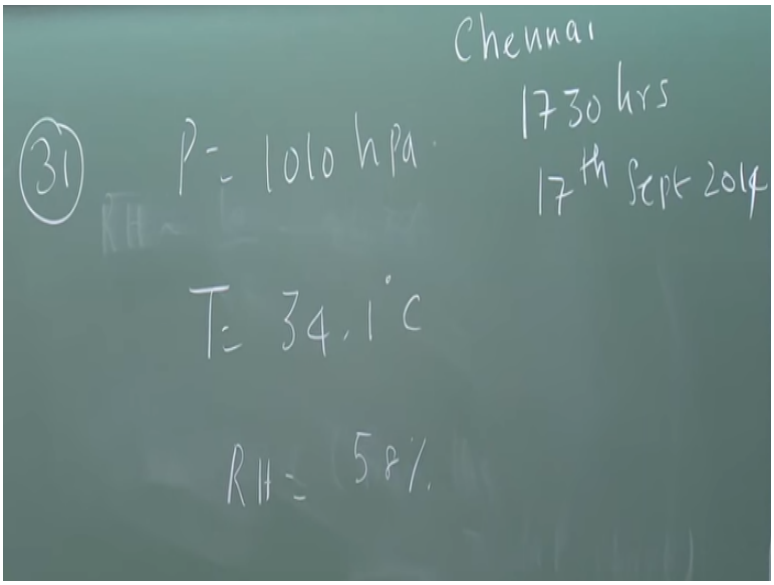

So P you can take it as. So here it is instead of omega RH is given. We want to see whether yesterday 5:30 was it uncomfortable or sticky or neither because you have experienced it no yesterday. Okay temperature is 34 okay and RH is 58. What is happening? Why is that line coming? I will just get out of the, no problem. We will work out here.

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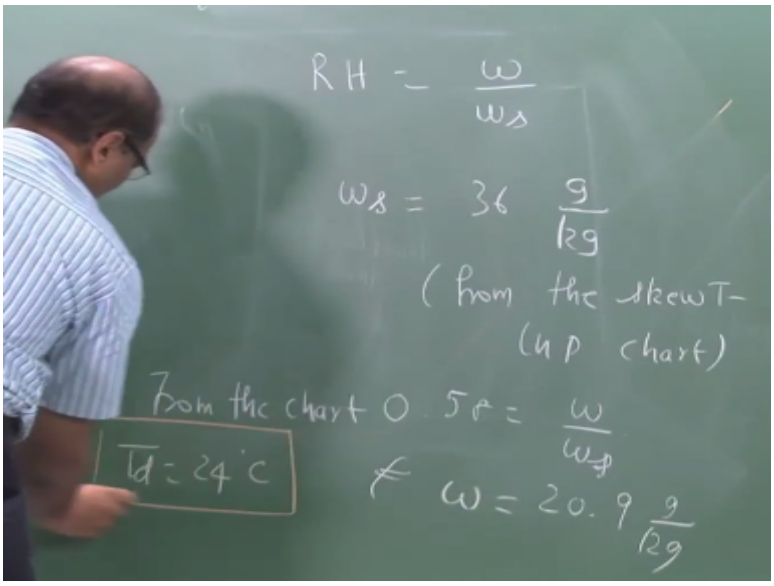

So T is 34.1 and so RH is what is omega s 36 g/kg is it okay. How did you get this? From this Skew-T ln P chart correct? RH was 58%. Omega is 20.8 okay. Yes, Subhash now I want the chart.

