Fundamentals of Electrical Engineering
Prof. Debapriya Das
Department of Electrical Engineering
Indian Institute of Technology, Kharagpur

Lecture - 33
First order circuits (Contd.)

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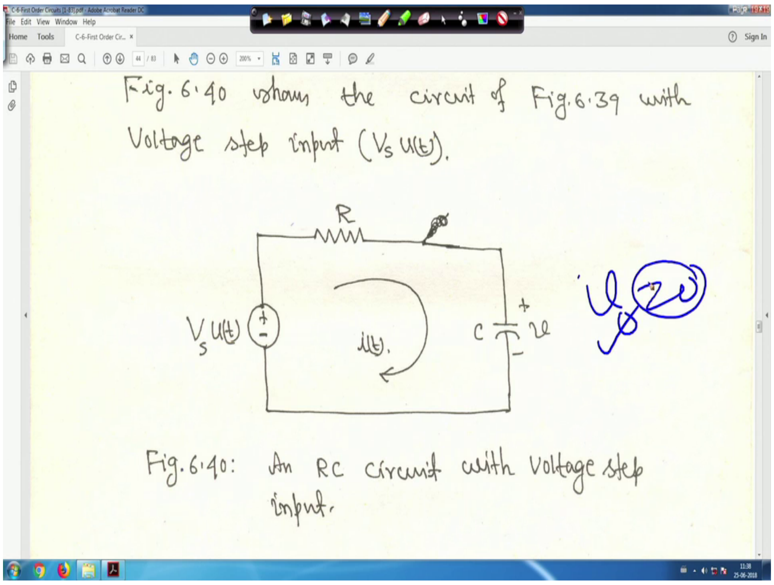

So, now this capacitor actually initially assumed, it was charged say some voltage say v 0 not necessarily that it will be charged all the time v 0 can be 0 also. But, we assume that this capacitor initially was charge at v 0. Just to get generalized expression right. So, what you can do this right.

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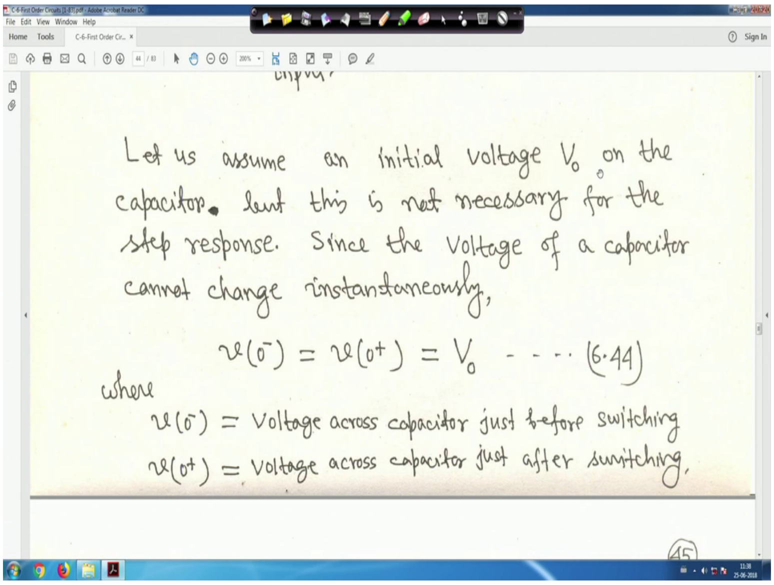

So, let us assume when initial voltage V 0 on the capacitor, but this is not necessary for the step response right. Since, the voltage of a capacitor cannot charge your change instantaneously that is v 0 minus is equal to v 0. What I want to mean for this circuit right for this circuit, that when switch was not close, it was open initially, suppose capacitor was this capacitor was charged at voltage v 0 right.

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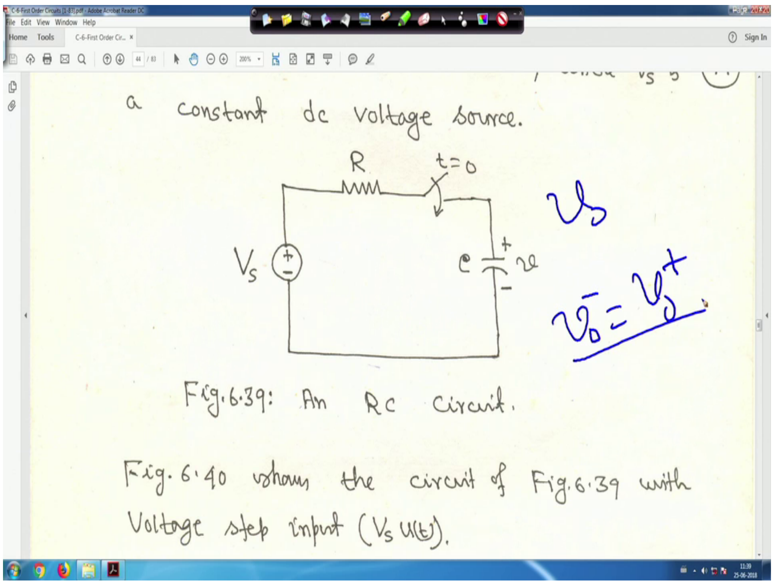

Suppose, this voltage if I write say it is say your v 0 just I making it say v, v 0 minus. So as soon as the switch is close that your what you call capacitor voltage cannot change instantaneously that means, it will be actually v 0 plus. Just before switching and just after switching, it cannot change instantaneously; earlier also we have discussed this. So, v 0 minus will be v 0 plus; this will just before switching, and just after switching right. So, let me clear this, because, sorry just hold on.

So, now let us come to the circuit. So, it is given v 0 minus is equal to v 0 plus, this way I have written is equal to v 0. Just your before switching and after switching that I can if voltage capacitor voltage cannot change instantaneously, so this is equation 44, where v 0 minus voltage across capacitor just before switching, and v 0 plus voltage across capacitor just after switching right.

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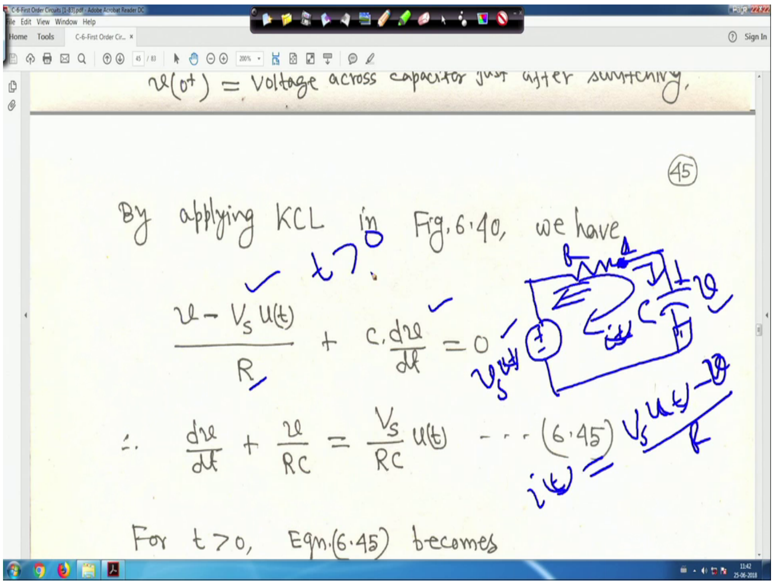

Now, applying KVL, I told you it is v minus your what you call V s u t upon R plus c dv by dt, this already I have told you. And for t greater than 0, this U t is 1. So, it will be basically v minus V s upon R plus c dv by dt are is equal to 0. Actually, it was circuit was like this know I am drawing it here. This is your v s; your U t right; this is V s u t, this was your R right; and this side it was the capacitor, and plus minus this voltage was v right. So, some point if you current direction was taken like this, this i t was taken like this right, i t was taken like this, and i t is equal to we wrote know, i t is equal to that is your i R plus v minus v that is your V s u t minus V divided by R minus this V divided by R. This is in this direction clockwise.

Now, if you take at any point here say this point is a, now if I take one current is going like this just, you think like this. And one current i c is going like this, although i c is equal to minus thing. So, this point if you apply your what you call that your KCL, then this as direction is changed, so it will be v minus V s u t. So, v minus V s u t by R divided by R plus your c this capacitor c c into dv by dt is equal to 0 right. Now, for when this as soon as the switch is closed, for t greater than 0 that u t is equal to 1 that is why this u t you put here it is written. But, after that this V s u t V s u t it is written like this right, but u t is equal to your 1 we will come to that.

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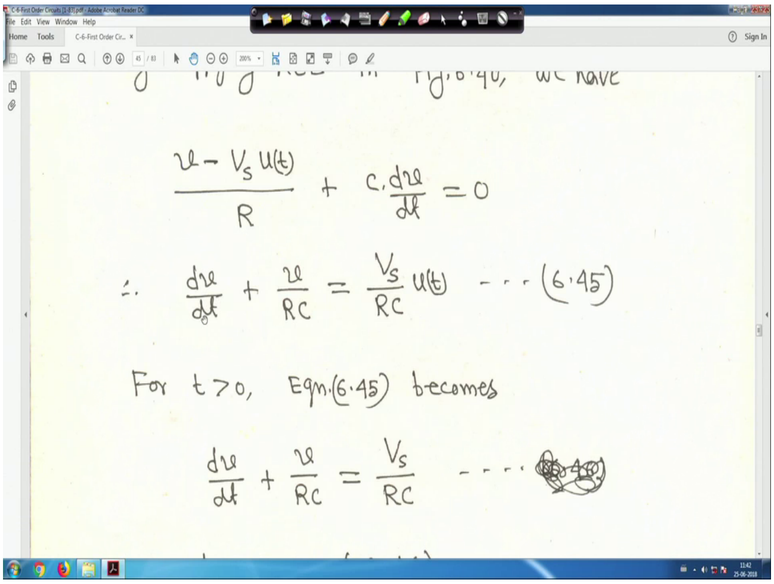

So, this is actually this one if you simplify, it is dv by dt plus v upon R c is equal to V s upon R C u t. Now, for t greater than 0 that means at that time u t is equal to 1 for unit function we have seen. For t less than 0, u t is 0; for t greater than 0, U t is equal to 1 so that is why in the in the derivation now u t is not there. Because, it is we are trying to obtain the response for t greater than 0, little bit understanding is required. For t greater than 0 your objective is to find out the response for t greater than 0.

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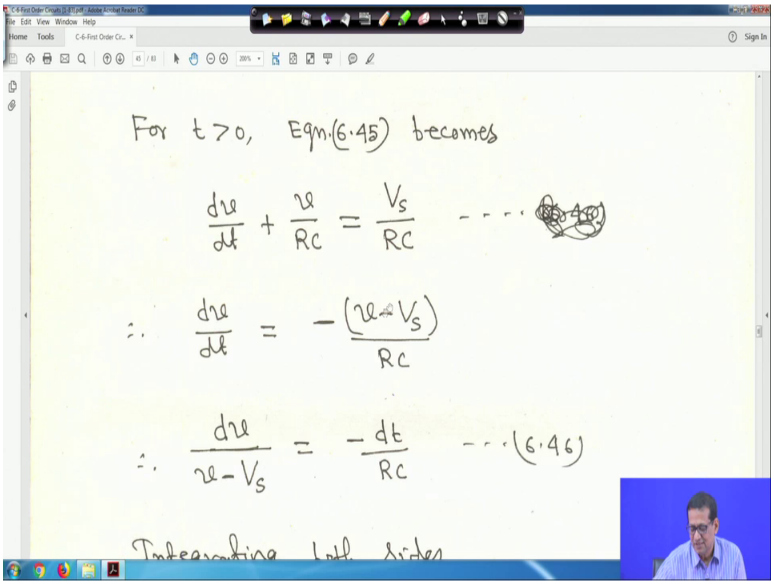

So, this equation 45 becomes, so u t is 1. So, it is dv by dt plus v upon R C is equal to V s upon R C or dv by dt upon simplification, v your what you call minus v minus V s upon R C or d v upon v minus V s is equal to minus dt upon R C, this is equation 46.

