Lecture 25

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

NPTEL
NPTEL ONLINE CERTIFICATION COURSE

Refrigeration and Air-conditioning

Lecture-25
Psychrometric Processes – 2

with

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Hello, I welcome you all in this course on refrigeration and air conditioning today we will continue with psychometric processes today we will discuss mixing of Airstream summer air conditioning hot and humid outside.

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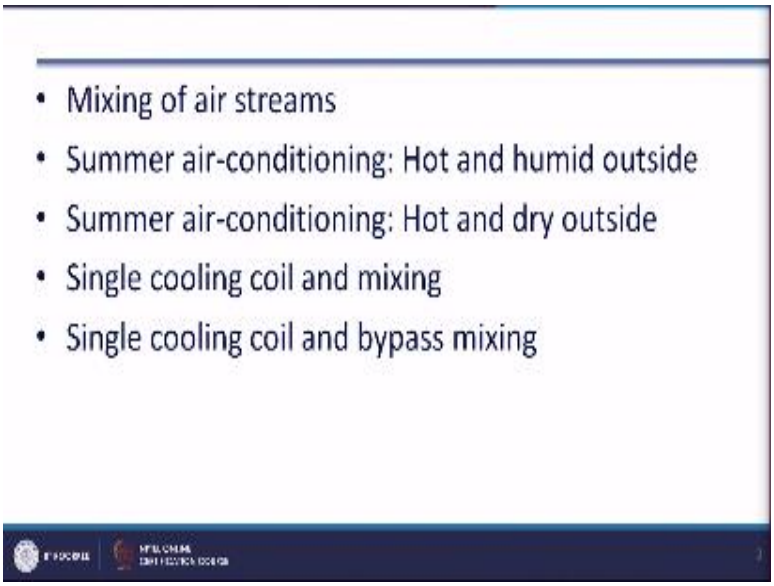

When the weather is hot and humid outside summer air conditioning when the weather is hot and dry outside single cooling coil and mixing single cooling coil and bypass mixing the mixing of return air with the fresh air this mixing is mixing of return air with the fresh air so first one is mixing of air stream if there are two air streams one and two.

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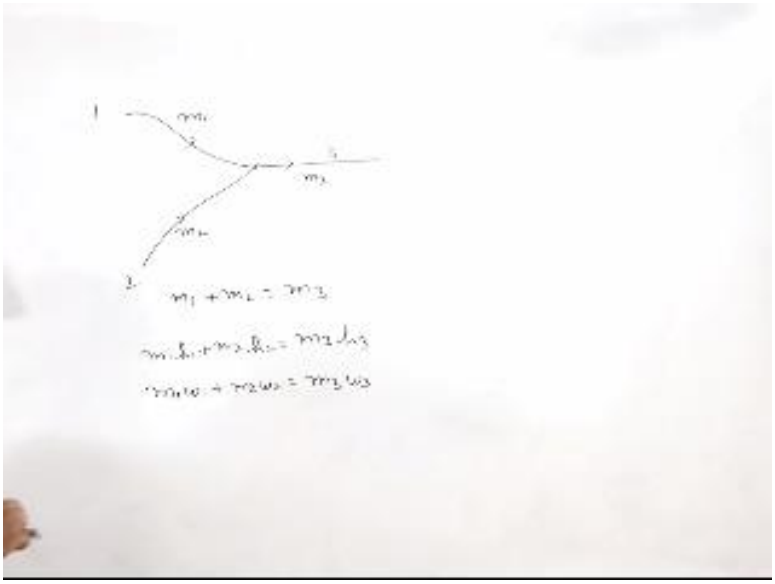

This is one air stream and that main stream air stream and they get mixed at one point and another stream is formed that is a stream three because we are doing this exercise because in air conditioning we will be frequently mixing the air return air with the fresh air or return layer with the air outside after the coil cooling coil so concepts of the mixing should be very clear in mind before we switch over to the real air conditioning processes.