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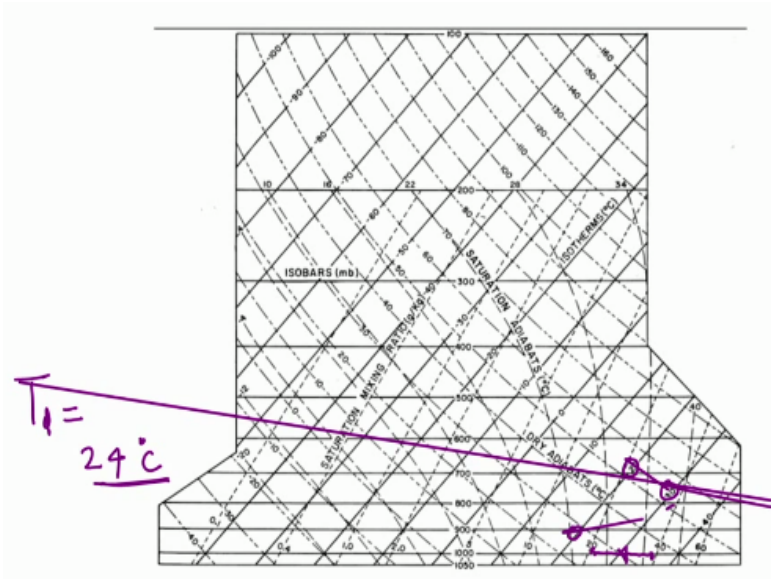

Okay now the condition was this these are the temperatures right. So 34 is here. 34 and 1010 somewhere here. Is it okay? And then we are moving horizontally up to where is omega 0.4 omega is 28 that is here is it correct? So this is 20. Sorry this is 20. This is 30. Therefore it is messing up. So T d is T d is 24. So yesterday the dew point temperature was 24. If it exceeds 22 you will feel sticky. You are feeling sticky right.

But you feel little better because it was much higher on other days. So 24 itself we feel it is good. On other day Chennai can be very close to near death conditions alright fine. Now we will move on to another important concept called the lifting condensation level LCL okay. So okay so problem 31 is done. Lifting condensation level. Please take down the formal definition of LCL.

The lifting condensation level LCL is defined as the level to which an unsaturated but moist parcel of air can be lifted adiabatically with respect to a plain surface of pure water. I come again, the lifting condensation level LCL is defined as the height to which an air parcel can be lifted till it reaches RH of 100% in simple English. So in complicated terms it is how much it can be lifted adiabatically with respect to plain surface of water okay. So during lifting what happens?

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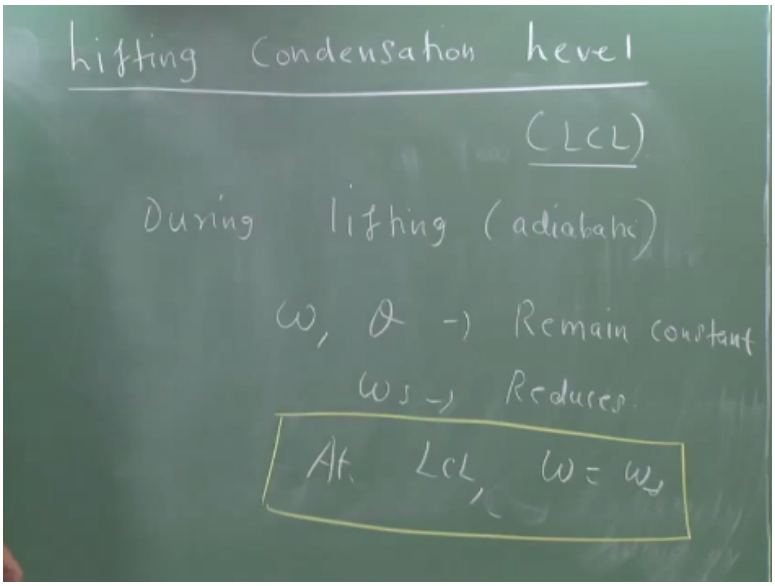

Pressure will decrease all that. Let us look at the moisture parameters. What about these two? Adiabatic lifting. During adiabatic process what is how will theta change, not change. It is not it is adiabatic and there is no mass transfer which is taking place. It is not accumulating or shedding any moisture. So what will be the omega, same. Omega and theta will remain constant. But in the troposphere as the parcel is lifted the surrounding air the temperature is going down.