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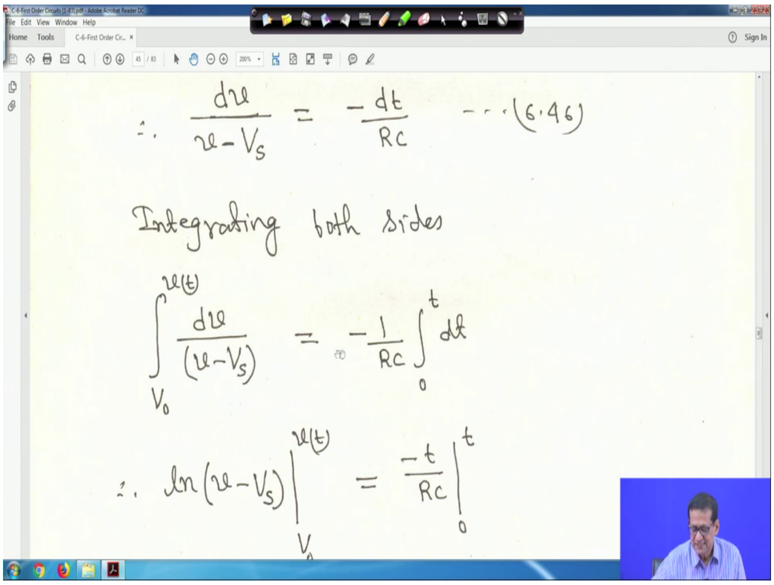

Now, you integrate both side. So, initially capacitor voltage across initial voltage across the capacitor was v 0; and at time t, it is v t. So, you are making v 0 to v t dv upon v minus V s is equal to minus 1 upon R C that integration 0 to t dt right. So, if you integrate this with natural log ln v minus V s limit your integration limit is v 0 to v t is equal to minus t upon R C here also 0 to t.

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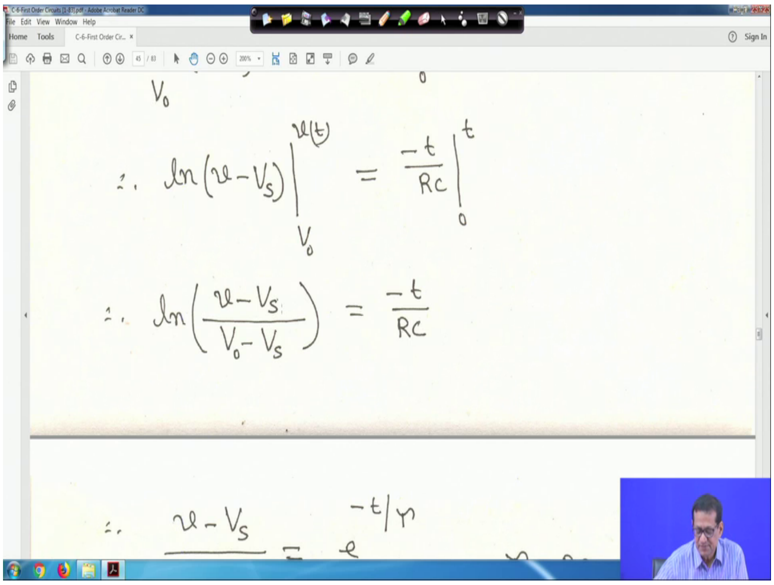

So, this is equal to l n v minus V s upon V 0 minus V s is equal to minus t upon R C that means v 0 minus, so it is natural log means log of base e right. So, it is v minus V s upon V 0 minus V s is equal to e to the power minus t upon tau; tau is equal to R C the time constant of R C circuit, this is R C. This is equation 47 right.

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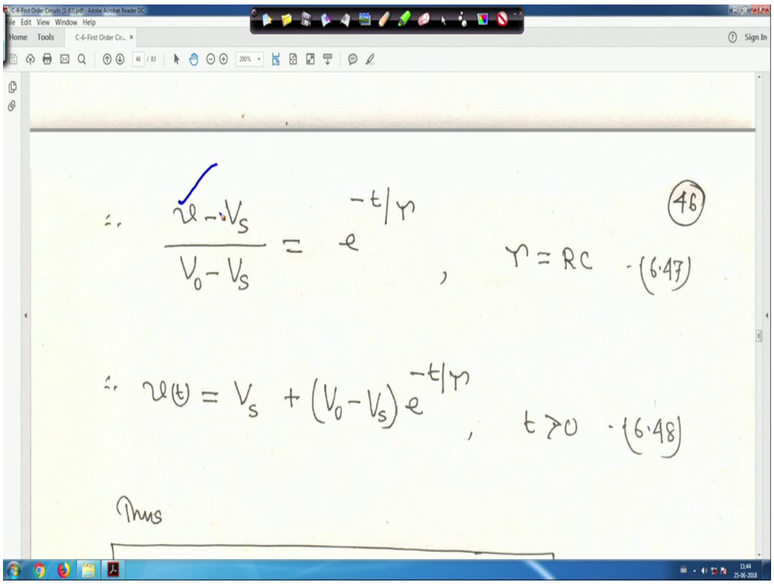

So, or v t I mean upon simplification just cross multiply and simplify, you will get v t is equal to actually what we what I am doing is this the up to this it is written your, what you call all the time not putting your, what you call v t, v t, v t right. But, now this v is replaced by, it is understandable to you, it is function of time it is understandable to you. So, that it is v t is equal to V s plus v 0 minus V s e to the power minus t up by tau. This is for t greater every time you have to write we are writing this for t greater than 0 right.

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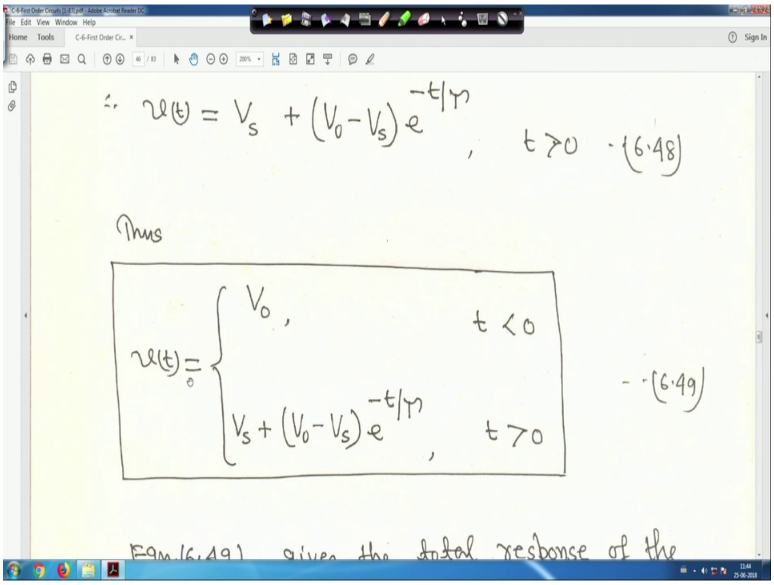

Therefore, you can write because v t is equal to v 0, initially capacitor was charged at voltage v 0 that is for t less than 0 that means complete response of voltage, you can write v t is equal to V 0 for t less than 0 right. And, v t is equal to this expression V s plus V 0 minus V s e to the power minus t by tau, this is for t greater than 0. This is we call the complete response much more we will see very soon right.

So, this is your what you call this way you can write, so for that this is called the complete response, that is in general minus infinity to your what you call that t greater than 0 means plus infinity. But, you know that say for earlier we have seen that up to 5 tau time constant, basically that responses or the I could say that dynamic circuit responses, it reaches to the steady state right for t is equal to say 5 tau. Because, it becoming this your what you call it is becoming your what you call less than 1 percent of the peak value right.

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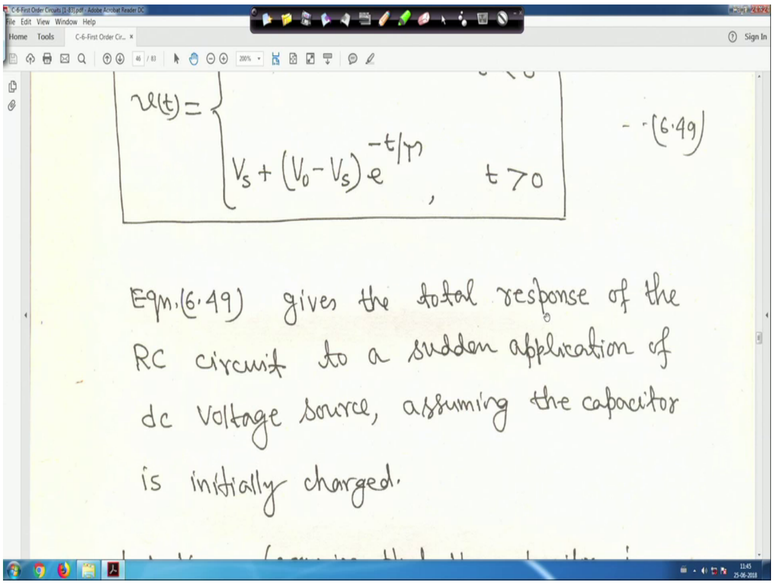

So, 49 gives the total response of the R C circuit to a sudden application of dc voltage source, that is R C circuit we apply assuming the capacitor is initially charged right. Now, if it is assuming that initially uncharged, that means V 0 is equal to 0.

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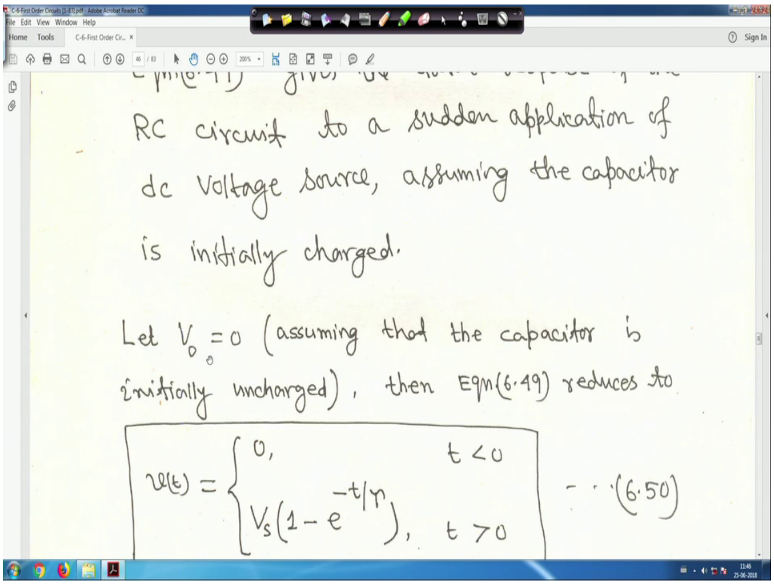

So, if V 0 is equal to 0 in this expression, if V 0 is equal to we put it, in that case v t will be is equal to 0, for t less than 0. And here also if you put V s is equal to your what you call V 0 is equal to 0, it will V s into 1 minus in bracket 1 minus e to the power minus t by tau.

