Fundamentals of Electrical Engineering
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Lecture - 18
Methods of Circuit Analysis (Contd.) and Circuit Theorems

So we will come back to this again the continue with this problem. Just before beginning this let me tell you one thing that for the dc circuits, we are trying to see so many different types of problems but at the same time when will come to the ac circuits right at that time number of examples, I have to reduce a because at that time complex number will be involved. And it (Refer Time: 00:42) it will take much more time as it conceive more time to solve such things, but basic idea for dc circuit whatever circuits laws and theorems you are learning, it is same as same for your ac circuits apart from your maximum power transfer theorem that we will see later right.

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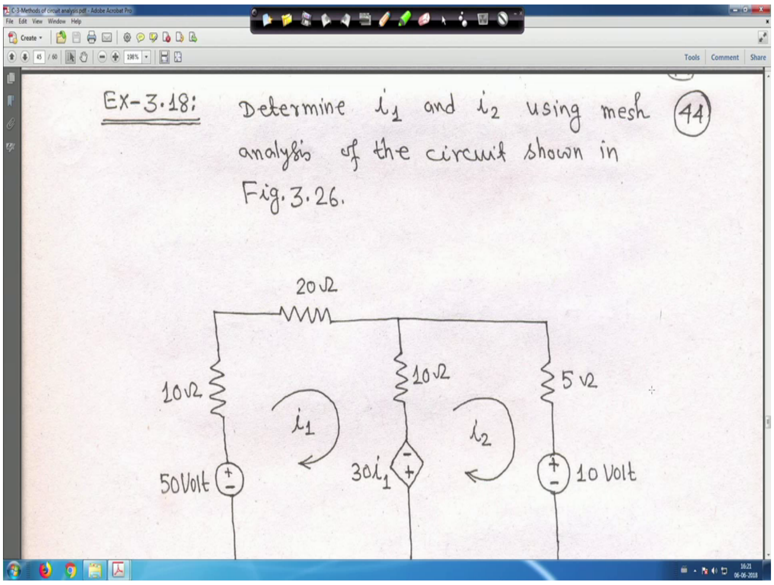

So, just come to another a another a another problem right. So, in this case, what we can do is that you determine your that for this problem we have to determine i 1 and i 2 using mesh analysis of the circuit shown in figure this figure right.

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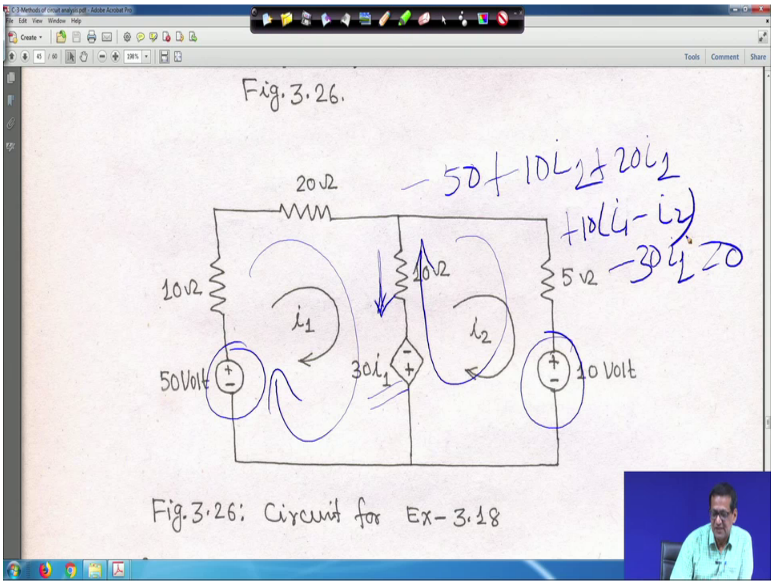

So, this is the figure. And I just this thing and your, in this case that you have one 51, 50 volt source right, and one your 10 volt source, so the 10 volt source. And let me clear it, let me clean it first right. So, we have one 10 volt source, and we have one 50 volt source. And you have i 1 and i 2 and this is a this is a dependent voltage source. And, here it is 30 i 1 and here it is your i 2 right. And you have to solve for i 1 and i 2. So, same as before, if you write the your KVL equations, for the for these one later it is written. So, basically if you move like this, for this is mesh 1 and this is mesh 2.