So therefore the omega s the saturation mixing ratio the surrounding air will reduce. At LCL omega equal to that is it, very simple. This is the concept. Now, how to get this LCL using this Skew-T ln P chart okay.

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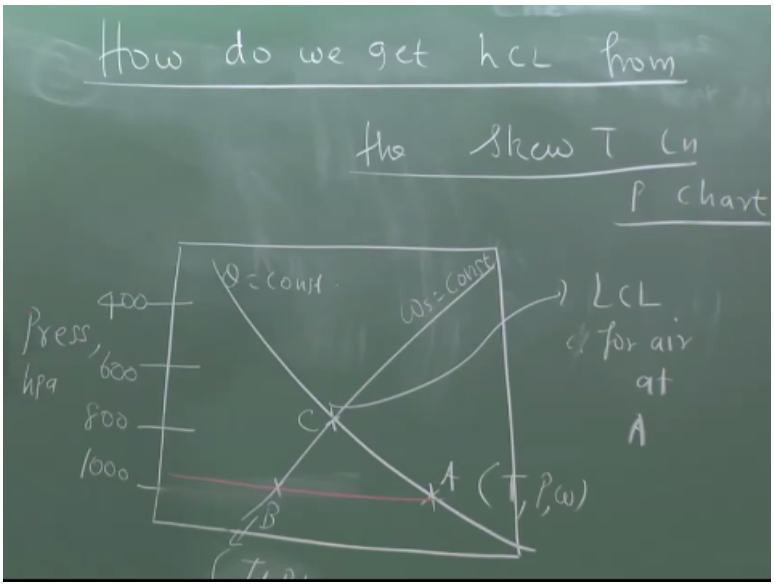

Some equations are there okay. We can solve the equations and get the LCL just like you can have an equation to get theta but theta can be obtained from the chart also. How to get LCL from the. So I will explain it here. Pressure okay. X axis I cannot say temperature because temperature is skewed, x axis is something okay. Now, how are the theta equal to constant lines. So theta equal to constant, shall I show it there but that pen is behaving funny today.

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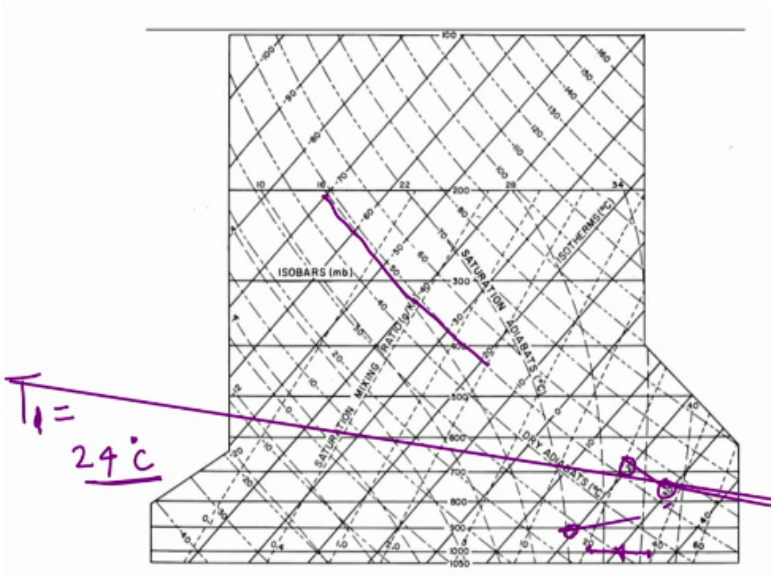

So theta equal to constant lines are like this. Now it is okay. Okay, so consider a point A. Point A is having temperature T, pressure P and mixing ratio omega. It has a theta potential temperature theta and theta is constant okay. That theta is constant is that dry adiabat. Now, I can go horizontally on this isobar. From A I reach a point B which is T d. So the point B is qualified by omega s. So there is a saturation mixing ratio line which is given by this correct?