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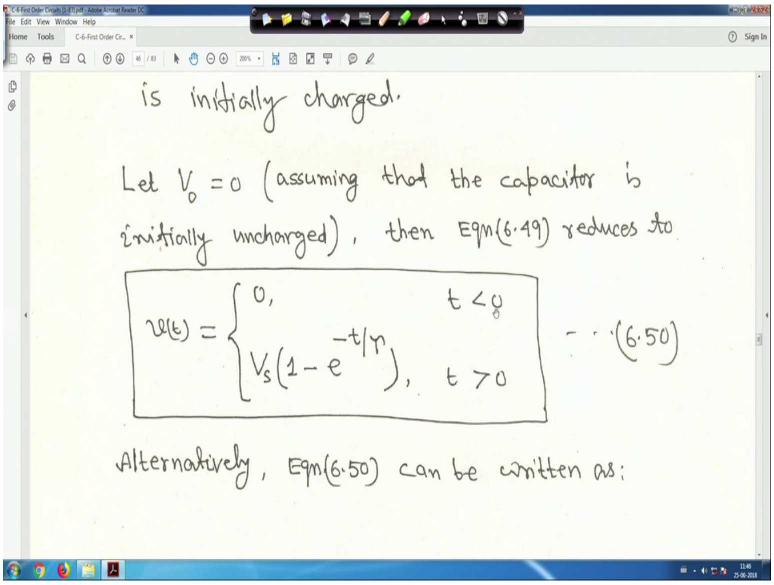

So, here it is it is 0 for t less than 0, and it is V s 1 minus e to the power minus t by tau for t greater than 0, this is equation 50 right. So, that means alternatingly this equation you can write this, this equation other way that it is v t is equal to V s 1 minus e to the power minus t into u t. Because, u t written for u t you know for t less than 0, u t is equal to 1.

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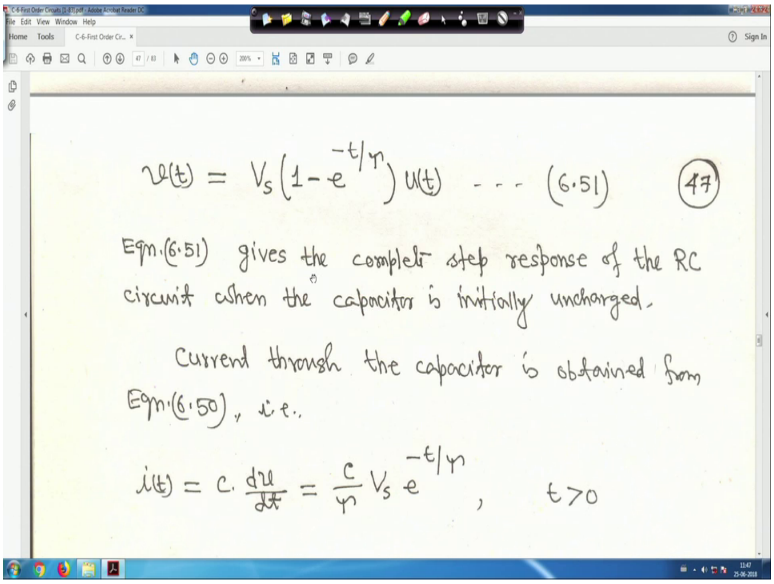

So, if you when t sorry u t is equal to 0, for t less than 0. So, when t less than 0, u t is equal to 0, then v t will be 0, so it is 0. And for t greater than 0, u t is 1; so when u t is equal to 1, it will be V s 1 minus e to the power minus t by tau. So, combining these two, we can write v t is equal to V s 1 minus e to the power minus t by tau into U t, this is equation 51. Hope this is understandable to you right, not very simple thing. So, this figure this equation 51 is that gives the complete response of the R C circuit, when the capacitor is initially uncharged right. So, current through the capacitor is obtained from equation 50, that is nothing but i t is equal to C into dv by dt. So, you take the derivative of your what you call your for t greater than 0, you take the derivative of this equation that dv t by dt for this 1 for t greater than 0.

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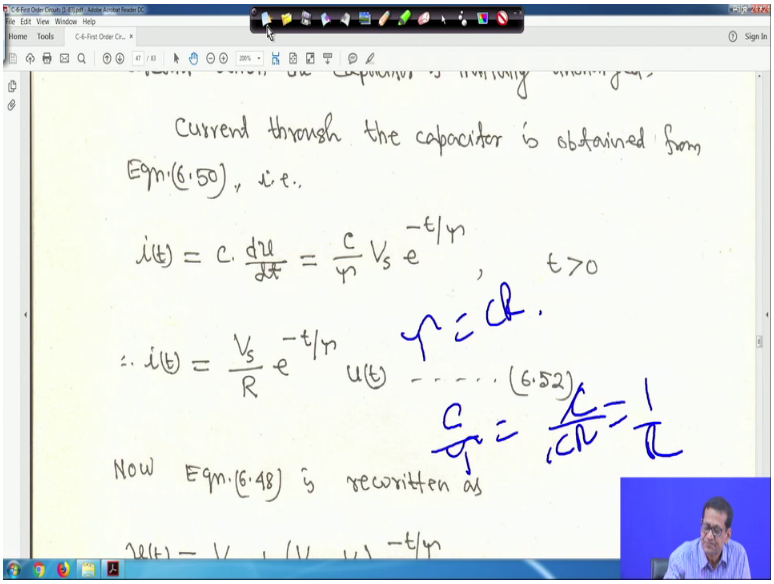

So, when you do so, i t is equal to c dv by dt that is here you have to write t greater than 0 right, that is c by tau then V s e to the power minus t by tau, you take the derivative of this equation right. So, it will be your basically and your this is c by tau V s e to the power minus t by tau. And tau is equal to R C right, so here tau is equal to say C R.

So, if you put tau is equal to C R, so C by tau is equal to C by C R; C, C cancel, it will be 1 upon R that is why V s upon R e to the power minus t by tau right. So, and if you and in generally if you want, then i t is equal to V s upon R e to the power U t again right. Here, here it is u t same philosophy same philosophy for t less than 0 u t is equal to 0, and for because circuit was open, so i was 0. And for t greater than 0, u t is equal to 1, so that is why again it is u t is multiplied right, because at that time t less than 0 the switch was open right.

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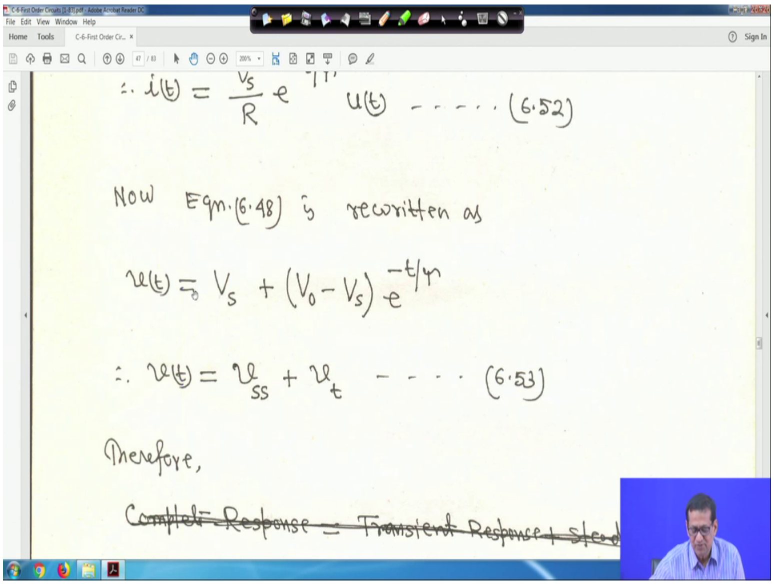

So, now equation 48 is rewritten as, we have again this equation 40 if this one v t is equal to V s plus V 0 minus V s e to the power minus t by tau, that means v t is equal to can be written as v ss plus v t that is your steady state response plus transient response. So, therefore, complete response the v t is the complete response is equal to steady state response plus transient response v ss plus v t right. This is your what you call v s is the steady state response and this is transient response.

Because, when t tends to infinity, if you look into that, when t tends to infinity, the circuit reaches to steady state. If you come to the circuit from the circuit only, because this we have to use again and again for solving your numericals. And we have to if you come to this circuit right, so our capacitor when this switch is closed for long time for do dc, because this switch is closed for long time, the capacitor act as your what you call open circuit right.

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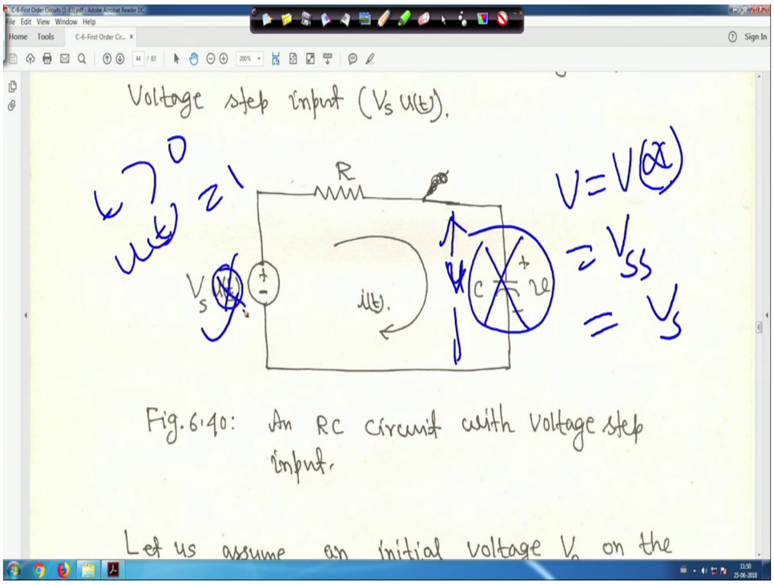

So, this is not required at that time no need to do that, because u t at that time u t is equal to 1 for t greater than 0. And if it is and that means, this is only V s this is not required suppose V s. And capacitor is open, then what is the voltage across this what is the voltage across capacitor is open. So, basically v is equal to your what you call in that steady state voltage in v infinity, sometimes, we call V ss steady state right is equal to actually V s this source voltage right. So, this is from your intuition, you can find out, because, to dc when switch is closed for long time, the capacitor act as a open circuit. So, this is actually just I am making it like this, and v will be is equal to V s. And at that time circuit representation is like this, so U t is equal to 1 right, so anyway.

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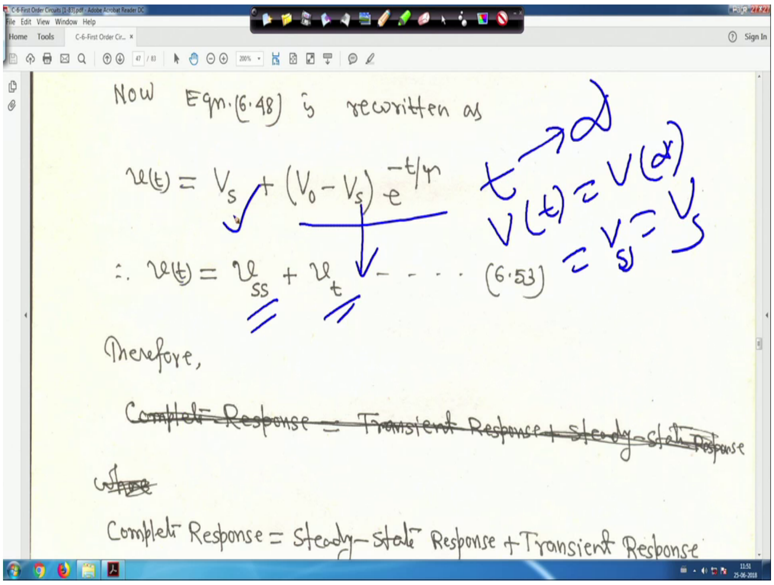

So, again we will come back to this. So, this complete response is here also here also if t tends to infinity, here also if you make in this expression t tends to infinity, the second term will vanish. And it will be your I mean, if you if you move like this, just hold on. If you if t tends to infinity that means this term will vanish; that means, at that time V t will be V infinity that is your steady state value that is your V ss will become your V s this value right. So, that is your steady state value that is this is that means this is your steady state value V s and this part is a transient part and this part is a steady state part. Let me clear it right.