So, if you if you move like this, so easily you can write down your what you call that your KCL KVL equation. For example, mesh 1 if I apply, so I moving like this, this clockwise moving like these, so it will be first minus 50 right, then your then plus 10 i 1 right plus 20 i 1 right. And here, we are moving in direction i 1 and this is your i 2 right. So, resultant in this direction is i 1 minus i 2, so plus 10 i 1 minus i 2 and encountering and moving this loop so minus terminal plus so minus 30 i 1 is equal to 0. So, this will be your one equation right. Later it is given but this is one equation. So, let me let me clear it. So, similarly when you apply when you apply your k KVL in mesh 2 right, same way you can do same way you can do it.

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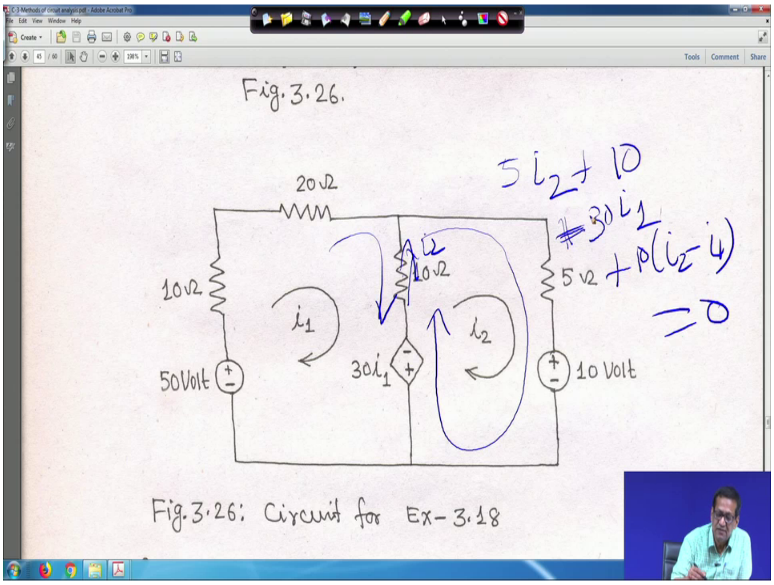

For example, I am moving from say starting from this 5 ohm resistor. So, it is 5 i 2 then encountering plus 10 volt plus terminal plus 10 right. Then here also, if you move like this so plus 30 i 1 is coming so plus 30 i 1 right. And we are moving in this direction this is i 2 and here i 1 is there, so in upward direction is i 2 minus i 1 so plus 10 i 2 minus i 1 is equal to 0 right. When I am writing such equations your this is plus right.

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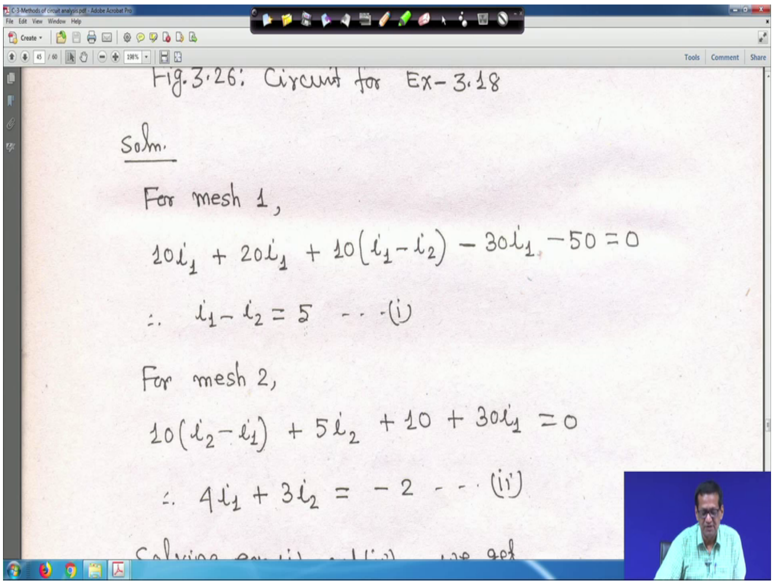

When I writing such equations, hope I am not missing anything right, so two equations you will get and accordingly from that you have to solve for i 1 and i 2 right. And there let me clean it. So, so, if you go to this for mesh 1, this is the equation finally it is coming i 1 minus i 2 is equal to 5 right.