So if there are two streams stream one and stream two and they get mixed and form stream three mass flow rate in stream one is M1 mass flow rate in the stream two is M2 and mass flow rate in stream three is M 3 now by law of conservation of mass we can always write M 1+ M2 = M3, this is an adiabatic mixing of two streams so there is no heat transfer M1+M2 when their enthalpies are added then M 1 H 1 + M2 H 2 = M3 H3, so enthalpy of stream 1 plus enthalpy of a stream 2 is equal to enthalpy of stream 3.

One more relation we can draw here that is W1 H1 sorry M1 W 1 +M 2 W 2 = M 3 W3 there are three relations which will be governing the mixing of two air streams, now W is a specific humidity or humidity ratio W1 W2 W3 is specific humidity of a stream one is specific humidity of a stream 2 and specific humidity of stream 3 now after mixing of a streams.

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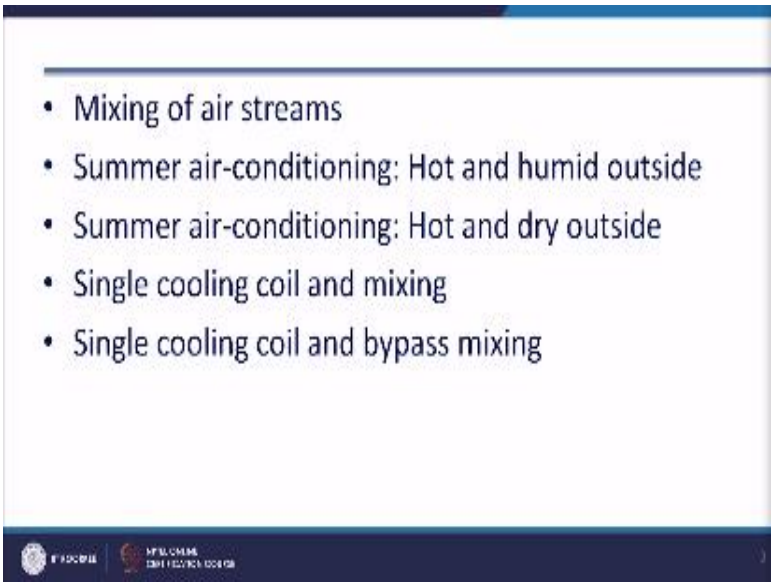

Now we can start with summer air conditioning hot and humid outside summer air conditioning summer air conditioning hot and humid hot and humid means you can take example of any coastal climate now for hot and humid climate we can take hot and humid climate as let us take some value for dry bulb temperature.

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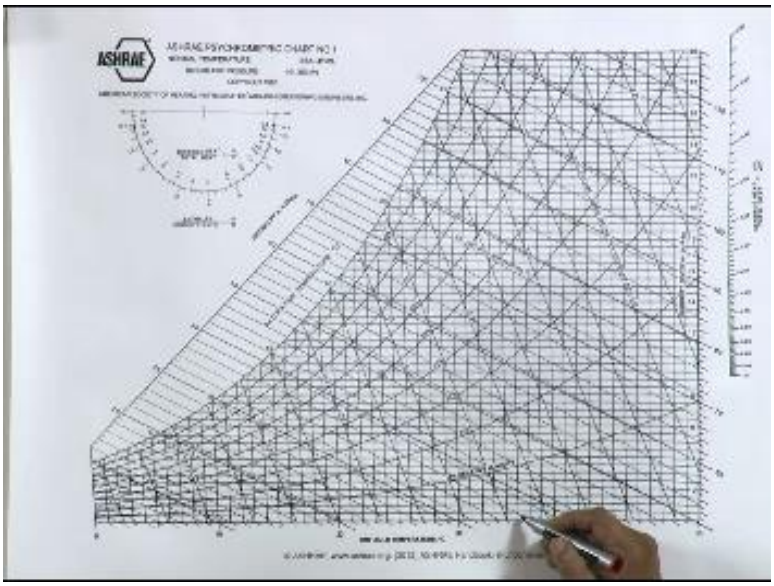