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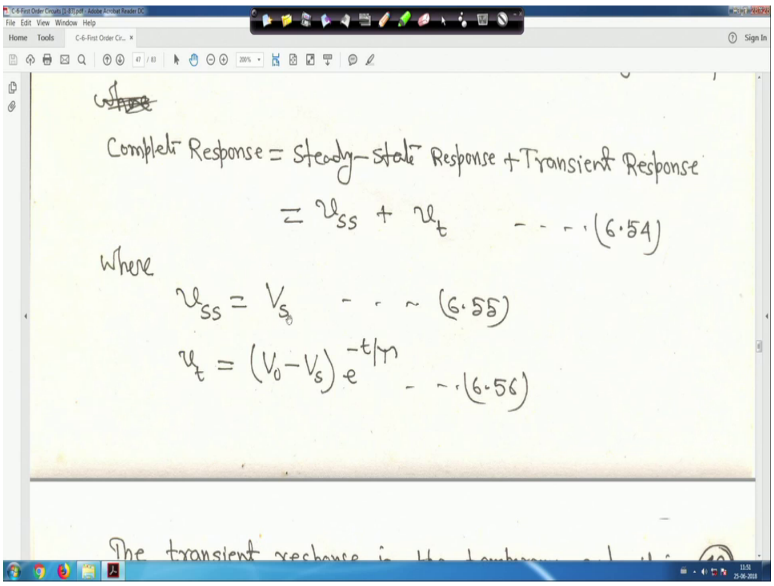

So, that is why V ss is equal to V s. And this is transient part, this equation 55; this is equation 56 right.

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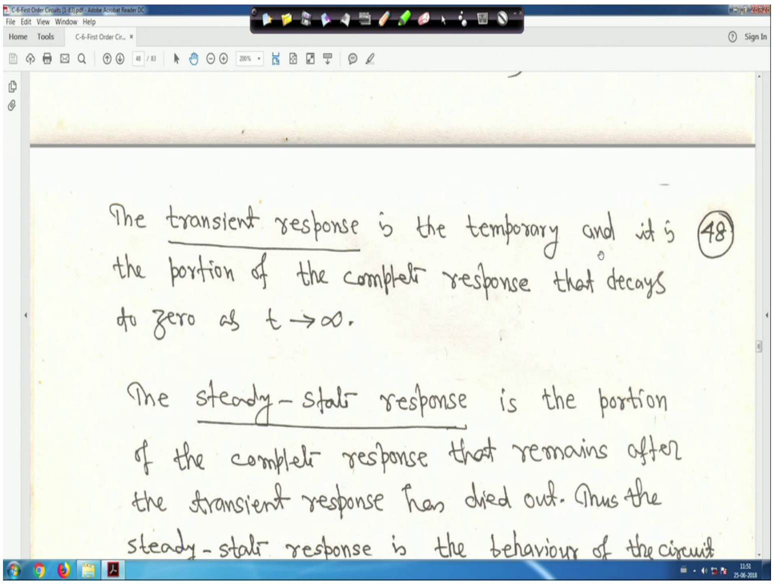

So, transient response is the temporary and it is the portion of the complete response that is your that your, what you call that decays to 0 as t tends to infinity. Because, when t tends to infinity your I told you, when t tends to infinity, this part term will vanish right, so that means transient will vanish only left out portion will be that is steady state.

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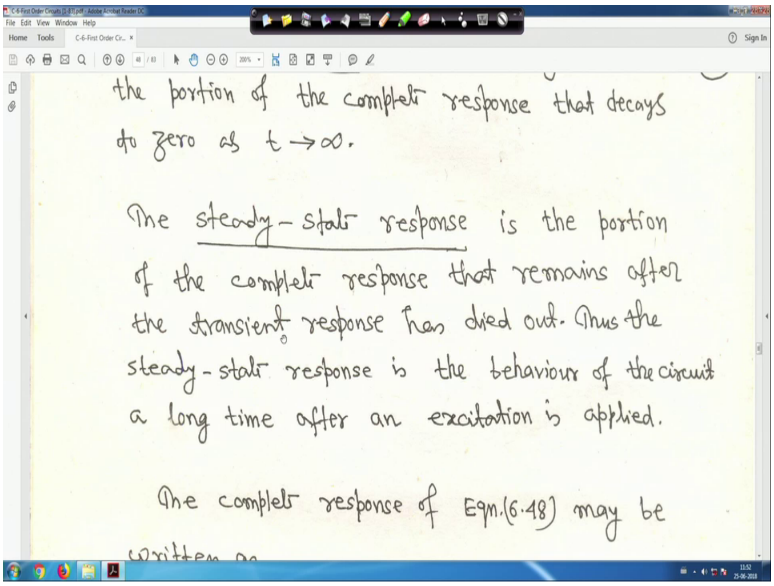

So, that require therefore and it is the portion of the complete response that decays to 0 at t tends to infinity. The steady state response is the portion of the complete response that remains after the transient response has died out, I mean transient is over right. Thus, the steady state steady state response is the behavior of the circuit a long time after an excitation is applied, that means you that your voltage source suppose it is switched on, and your steady state will achieved after long time right. So, the complete response of equation 48 may be written as, this can be written as something like this. if you come to this one, if you come to this response this one, I mean this one look this one, it is this is the thing you are obtaining at infinity and this is your initial value.

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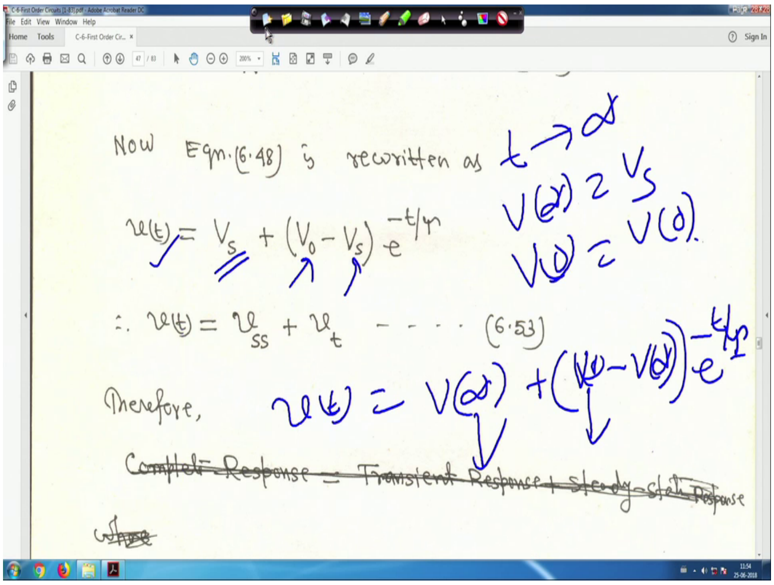

And this is again your at this V s actually your, at t tends to infinity at t tends to infinity, your V infinity is equal to V s right, that is steady state value. And initial value V 0 was is equal to I can make it V 0 right that means, this equation v t, I can write like this V s is equal to steady state value, that is V infinity plus I can make V 0 minus V infinity right, then your then your this one e to the power minus t by tau. That means, v t will be V infinity plus v 0 minus v infinity e to the power minus t by tau. That means if you know, the initial value, if you know the final value, the steady state values, and if you know the time constant, easily you can compute v t right, this you have to keep it in your mind for solving numerical. And for the for the exam also, you have to keep it in your mind right.

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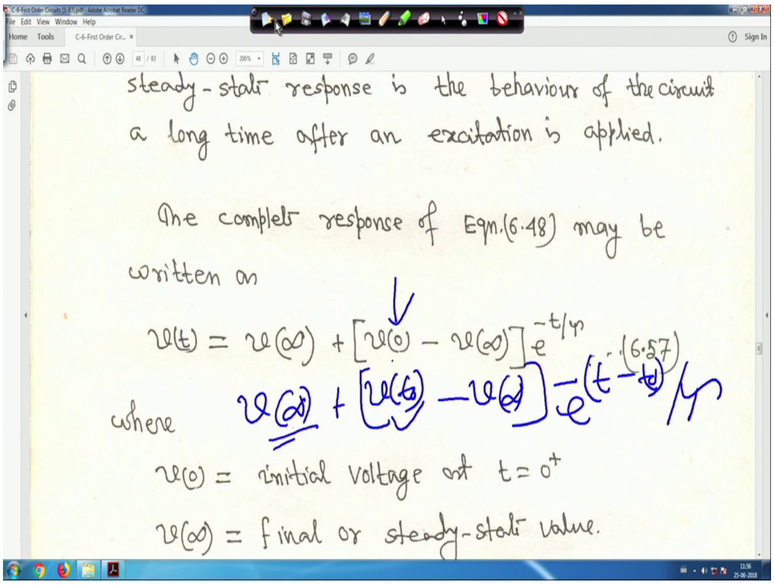

So, that means this one we can write the v t is equal to v infinity, this is the final value v infinity plus initial value that is v 0 minus final value v infinity into e to the power minus t by tau, this is equation 57 right. So, v 0 is the initial voltage at say t is equal to 0 plus just after switching and because capacitor to capacitor the voltage cannot change instantaneously. So, v 0 minus is equal to v 0 plus. And v infinity final or steady state value right, so this equation v t can be written as v infinity plus v 0 minus v infinity bracket close e to the power minus t by tau right. Therefore, your note that if the switch changes position at t time t is equal to t 0, so whatever we are considering that that is at t is equal to 0.

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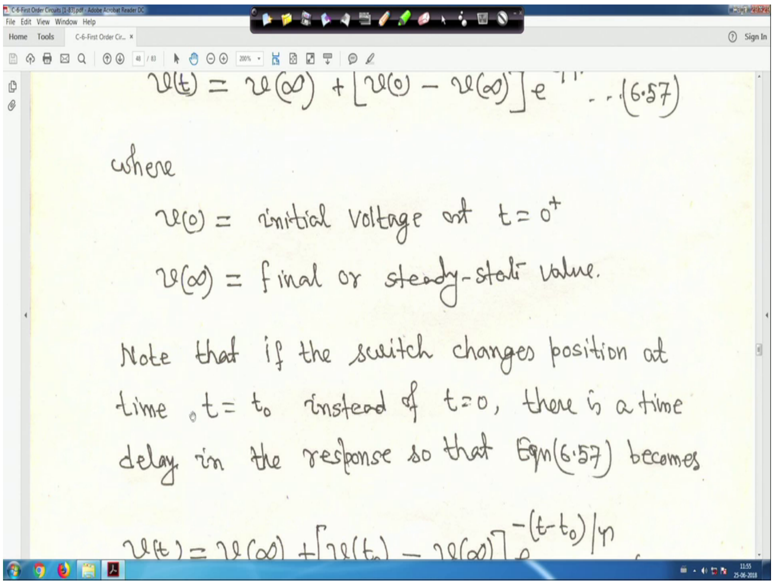

Now, suppose if the switch changes position at time t is equal to t 0, t 0 is a naught is equal to 0 for example, so instead of t is equal to 0. There is a time delay in the response of that equation 57 right. So, there will be a time, in this case what will happen, in this case what will happen, before going to this thing in this case this will remain as say v infinity plus now this one, this was your there when t is equal to 0.