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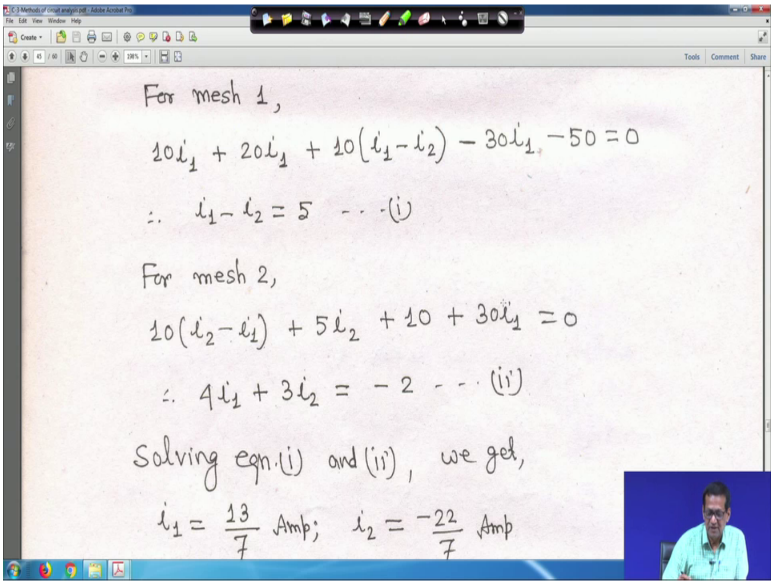

And for mesh 2, it is your coming your this thing your 4 i 1 plus 3 i 2 is equal to this is for mesh 1, this is for mesh 1, i 1 i 1 minus i 2 is equal to 5 right. And this is for your mesh 2 that is for your 4 i 1 plus 3 i 2 is equal minus 2. If you solve it, you will get i 1 is equal to 13 by 7 ampere; and i 2 is equal to minus 22 by 7 ampere right.

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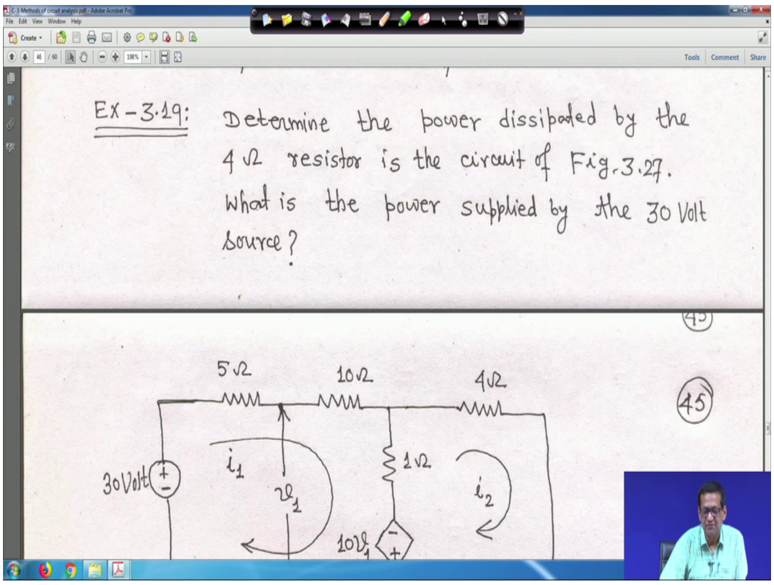

Next one is determine the power dissipated by the 4 ohm resistor in the it is actually hold on. Actually, it is just hold on. It is in the circuit right of figure 3 your figure 3.27. So, what is the power supplied by the 30 volt source right.