We can take 35^0 centigrade and humidity maybe 70% that is a typical coastal climate dry bulb temperature or outside temperature is 35^0 centigrade and relative humidity is 70%, now inside condition we will maintain this one 24^0 centigrade temperature and 50% relative humidity 24^0centigrade dry bulb temperature and 50% relative humidity, now we have term from this point 1 to this point 2 we cannot directly come from this point to this point we have to follow certain psychometric processes.

So here as I discussed earlier also that for such type of situation cooling with dedication is done so cooling with dehumidification so through cooling and dehumidification we can follow this line and then we can come here and after this at appropriate point the heating can be done and we will be getting this point, so for this type of arrangement we should have a duct having dampers.

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Filter then a cooling coil a cooling coil air is blown over the cooling coil and after the cooling coil there is a heater and after the heater the air is sent to the room so after the heater air is send to the room direction of flow is this enough from the room it will go to the surroundings so the process one the state one will be at the entry of the cooling coil this is a state one then state this is state two this is let us say state three this is state three this is state three we will get at the entry of heating coil this is a heating coil.

And after the heating coil the air will enter the room so this is the room supply condition these coils to have some bypass factor so if we take into the consideration by pulse factor in that case suppose rooms of here we are getting supply temperature approximately13^0 centigrade since this coil has bypass factor so coil temperature is 30^0 centigrade bypass factor is 0 we will be getting air at this point at 13^0 centigrade since every coil has certain by a pass factor suppose this coil has a bypass vector of 0.1 or 0.1or 0.15 any value in that case for the purpose of cooling this temperature of cooling coil shall be less than 13^0 centigrade.

So the cooling coil temperature has to be maintained somewhere below this depending upon depending upon the bypass factor higher the bypass factor lower is going to be this temperature suppose.

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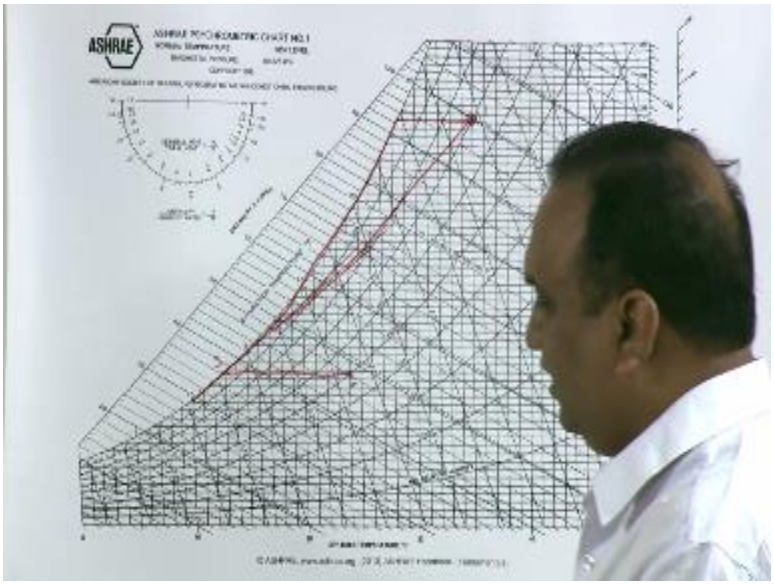

We find that the cooling coil temperature has to be10^0 centigrade then this humidification will continue up to 10^0 centigrade and we can draw this we can join these two points we can join these two points and through a straight line we can join these two points to a straight line and this is the process and we will be getting certain value of temperature which is higher than 13^0 centigrade if I defect the process here this I think on the board it will be clearer to you this is a psychometric chart.