Now, switch this on at t is equal to t 0, therefore initial values will be v, it is v t 0 minus v infinity will be there as it is, it is there as it is, then e to the power minus then t minus t 0 divided by tau. So, if this was actually a t is equal to 0, switch was just closed at t is equal to 0, 0 plus say right. So, but now if we make it t is equal to t 0, then it will be instead of v 0, it will be v t 0 right. But v in steady state will remain same v infinity plus your v t 0 minus v infinity then e to the power minus instead of t, it will be t minus t 0 divided by tau right. So, let me clear it.

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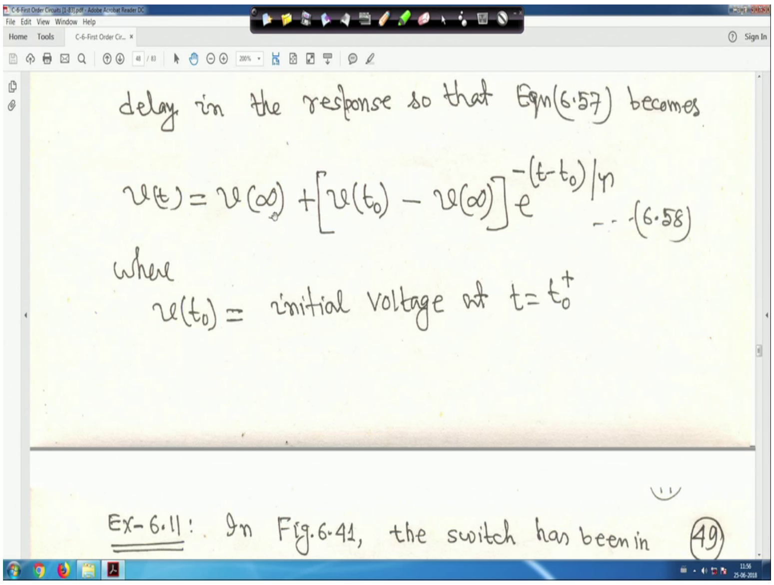

So, this is the expression v t is equal to v infinity, what I told plus v t 0 minus v infinity then e to the power minus t minus t 0 by tau this is equation 58. Now, where v t 0 initial voltage at t is equal to t 0 plus. If t 0 is equal to 0, then it will be v 0 right. Here, also it will be it is 1 minus t by tau, if t 0 is equal to 0. So, this is that your what you call the R C circuit, that your what you call that your initially you have studied the source free, now you are studying that your circuit is involved with sources right.

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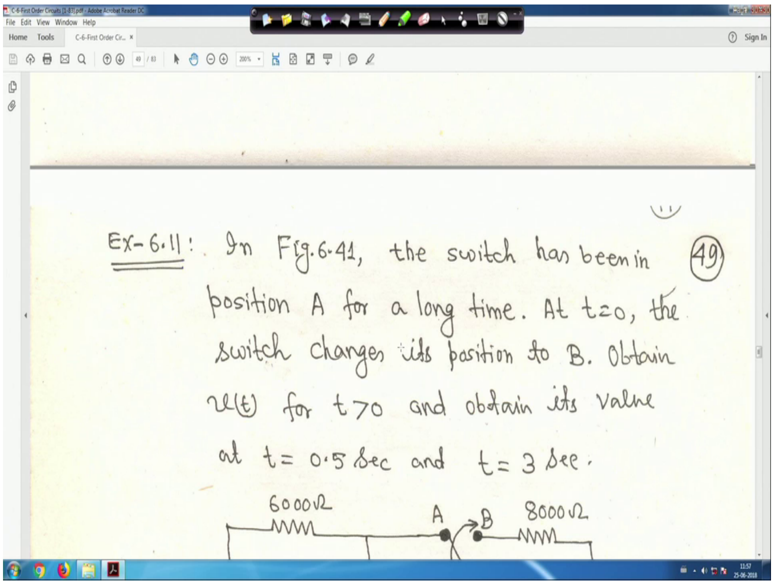

So, now look the example, so in figure this is 41, the switch has been in a position a for long time this that means, if you look into the circuit that, this is this was in this position for long time at position A, this is A right.

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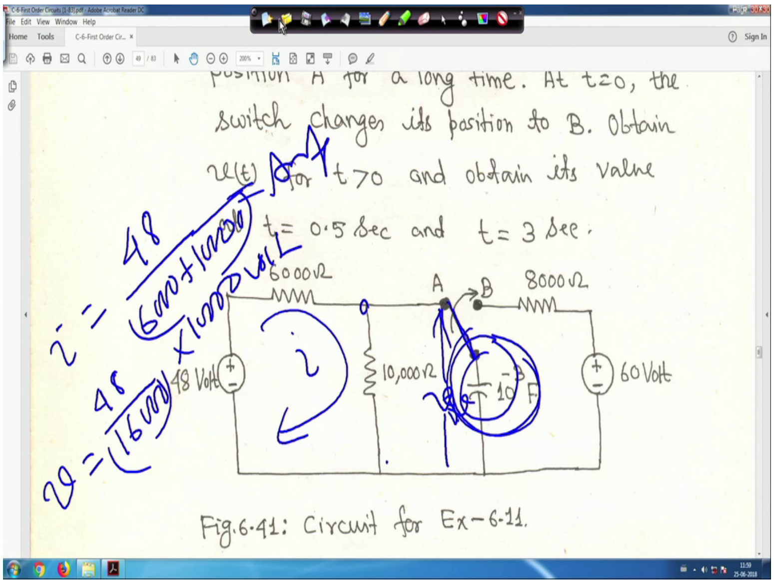

Now, at time t is equal to 0, the switch changes its position to B. Now, at t is equal to 0, the switch is your changing its position from A to B right, obtain v t for t greater than 0, and obtain its value at t is equal to 0.5 second; and t is equal to 3 second. Now, this switch was at position for long time at A right, that means that means circuit at the time for that case circuit was a steady state, because, switch was at this position. And for long time, that means this capacitor is open circuited, and then voltage your this voltage v t actually you have to find out across with your this thing this is the voltage B across the capacitor.

And capacitor value is 10 to the power minus 3 farad, so at that time this was open right. But, that means you have to find out the initial values of the your, what you call voltage across the capacitor initial, because switch is moved now. After that at t is equal to 0 switch will move from A to B. So, in that case, what will happen that first as it this is open circuit that means this voltage this voltage was v right. And say this is v and this is v 0 right.

So, in that case, it is open so first you find out what is the current here, so current through this is i. And i equal to your 48 right divided by 6000 plus your 10000, this is your writing on it all ampere right. And then what is the voltage across the capacitor, because capacitor is open circuit, this is open circuit. Therefore, your v is equal to you your this is the current 48 6000 plus 10000, this is 16000 into this is this point you find out the voltage across capacitor into your 10000 this much of volt. So, this is your v right, because switch was at this position, so capacitor was open circuited for long time. So, now let me clear it.

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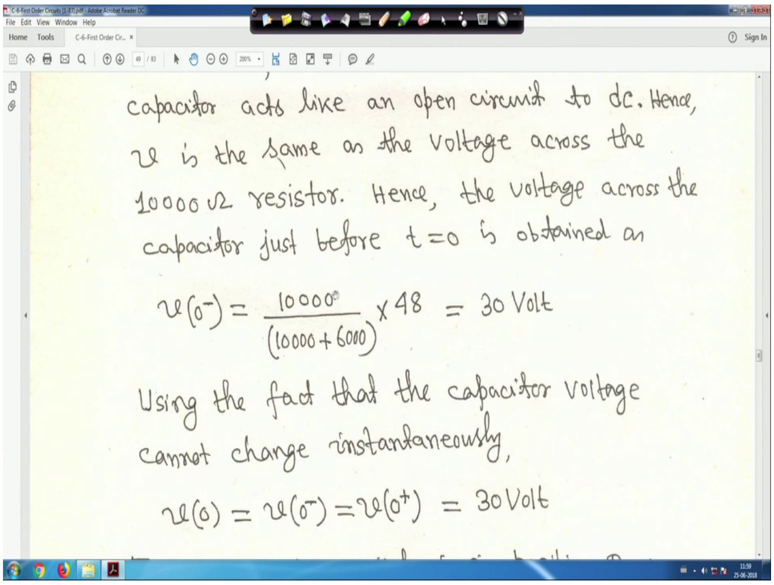

So, whatever, whatever we have made it that this is whatever I have told that 10000 by 6000 plus 10000 48, it will be 30 volt right. That means, just before switching v 0 minus, the voltage that initial voltage across the capacitor was 30 volt, now switch is closed right.

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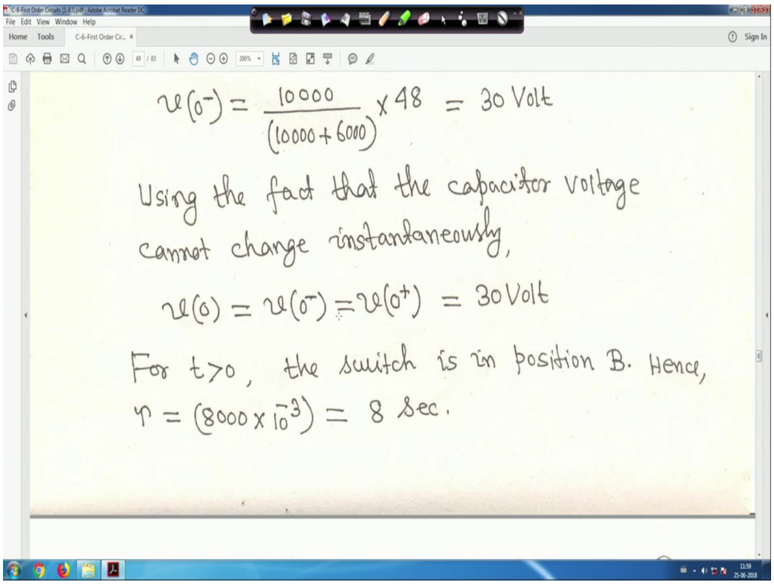

Therefore, say your that means, your using the fact that the capacitor voltage cannot change instantaneously, so which switch is close v 0 is equal to v 0 minus is equal to v 0 plus is equal to 30 volt right. So, now switch has moved from this position to that position right. So, now switch has moved here this part is not there, switch has moved from this position, so this part is not there.