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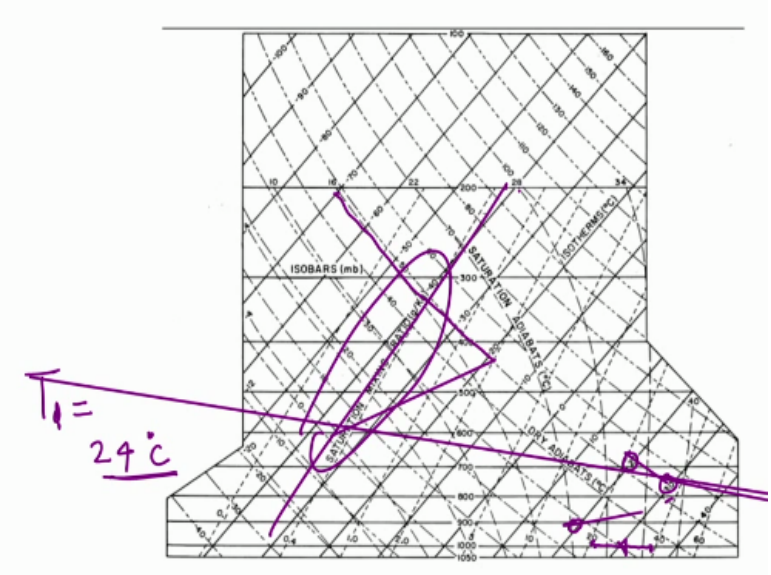

Therefore from B you can have a constant. These 2 fellows will intersect at point C. Point C is the LCL. It is the lifting condensation level for an air parcel which is at A. It is the height to which an air parcel can be raised adiabatically till it becomes fully saturated. So this gives an approximate indication of the height of the cloud base. In a strong convection it gives you an idea of the height of the cloud base.

Beyond that it is quite possible that it will start raining if it goes further up. But for little bit height it may still not it may get you may have a supersaturated cloud. But there is a possibility that slightly above this, how it is rising because of winds or something, if it rises further there is a chance that it can shed its moisture. Therefore, the calculation of LCL is fundamental in meteorology or atmospheric science.

The cloud base height which can be correlated with rain and you can also correlate it with 2 types of rainfall, convective rainfall, stratiform rainfall, mixed rainfall. So the first step is the

calculation of LCL. So how may parameters you require to calculate LCL? Is the question clear? How many parameters do you require to calculate LCL? Yes, tell me correctly. Very good, 3 parameters are required to calculate LCL. First temperature and pressure are required.

Then any of the moisture parameters. Any moisture parameter, you give me RH, you give me omega, you give me omega s, you give me dew point, one, if one is known then you can find all the others.

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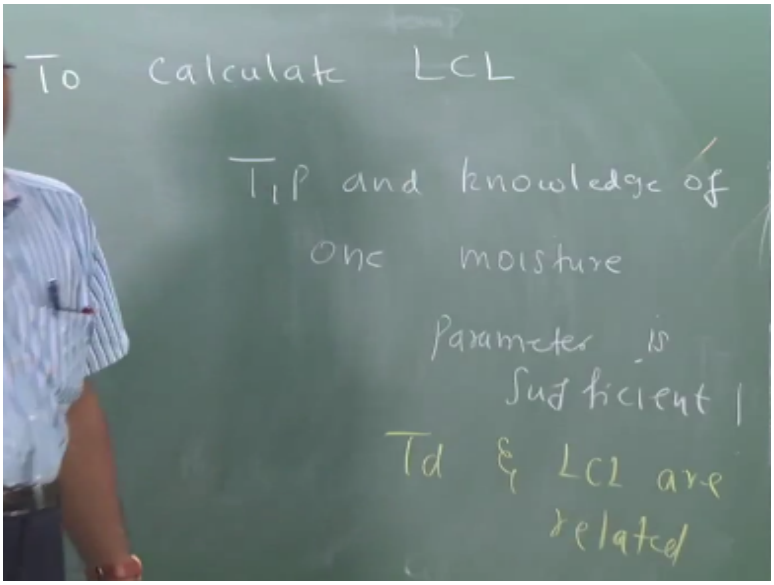

Therefore. No saturation adiabat we will go only after crossing the LCL. That I will explain in later class okay. So, so T d and LCL are related correct? The T d and LCL are related. They are not independent quantities. One of the two is sufficient for you to so another point is okay. Yesterday's class we worked out a problem what was that? Getting the dew point. Problem number, problem number 30. Now what is the new problem number? 32 okay.