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And this is cooling and dehumidification process. But this process has certain bypass factor so instead of cooling up to here it will get cooled up to here and from here air will be heated up to the room temperature right so this air which is getting heated in the heater in ideal case it was a saturated vapor but here it is not a saturated vapor it is vapor slightly higher than temperature 13^0 centigrade right.

Similarly we can consider bypass factor for heater also, so heater has to be not only at 24^0 centigrade maybe 26^0 centigrade in order to accommodate the bypass factor so this is the air conditioning process for summer where dehumidification and heating is required, now another type of climate is the climate where the weather is hot and dry weather is hot and dry outside before I start this the hot and dry weather we should understand that what will happen if I mix two streams.

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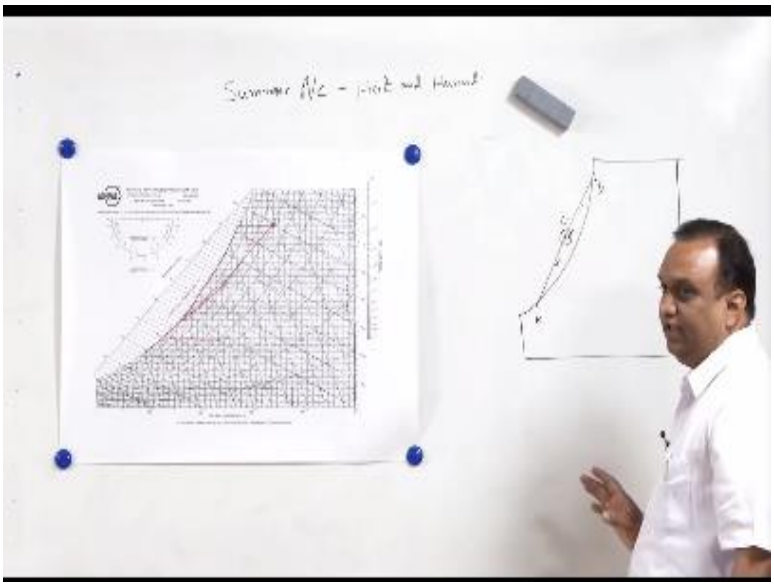

Suppose one situation is this which is very humid hot and humid air and there this is very cold and humid air if I mix these two streams if I mix these free streams stream a and stream B let us say in 5050 I will be somewhere here, now what will be the situation of air in this position C in the position C or state C if form will be formed a form will be formed and the air will become foggy so such type of situation may also arise we are highly humid very cold air and highly humid hot air mixing is there in that case we can get the state of fog as well.

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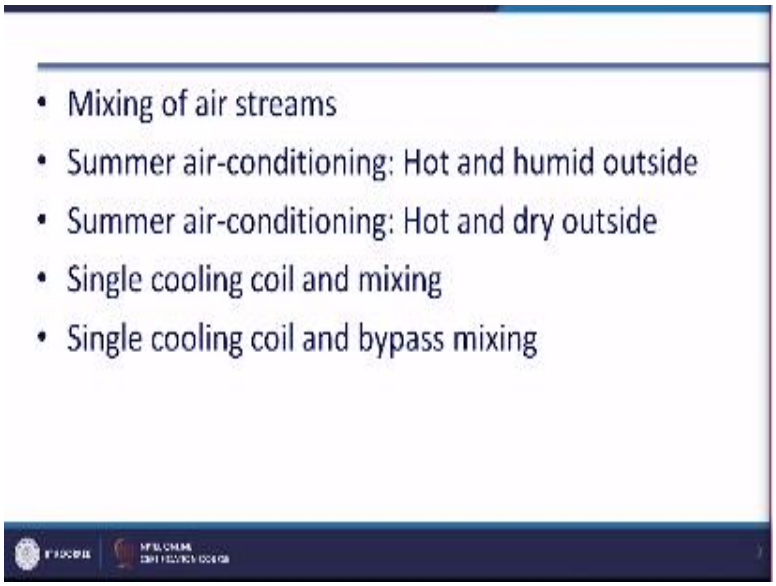