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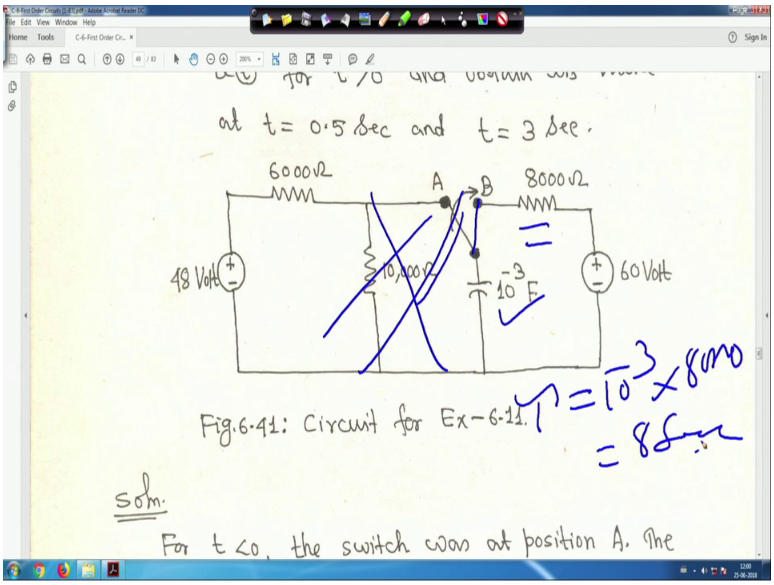

So, capacitor is your 10 to the power minus 3 farad and 8000 ohm. So, first you have to find out the time constant of the circuit, it will be then 10 to the power minus 3 into your

8000 right, so it is C R. So, it will become your 8 second right, this will be tau, because switch has moved from this to that so just let me clear it. So, in this case tau is equal to I told you 8 second. Now, since the capacitor acts like an open circuit to dc, at the steady state V infinity is equal to 60 volt.

Now, come to this circuit, now when switch position is your, what you call switch position is like this, this site is not there. So, switch is close at B moved from B. And for long time, that means capacitor will act as your, what you call an open circuit; at that time what is the value, that is the V infinity right.

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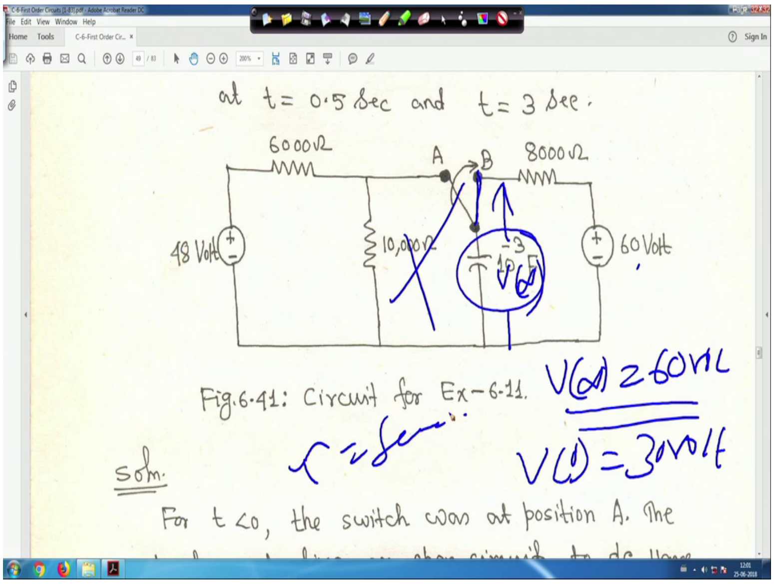

So, as it is open circuit, so V infinity is the final value will be just 60 volt, because this 60 volt is applied across, this and switch was closed at this position for long time that means this is open right. So, V infinity will be 60 volt and initial voltage V 0 your 30 volt we got right and tau, we got it is 8 second right. So, we will apply that formula. So, let me clear it.

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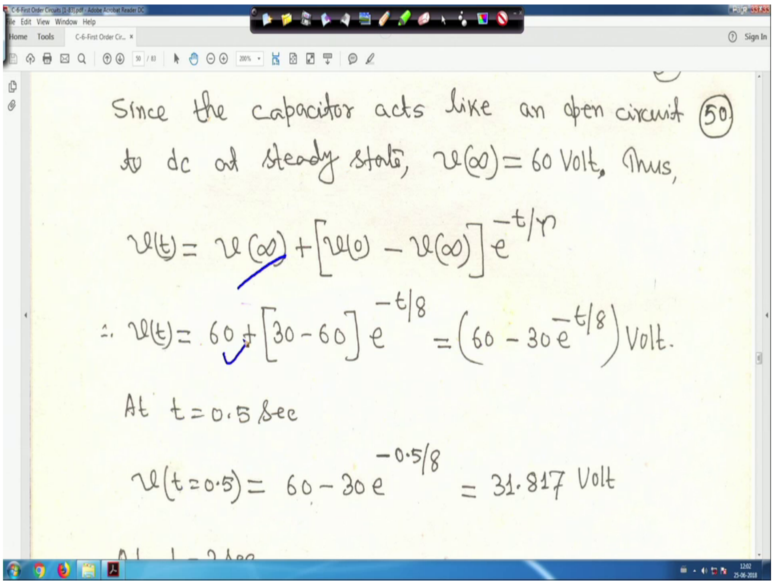

So, here it is from here it is v infinity 60 volt we explained. Now, v t is equal to you know this formula v t is equal to v infinity v t is equal to v infinity plus v 0 minus v infinity e to the power minus t by tau. So, v infinity is 60 volt; v 0 we calculated 30 volt 60 volt e to the power minus t by 8, so it is 60 minus 30 into e to the power minus t by 8 volt right. Now, at t is equal to 0.5 second, you put here at t is equal to 0.5 second, so v at t is equal to 0.5 is equal to 60 minus 30 into e to the power minus 0.5 by 8, so it will become 31.817 volt right.

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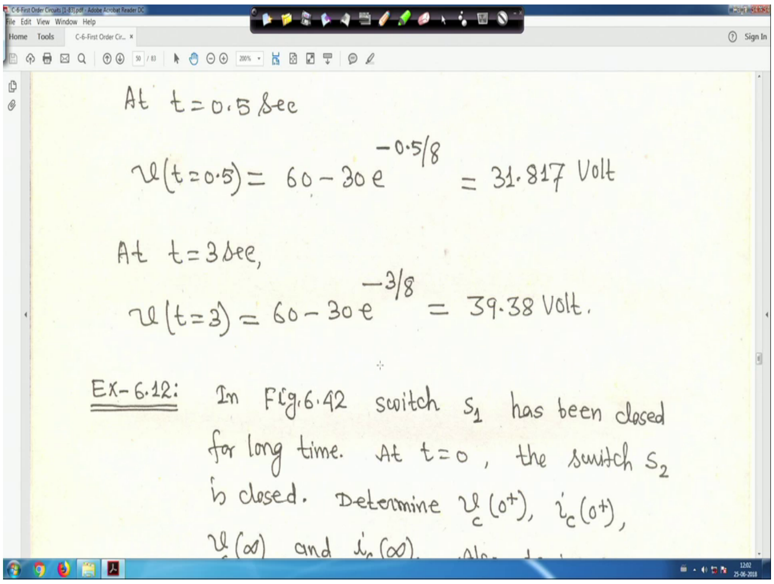

And another one is that at t is equal to 3 second. So, at t is equal to 3 second, you put here t is equal to 60 minus 30 into e to the power minus 3 by 8, so that is 39.38 volt these are the answers right. So, hope you have understood, hope you are understanding this. Just little bit you know, so many varieties of problems we are solving, just open any good book and just take few problems and just try yourself. Because, whatever various kinds of problems are there perhaps trying to cover all types of your problem, such that whatever book you will open, you will find problems are almost similar to that whatever has been done here right.

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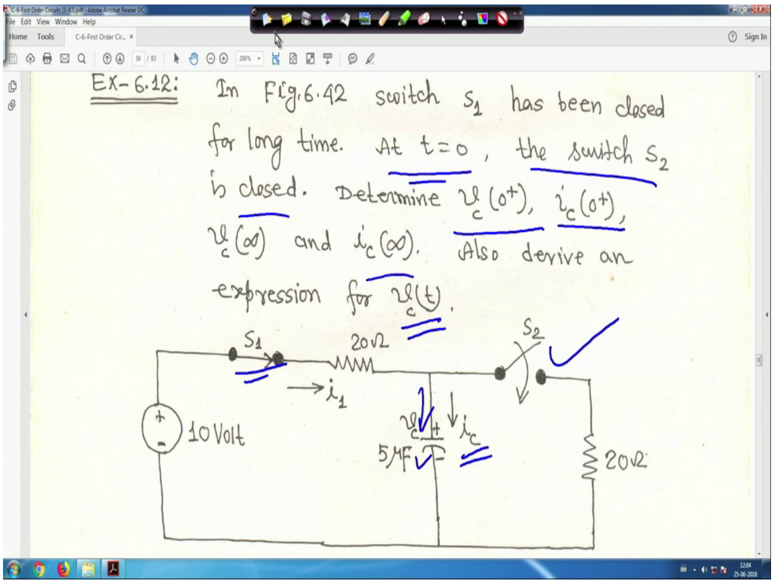

So, next one is that in figure 42, this is figure 42. You have to actually here know understanding is more required. Just blindly we cannot do this we have to understand the philosophy or physics while this switching circuit right. So, in figure 42, switch S 1 has been closed for long time this is your switch, this switch actually this switch S 1 was closed for long time right. And then your at t is equal to 0 that the switch S 2 is closed. The another switch is here S 2 that at t is equal to 0 switch S 2 is closed. You have to find out v c 0 plus, i c 0 plus that is your v c 0 plus means this one, this one (Refer Time: 25:53) that is that your voltage across the capacitor v c 0 plus.

So, v c 0 plus is nothing but the v c 0 minus, because at the time of switching the voltage cannot be change instantaneously across the capacitor right. And you have to find out v c infinity, that means this one, what will be the final value of this one. And i c infinity what is the this i c infinity, what is the steady state value also derive expression for v c t, that is the voltage across the capacitor. All these things we have to do it right. And this is 20 ohm; and this switch was closed for long time. So, let me clear it.

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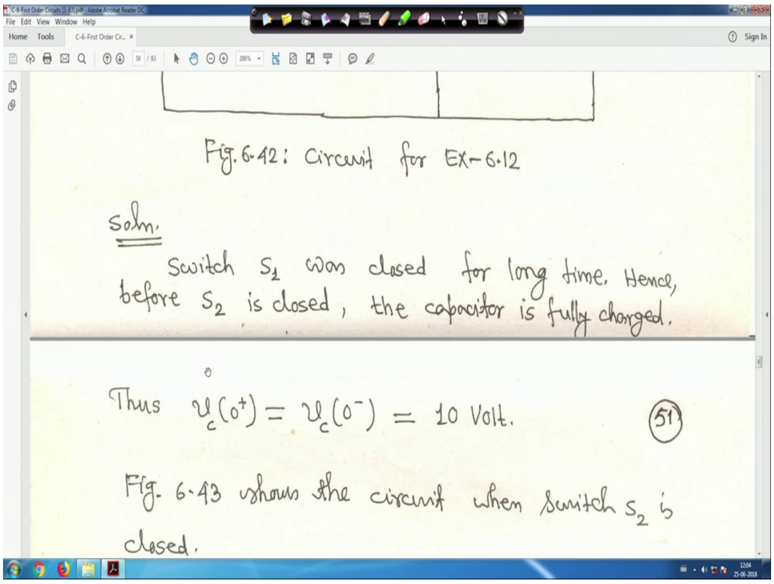

So, this is this switch S 1 was closed for long time. Now, look this switch was closed for long time, hence before S 2 is closed the capacitor is fully charged. That means, if capacitor is fully charged and this was is open, that means just let me make your thing clear. That means, this is this was open and this switch was closed for long time, that means capacitor is acting as an your open circuit.