Is everybody through the LCL, any doubt. I will come again. What we will do is first locate the temperature and pressure point A okay. The air parcel is initially at point A. Then when it is lifted adiabatically it will go like this. Then we would like to know when the omega equal to omega s. In order to find that what we have to do is you first horizontally go from A to B, get the dew point, the procedure for which is already known to you.

From the dew point you go along the constant omega s line. So the constant omega s line and the constant theta line will intersect at a point C that is the LCL. It is LCL but actually what you are getting is the pressure. From the pressure you know how to calculate the height. Is it okay. That is already known to you. Problem number 32. Revisit problem 30. Calculate the LCL for the air parcel. Problem number 32, revisit problem 30. Calculate the LCL or determine the LCL for the air parcel. So problem 32 okay.

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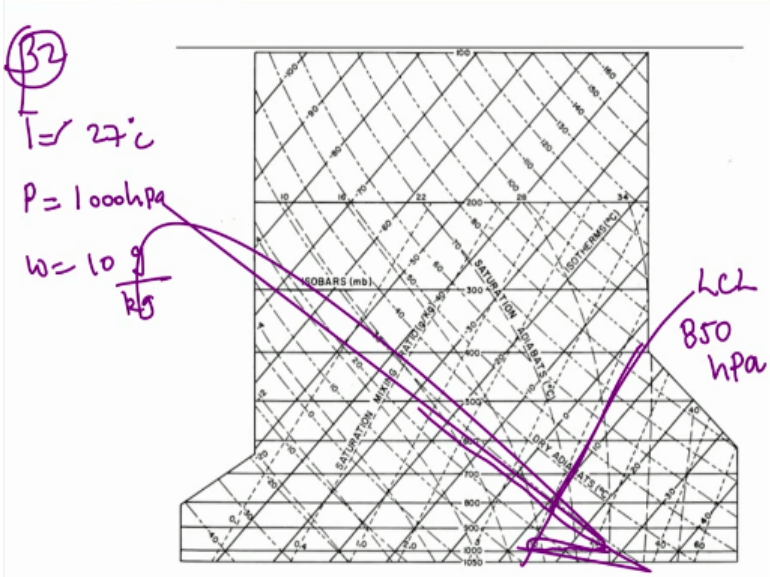

So what was the T? Why is it doing this? I am not touching. Then, P 1000? Okay. Alright. Now, the omega was. So saturation mixing ratio is dotted line so we go all the way, correct? Now, from this fellow, it is going to get messed up. The dry adiabat is like this. The saturation mixing ratio is like this. I do not know which line now. Where is the LCL, 800? 850 okay. Okay. So the LCL is around 850 hPa very good, okay.

Is everybody through with this? Problem 33. A parcel of moist air, problem 33. So problem 32 the solution is on the board. The LCL is 850 hPa which I have indicated. Problem 33. A parcel of moist air has a pressure of 975 hPa. A parcel of moist air has a total pressure of 975 hPa and a temperature of 15 degree C. Total pressure of 975 hPa and a temperature of 15 degree C.

If the mixing ratio is 1.80, if the mixing ratio is 1.80 g/km determine a. vapour pressure, b. virtual temperature 3. LCL. That will take us through to the end of this class okay. So a. vapour

pressure, b. virtual temperature and c. LCL okay. So I will write it down on the board then you can start solving.