Now coming back to summer air conditioning when the weather is hot and dry outside now hot and dry weather let us assume outside temperature is 40^0 centigrade and relative humidity is relative humidity is 10% this is 10% relative humidity line and outside temperature is 40^0 ^{c}entigrade so it is a typical desert weather DBT is 40^0 centigrade and relating humidity is 10 % or 15% or 20 %we can take any value I mean this is a typical of hot and dry weather hot and dry outside.

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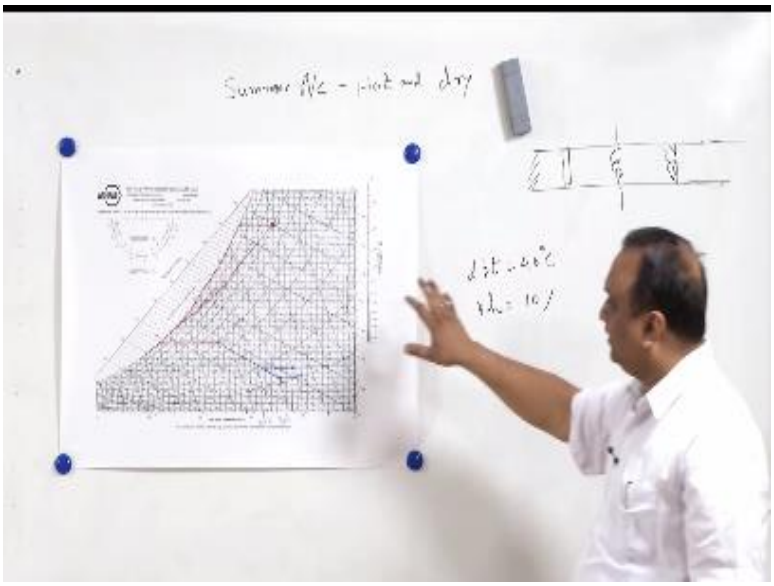

Now in this situation best way is in hot and dry weather is whenever there is a low humidity we can always make use of evaporative cooling process because your pretty cooling Cross process is low-cost process and can be easily attained evaporative cooling means we will have to follow the wet bulb temperature line but here in this case if you follow the wet bulb temperature line will not be coming to this state in this situation either at 24^0 centigrade the relative humidity around 60% or if you want to maintain the relative humidity then the air will be on slight slightly higher temperature of 26%centigrade.

Either here or here if you are maintaining humidity 50 % then temperature will be higher if you are maintaining human temperature as 24^0 centigrade in that case humidity will be higher so in order to avoid this situation sensible cooling is done the sensible cooling or of air is done from let us say from state 1 to state 2 and after sensible cooling when we are on the wet bulb temperature line passing through this point evaporative cooling can be done and we can attain this state right.

Suppose the relative humidity of outside temperature is 45^0 centigrade relating humidity is 10 so if the outside temperature is 45 relative humidity is 10 you are somewhere here, so now if you do

the evaporative cooling right from this point the humidity will be 70% too high or more than 70%75% at 24^0 centigrade that may not be acceptable or if I want to maintain the humidity in that case the dry bulb temperature will be around 29^0 centigrade temperature shall not provide the required comfort.

So in this case also sensible cooling shall be done up to this point this is let us say 0.3 and this is 0.4 sensible cooling will be done up to this point the up to this temperature 32.5^0 centigrade here the sensible cooling was done 36^0 centigrade and then evaporative cooling shall be done and arrangement for this type of climate will be first of all some dampers will be provided right then filters after that cooling coil and for vibrating coolly an air washer shall be provided.