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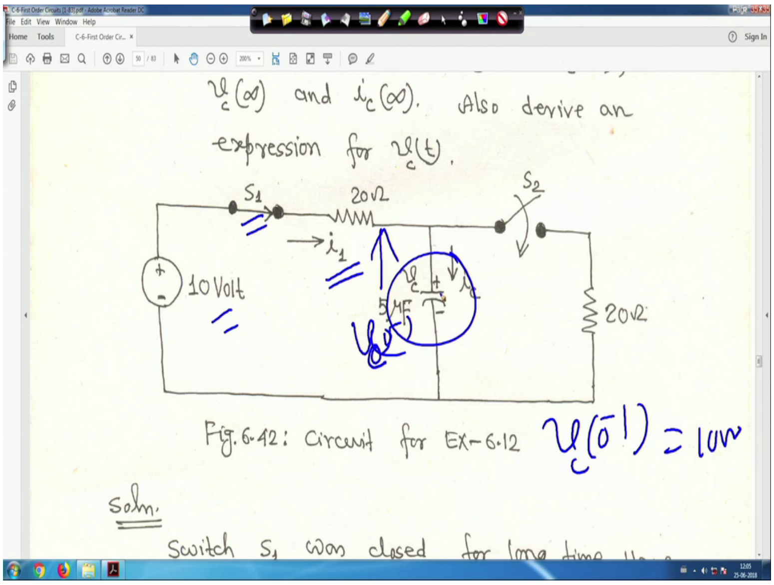

That means, this is your say v c 0, your what you call that v c 0 minus right. So, as this is open, this is also open, so no current flowing through this. So, basically your v c 0 minus will be is equal to 10 volt, because, this is the voltage across the capacitor. So, let me clear it, so this is your v c 0 plus is equal to v c 0 minus is equal to 10 volt. Now, now top figure this set figure is that switch S 2 is closed right. Now, switch S switch S 2 is close, S 1 was closed; now at t is equal 0, switch S 2 is closed, now this switch is also closed. So, at the time of just your at the time of t 0 plus you apply KVL and KCL right.

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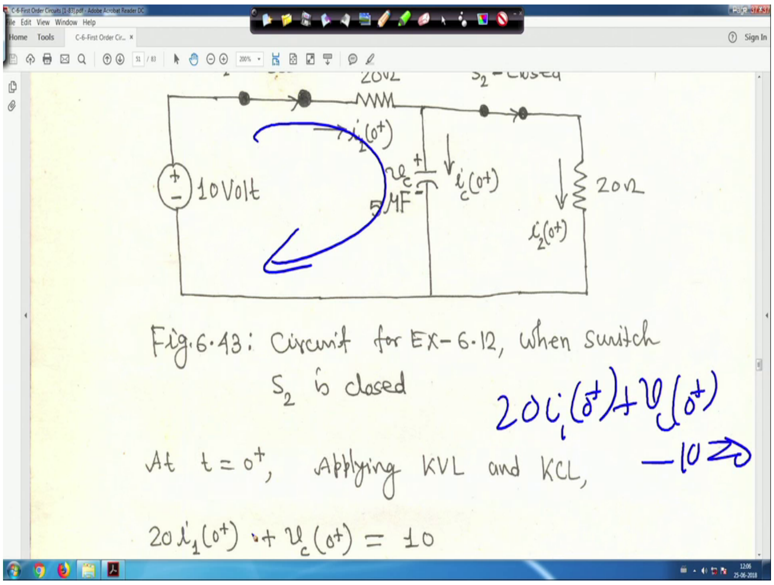

So, if you at the time of when switch is closed, just at the time of your this switch at the time of your what you call, just switch is closed right at that time you apply KCL and

KVL. So, here if you apply your KVL at your in this mesh right, so how it will look like, it will be 20 i 1 0 plus v c your 0 plus minus 10 is equal to 0, just let me this thing. So, here we are writing 20 i 1 0 plus v c 0 plus minus 10 is equal to 0, that means 20 i 1 0 plus v c 0 plus is equal to your what you call 10. I mean as soon as the switch is closed, little bit understanding is required, you apply here this your, what you call that your KVL. So, it will be 20 i 1 0 plus that is just at the time of switching, just after switching plus this voltage at that time across the capacitor is v c 0 plus minus 10 equal to 0 right. So, we know v 0 plus, so let me clear it.

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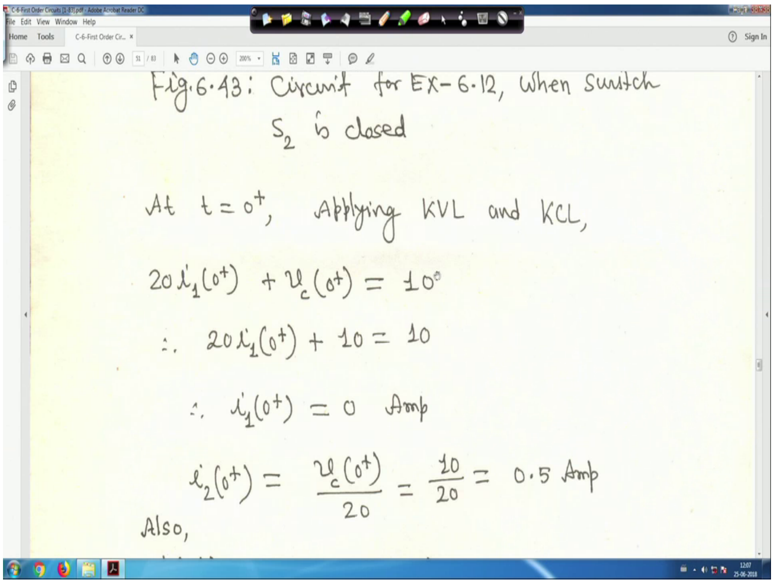

So, in this case v c 0 plus is equal to your this thing 10 volt. So, i is i 1 0 plus is equal to 0 ampere right. Here, your v c 0 plus is equal to v c 0 minus is equal to 10 volt. Because, two capacitors at the time of switching again and again I am telling voltage cannot your, what you call across the capacitor voltage cannot change instantaneously. So, in that case i 1 0 plus is equal to 0 ampere. Now, come to i 2 0 plus. Now, i 2 0 plus your this is your i 2 0 plus and at that time voltage across the capacitor that is v c 0 plus, so it is 20 ohm is connected across this, so i 2 0 plus will v c 0 plus by 20. So, i c 0 plus is equal to your v c 0 plus by 20. So, v c 0 plus is 10 volt, so 10 by 20.5 ampere right.

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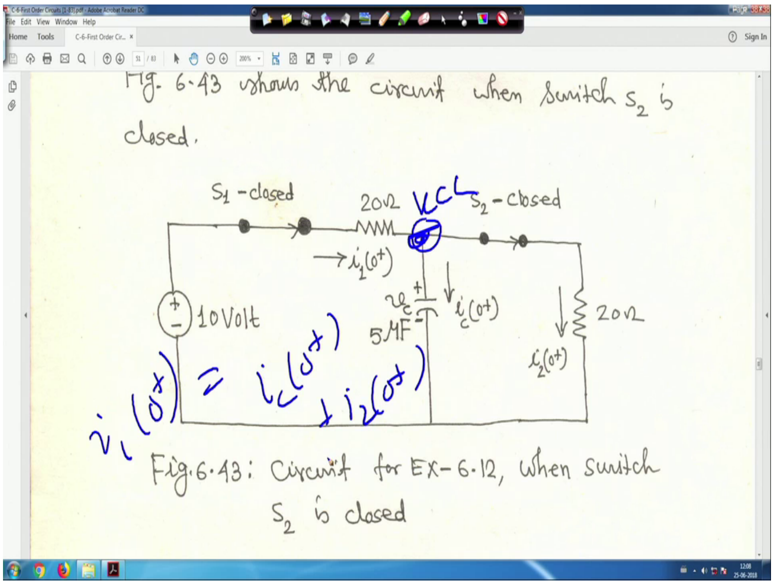

Also, if you apply here at this point, if you apply at this point your KCL, you apply at this node right, then you will get your i 1 0 plus is equal to i c 0 plus i 2 0 plus right, so that means I am writing here i 1 0 plus is equal to your i c 0 plus right plus i 2 0 plus right, you apply KCL at this point.

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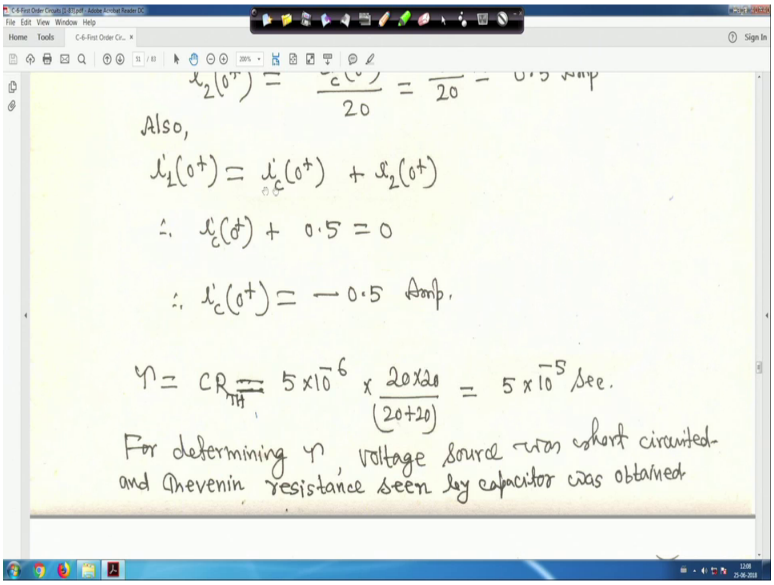

So, let me go to this. So, here i 1 0 plus is equal to i c 0 plus plus i 2 0 plus. So, your what you call i 1 0 plus was 0. So, i c 0 plus plus i 2 0 plus is 0.5 is equal to 0. So, i c 0 plus is minus 0.5 ampere. And tau is equal to c into R Thevenin. So, it is 5 into 10 to the power minus 6, c value is given and R Thevenin means, this 1 right across the I mean you have to find out R Thevenin. So, this is a this is the terminal, this is the terminal for the capacitor right. When you find the R Thevenin, this voltage source is sorted, we have seen this right.

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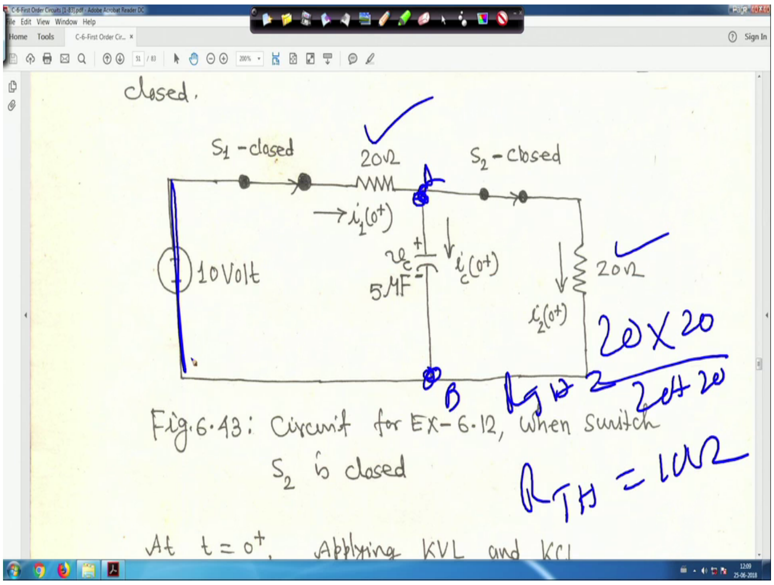

And this 20 ohm and this 20 ohm, both are in parallel right. So, it will be 20 because at this point say, this is point A, this is point B, we are trying to find out R Thevenin, so it will be 20 into 20 by 20 plus 20 this is your R Thevenin you have to find out. Therefore, R Thevenin is equal to 10 ohm right. So, because this we have seen before that your what you call how to find out your what you call R Thevenin right.