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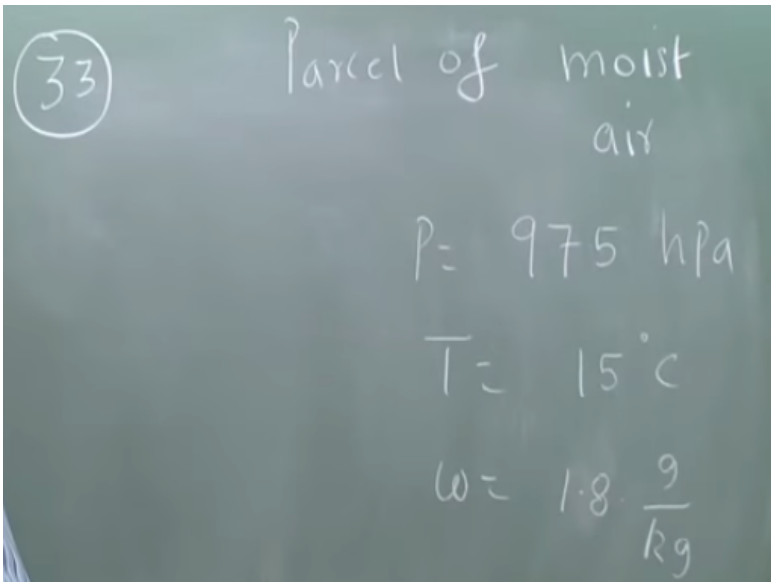

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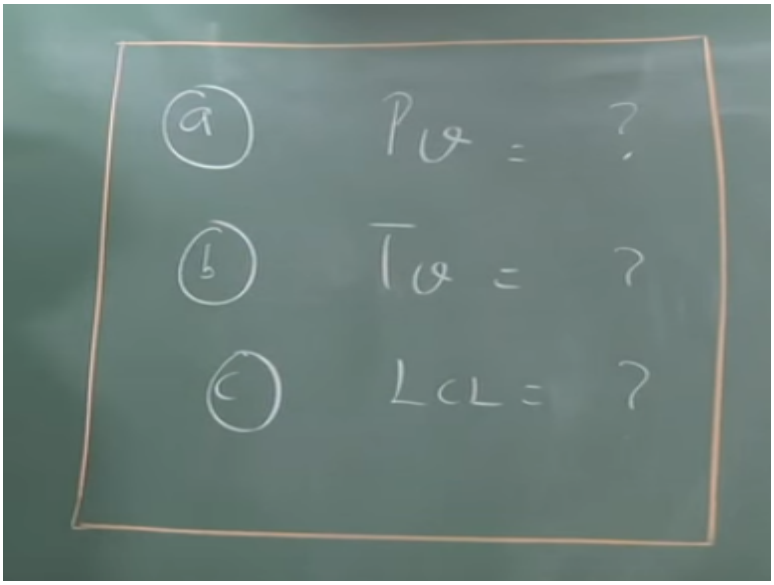

So this is the question. So parcel of moist air total pressure 975 hPa 975 hPa T equal to 15 degree C and omega is 10 g not 10, 1.8. So there is a definition for RH in terms of partial pressure also right and P sat can be taken to be P total? Ya the omega is so less. P equal to P sat correct? Amit, sleepy? Harpan what is up? You are okay alright. Shall we start solving or I will give you some time. What do you want? Solve, okay. I will solve.

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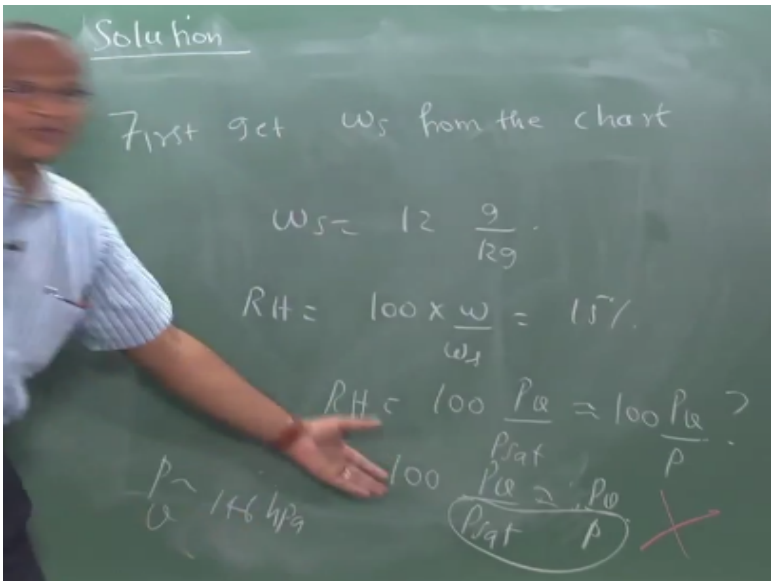