Air washer shall spray the water in air and due to evaporation of water this cooling will take place now here also we can consider the bypass factor similar in a similar fashion as we considered in the case of hot and humid environment, now after this we will take up single cooling coil and mixing process now mixing is often done in air conditioning systems because why mixing is done mixing is done in order to save energy.

Now fresh air is taken from outside part of the fresh to get air is taken from outside temperature of the fresh air is 42^0 centigrade the air which is leaving the room is at let us say 27^0 centigrade so now cooling 27^0 centigrade air will is much easier or I mean much is less expensive than the cooling air at 42^0 centigrade. So here mixing of a stream comes into the picture outside air is at 42 degree centigrade air which is leaving the room, let us say t_x is 27^0 centigrade.

So if I want to cool this air definitely I will be saving a lot of energy cooling from 42 to the required temperature and cooling from 27 to required temperature, but I cannot use this air 100% because, if I make 100% recirculation the quality of air will reduce, oxygen content of air will reduce, carbon dioxide content will increase and it is not advisable, so part of this air is mixed with this let us say 50: 50, 50% of this, 50 % of this so, the average temperature will be if I take 50:50 mixing then 27/ 2 that is 69/2 approximately 34.5.

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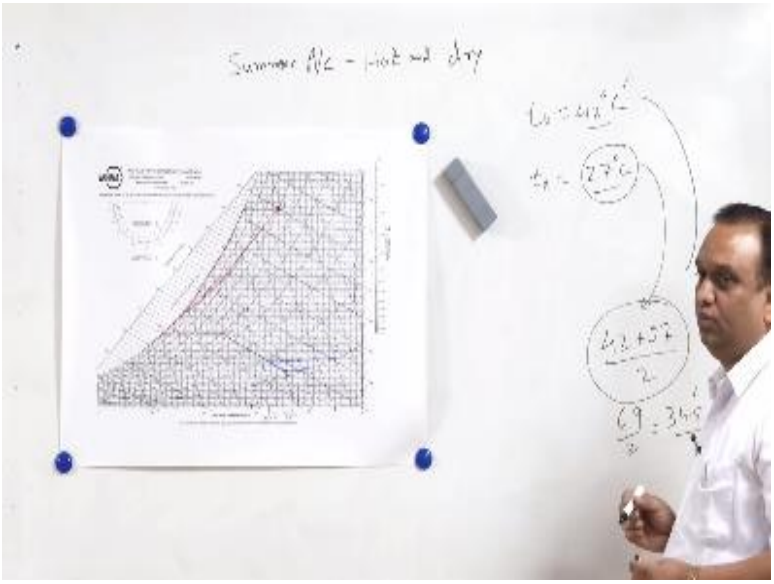

So air entering the coil will not be at 42^0 centigrade it will be 34.5 and it shall be meeting the requirement of oxygen and diluted pollutants. So this mixing is done basically in order to reduce the load on the plant, now we will take the mixing cases one by one, now the first mixing case is single coiling coil and mixing, now in this case there is a cooling coil which pulls the air and this air that goes to the room there is a room and after cooling in the room after leaving the room let us say, this is which is going into the room this is outside air state one from state1 it is entering the coil leaving the coil at state 2 then entering the room at state 2 and leaving the room at let us say state 3, at state 3 part of the air leaving the room is mixed with 1 and we get state 4.