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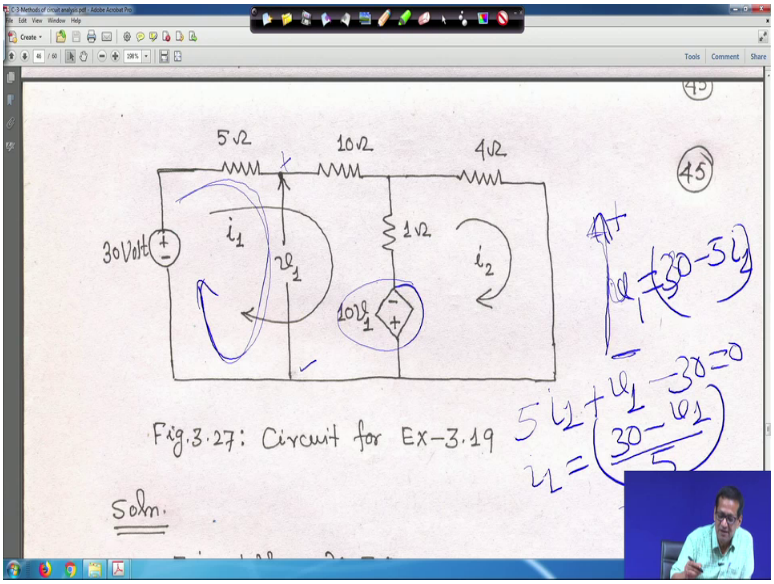

So, your if you if you let me clear it, and if you if you just look into this in this circuit that, you have a one dependent voltage source 10 v 1, the dependent voltage source is there 10 v 1. And this v 1 actually this is the voltage right. And one thing is there look whenever we are drawing circuit, if I show arrow upward I mean arrow like these and arrow is always plus and nothing is mark means this is minus right this way you have to assume. Whenever will put arrow, so here arrow is there and this is minus let me this point you take plus and this is your minus right.

Even if it is not mentioned, but any if it is arrow here nothing is here means this is plus, this is minus. And this volt 10 v 1 means this v 1 actually this is the voltage, this is the v 1, and this the dependent voltage source is given something like this 10 v 1 right. So, if it is, if it is so then first what you do is you find out the expression of i 1 in terms of v 1. Earlier, we have seen that how to find out. So, what you can do is that first take KVL like this, you take KVL here.

So, in this case, what will happen not going not going like this, the way it is shown. I have shown it here, but go like this. Then in this case what will happen, this i 1 so it will be actually, if you just putting it here, taking v 1 together right, then what will happen that your you write 5 i 1, and this terminal this point is plus i marked it here right, plus v 1 right and encountering minus terminal here. So, minus 30 minus 30 is equal to 0 right that means my i 1 will be is equal to 30 minus v 1 divided by 5 right, because, we have to obtain first i 1 in terms of v 1 right; or in other way other way I can make that your v 1 this is i 1, or other way here I am writing v 1 is equal to your 30 minus 5 i 1.

I think this is required for our this thing 30 minus 5 i 1 right, that is your that is your v 1. So, v 1 you have to obtain in terms of i 1, because we have to solve for i 1 and i 2 plus right. So, v 1 is equal to from these it is clear that I applied that KVL here only that is your 5 i 1 plus v 1 minus 30 is equal to 0 right. This is required because before going to the equations first try to let us make all these things clear your, what you call clarification here itself right, so I am clear.

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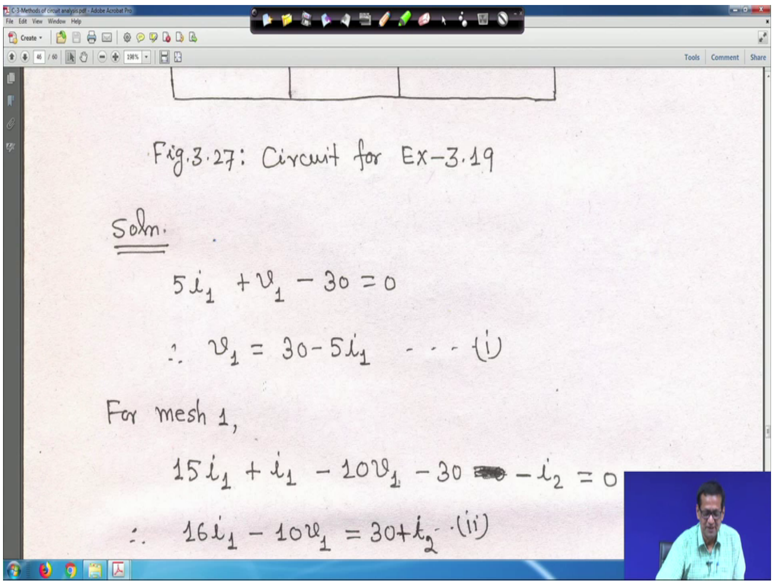

Now, I am clearing it right. So, once it is done, then what you do that is why first I am writing 5 i 1 v 1 minus 30, so v 1 is equal to 30 minus 5 1, I showed you. Now, you apply your what you call that KVL in mesh one.