First get omega s from the chart. What is omega s? How much you are getting? 12 okay. RH equal to no 15% is it? 15%. This is correct? This also alright? Did I mess up? Is it correct or no, the 0.0015. Let us do this. Is this correct 100 into P v by okay so 15 then it is correct no? Is this formula correct or it is P v/P sat. Just check. Be careful. No 100 into, it is there. So what is P what is P v finally? 146? It is too high. 146 hPa? This is correct? I am not sure, are you sure? Ha this is I have a doubt about this. Let us go to the omega formula okay.

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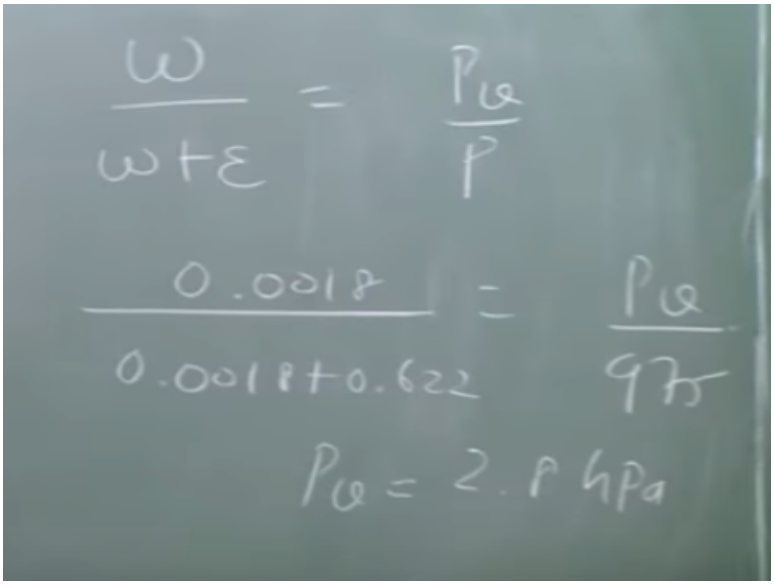

Omega is ya that is a better way to calculate. Omega is 0.622 omega is which formula did you use Akil okay so this is, where was the problem that 100 was the problem I think here. Sorry 1.8/18, which is 18? No is this formula correct. No what is the actual formula then. Why are you

messing up okay. No let me do it. Omega s is 0.622 P sat/ P. Then what will you okay. So I told you RH is equal to 100 P v/P sat no. Oh P sat is not P. That is where I made a mistake.

Okay. So what formula you use finally after all the simplification. Omega by, we already derived this right. So we should not mess it up okay. So omega is correct. Let this also be shown okay. So ya P v equal to so I know that it should be of the order of few hPa only that is why I immediately when you got 146 okay P v is fine. Then T v/T you know that no? T v/T equal to what is the relationship? Virtual temperature.