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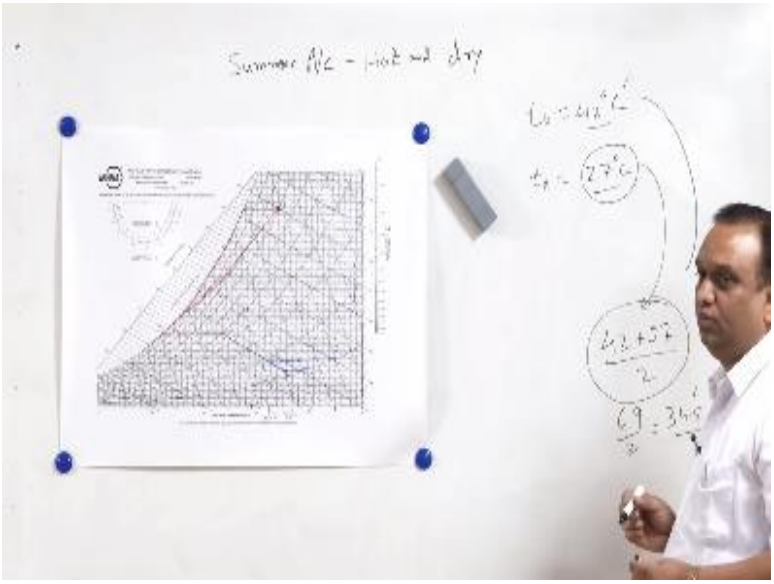

And now this is state for the actual diagram is this mixture of state 3 and state 1 is entering the coil, getting cooled there then it is going to the room and the part of the air is vented outside and part of the air is again goes go for recirculation. Now if I want to depict this process on psychometric diagram now here suppose at 35^0 centigrade and let us take some example, 35^0 centigrade and 70 % relative humidity, some coastal climate right and this air is fixed with the return air which is at let us say, 26^0 centigrade and 60 % relative humidity.

So this is state 1 outside air and this is state 3 air which is leaving the room, now these two streams air streams they are mixed if it is 50:50 the mixture will be at the exactly at the middle of this line I am just taking the approximate position and that is going to be state 4 in this type of mixing, the mixing is done because geometrically we have to do it or mathematically also we can do. Geometrically suppose there is a PH diagram there is a mixing from 1 to 3 this is 50:50 so M1 / M 3 is equal to suppose this is A and this is B.

So M1/M 3 is going to be A/B in reciprocal M 1 / M 3 is going to be A/B the length of this divided by length of this or we can take in terms of dry bulb temperature also, difference in dry

bulb temperature also so, difference in temperature between this point and this point is a difference in driver temperature between this point and this point here.

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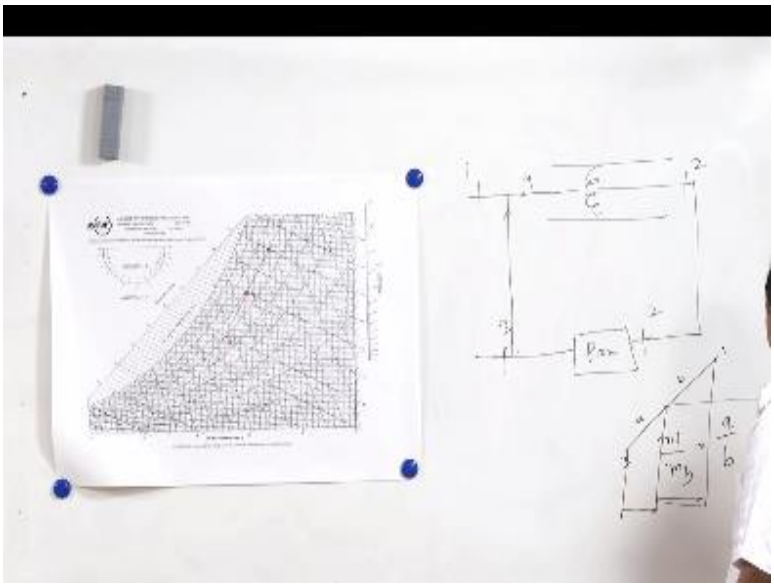

We can take projection on y-axis also where the specific humidity is there then again the difference in the specific humidity's, difference in the specific humidity's can also be considered in order to find the ratio. So once a ratio is with us we can easily locate the 0.4 either with the help of temperature or with the help of a specific humidity or simply by taking the geometrical value through this reciprocal equation. Now state 4 is attained, now after in state 4 it passes to the room rest of the process remain same coil temperature let us say it is 40.