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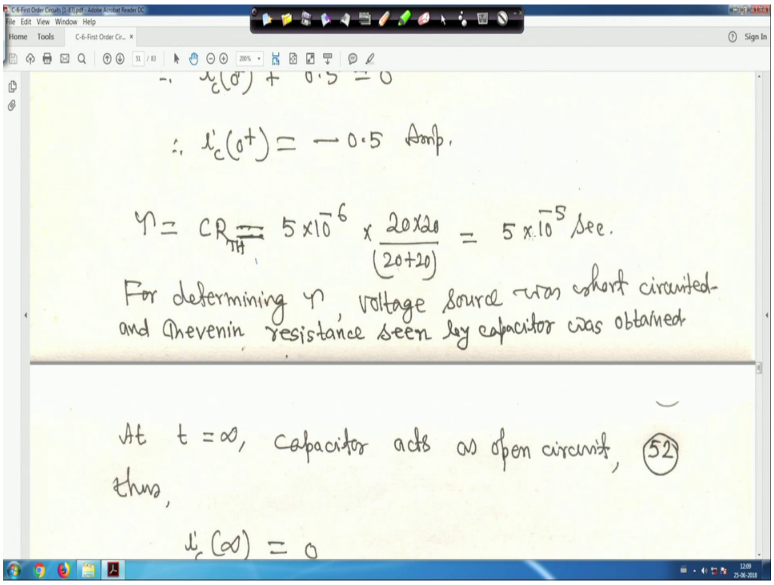

So, this so we got this one your, what you call this R Thevenin is equal to directly, we are writing 20 into 20 upon 20 plus 20. So, basically it is your, what you call that is 10 ohm, so multiplied by 5 into 10 to the power minus 6, so it will be 5 into 10 to the power minus 5 second right.

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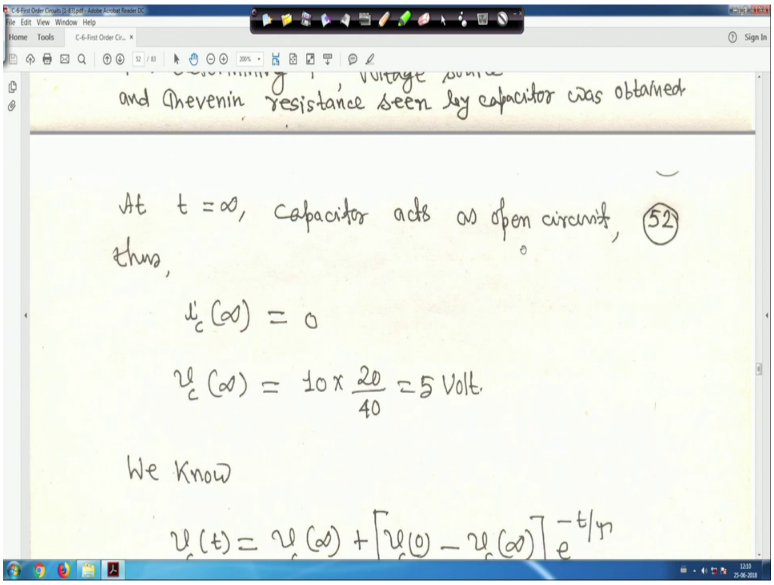

And at t is, at t tends to infinity capacitor acts as an open circuit. So, for this thing switch is closed; and for it was it remain closed for long time, so capacitor will act as open circuit. So, i c infinity is equal to 0, because capacitor will be an open circuit, when switch is closed for long time.

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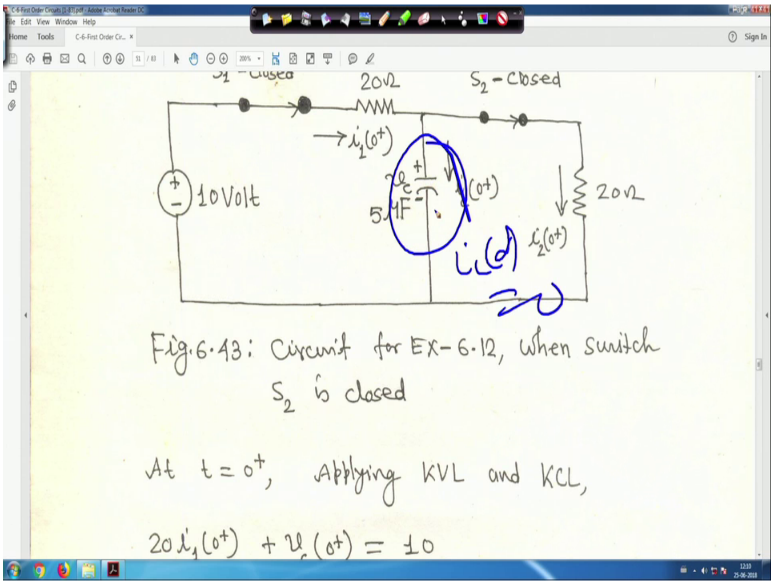

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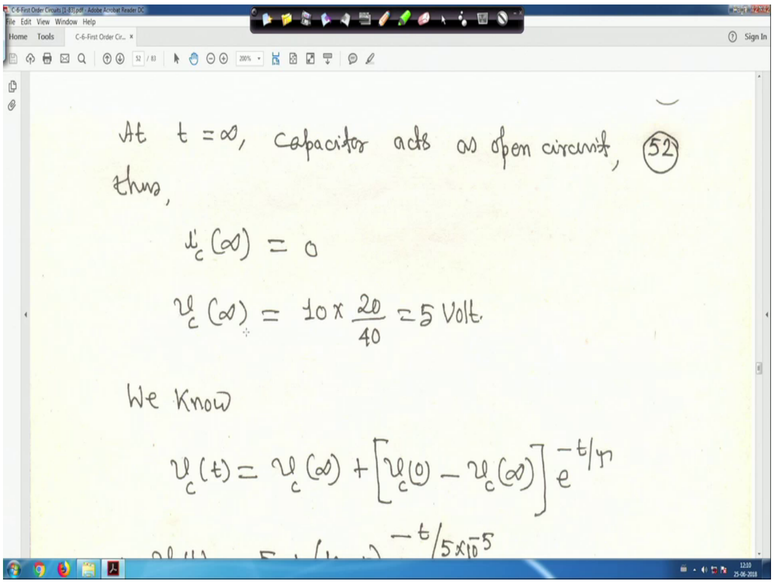

Therefore, right, i c infinity 0 and v c infinity will be 10 into 20 by 40 is equal to 5 volt. So, if you come here what will be your v c infinity right. So, if you look, if you look into that the capacitor acts an open circuit acts as an open circuit right. So, question is that this is open, this is your this is open right, so this is open circuit, so find out what is the current flowing through this what is the current flowing through this.

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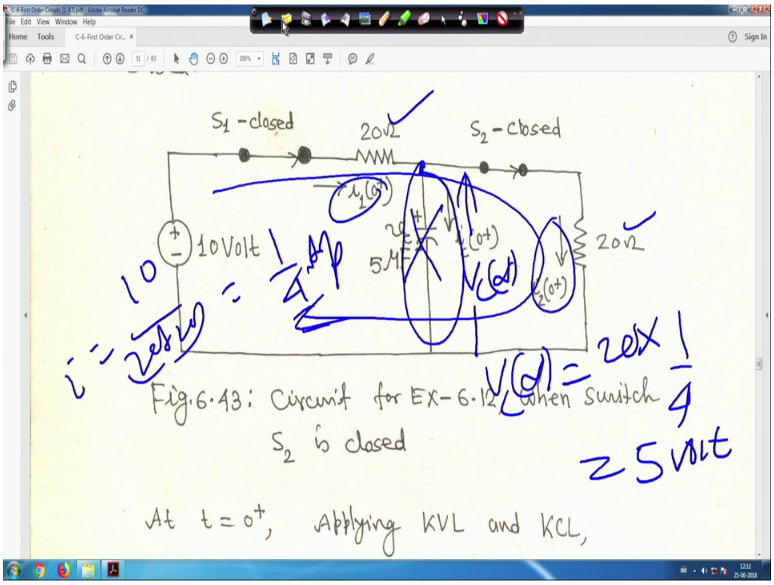

So, this is open circuit, so what is the current flowing through this the i it is 10 by 20 ohm plus 20 ohm. So, 20 plus 20 so 40 that is 1 by 4 ampere this is your what you call the current flowing and this voltage your and this1 by 4 ampere. So, at that time nothing is there it is a steady state, it is a steady state, it is at infinity. That means and then open circuit voltage, I mean voltage across the capacitor that v c infinity right, that is v c infinity this is the this is your voltage v c infinity this is the voltage right is equal to your this 20 into this 1 by 4 ampere, that is equal to 5 volt right, because, capacitor is open circuit at that time. So, current you have to flowing like this and this capacitor is connected this 20 ohm resistance is connected across the capacitor right. So, you can find out easily v c infinity 20 into 1 by 4, so 5 volt right. So, let me clear it.

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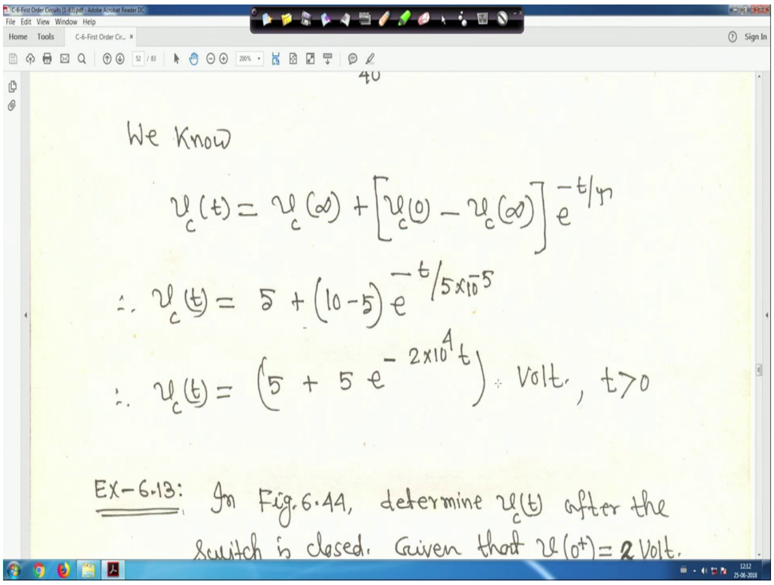

So, that means v c 0, v c infinity all are known to us right so that is your 5 volt. This is v c infinity directly I have written here I hope you understood this right. Therefore, v c t is equal to v c infinity the same formula, that v c infinity plus v c 0 minus v c infinity e to the power minus t by tau generalized formula, you substitute v c infinity 5 volt, v c 0 10, v c infinity 5, and e to the power minus t, then by 5 into 10 to the power minus 5 that is tau time constant for t greater than 0. So, that means v c t is equal to 5 plus 5 e to the power minus 2 into 10 to the power 4 t your, that means that is for t greater than 0. Hope you have understood this, little bit understanding is required.

Thank you very much, we will be back again.