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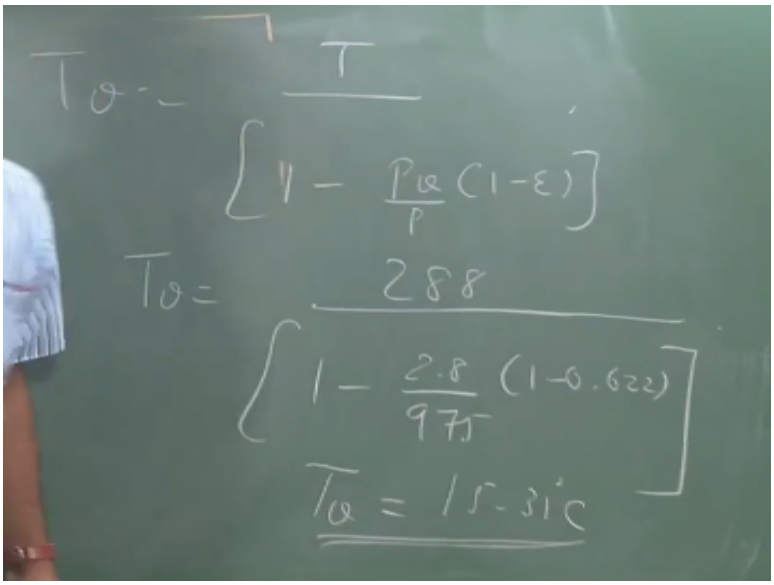

T v/T or T v = T by into 1 - epsilon. What was T, t temperature. P v/P was 15 point. So able to see that the difference between T v and T is very close. T v and T can be as apart as 4 or 5 degree C if it is extremely moist. Is a case of very little moisture 1.8 g/kg correct. What was your RH now 15%. So it is relatively dry okay. The last step in this problem is the LCL which I want to do. Subhash, please help me with the new chart or I will take the eraser.

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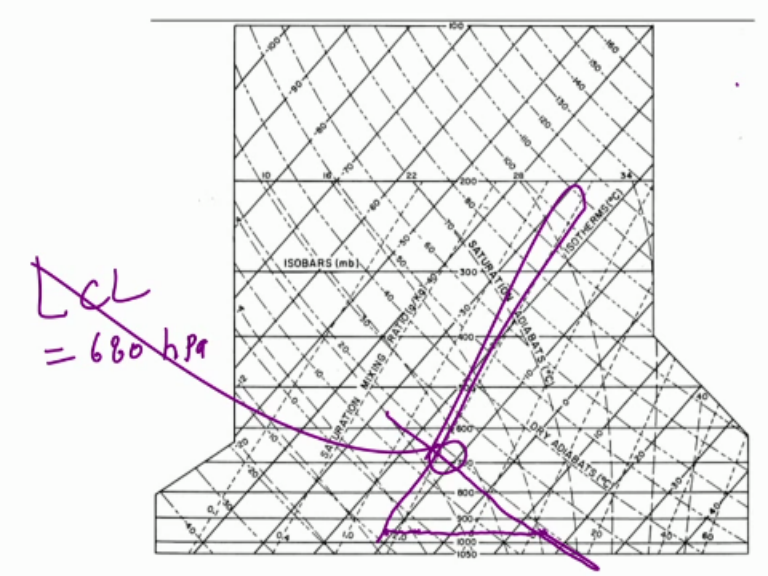

Just hang out for 3 minutes we will complete this. You got the LCL. Anyway whatever you do it will be 800, 850. In the next class what we will do is we took the Chennai data, on Tuesday's class we took the Chennai data. We will calculate the LCL for Chennai, yesterday evening 5:30. Then we will take the solution from the problem number 5 of the quiz. Assume a lapse rate of 6.5 K/km for Chennai and find out what would have been the height of a cloud base yesterday evening in Chennai. It is possible to do right, yes.

That we will do in the next class. Now you please tell me 15 degrees is here, 15 degrees and the pressure is 1000 or 975 is this okay, somewhere there okay. What is that escape? So 50 isotherms are solid lines? So I am getting somewhere here. Now, I have to go on a dry adiabat. And then from here we have to go horizontally till where till I reach that 1.8, here 1.8. I take the saturation mixing ratio. I am getting, I am getting around 700. How are you getting 880?

I am getting some 680. If it is very dry it can go further up man. If it is fully moist, if it is highly saturated it will if it is 90% it can reach 100% very fast. If it is only 15% it can go high up okay. So LCL. So we will clean this up in the next class. Thank you very much.