So it will come here and then coil temperature it will be so this is the next process cooling and dehumidification, cooling and dehumidification if bypass factor is there then instead of sorry you want to so, the coil temperature has to be higher than this so suppose the coil temperature is 10 degree centigrade because, if it if I take called temperature 15^0 centigrade I will not be able to attain this position or this supply condition this room condition so, the temperature of the coil is less than this approximately 10degree centigrade, it has some bypass factor also so instead of

being supplying a 10^0 centigrade air maybe supplied at let us say here at 13.5^0 centigrade and then heating can be done and we will get the desired state.

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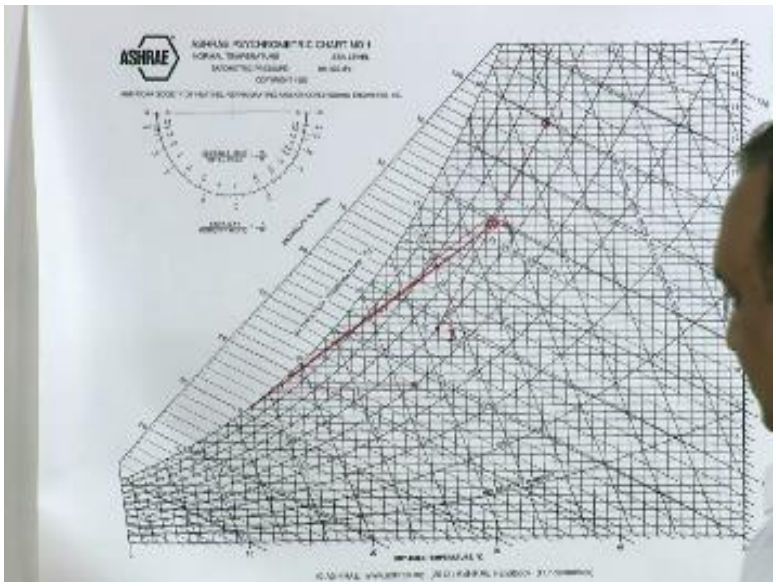

So here I have missed the heater, so one heater is also her, one heater is also here because cooling and then heating, cooling and then heating and that is how we are getting the state of the supply air, now the last one is single cooling coil and bypass mixing now, here in this arrangement after the cooling coil, after the cooling coil mixing of this air can also take place after the cooling coil mixing of this air can also take place.

so part of this air now there are three laces, mixing is taking place at 3 places 1 & 3this is also 3 this is also 3, 1 and 3 here and 3 and after cooling in the cooling coil mixing is taking place. So for such a situation this is the return air it is very simple to locate this is our return air this is our supply air, so now mixing is taking place after the cooling coil between this point and this point and we will get finally this point maybe 0.4 at point for the vapor will be or sorry the air will be entering the room.

In actual practice the temperature of supply air is not 24 degree centigrade for the sake of understanding only I have taken temperature 24^0 centigrade. Normally temperature supply, temperature of the supply air ranges between 13 to 17 degree centigrade, it is known as grill temperature. So suppose in this room I want to maintain certain temperature of 24^0 centigrade room will have some sensible load and latent load and temperature may be let us say, 17 degree centigrade so this or 15^0 centigrade we can take 15 degree centigrade supply temperature.

And then return air temperature may be at 25^0 centigrade and 50, 50% relative humidity and this is the load line, the load line will discuss later on. This is room load line and this room load line we will discuss later on I have assumed supply temperature 24^0 centigrade for the sake of convenience and, for the sake of convenience of understanding these processes, likewise we can have number of combination of the processes in order to attain the desired state of air in the room.

But we must understand that whatever process we adopt it should be energy efficient, which we can come from this point to this point we can come by other methods also but those methods will be energy consuming and therefore this is the most convenient way of attaining this state, this is all for this lecture and in the next lecture we will continue with the psychometric processes.

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