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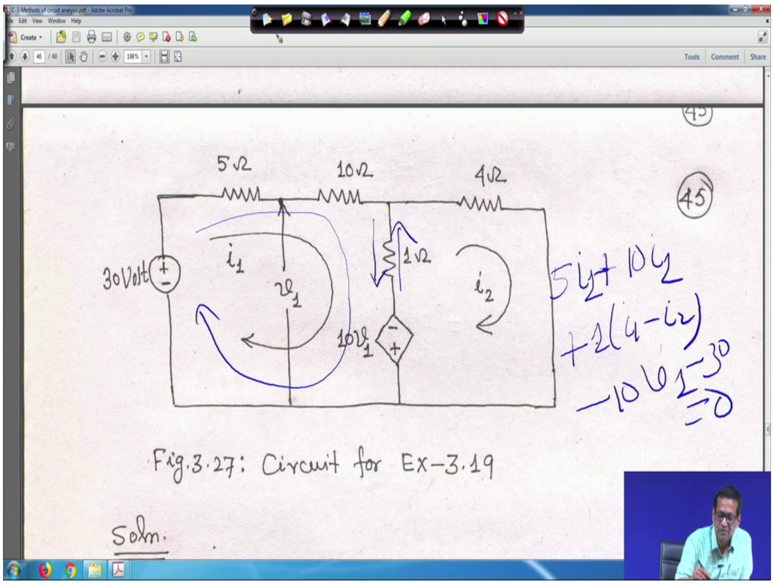

So, if you do so, if you do so, if you write, if you write KVL here look, how you are write it. If you write KVL here, KVL here, so it is actually your 5 i 1 right. I am writing here, later it is written 5 i 1 plus it is also 10 i 1 that is it is 5 and 10 are in series right. So, basically 15 i 1, so plus 10 i 1 then plus this current is i 1 this direction and i 2 is going this direction. So, it is 1 into i 1 minus i 2 right. Then minus 10 v 1, then here it is minus 30 is equal to 0. This will be your what you call that your, if you apply KVL in this mesh. Similarly, if you apply your what you call KVL in mesh 2. So, let me clear it. If you apply KVL in mesh 2, so same way you can move. So, in this case it will be move starting from here.

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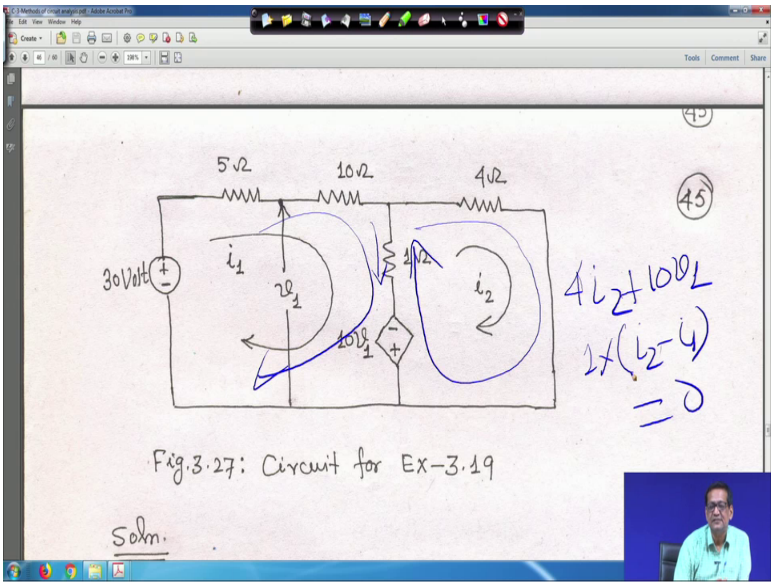

If you move like these starting from here, so it is 4 i 2 right, you come like these plus 10 v 1 right v 1 especially got in terms of i 1. And going upward, so 1 into and this is your i 1 because current i 1 moving like this, so i 2 minus i 1 right. Hope I have not missed anything is equal to 0 right.

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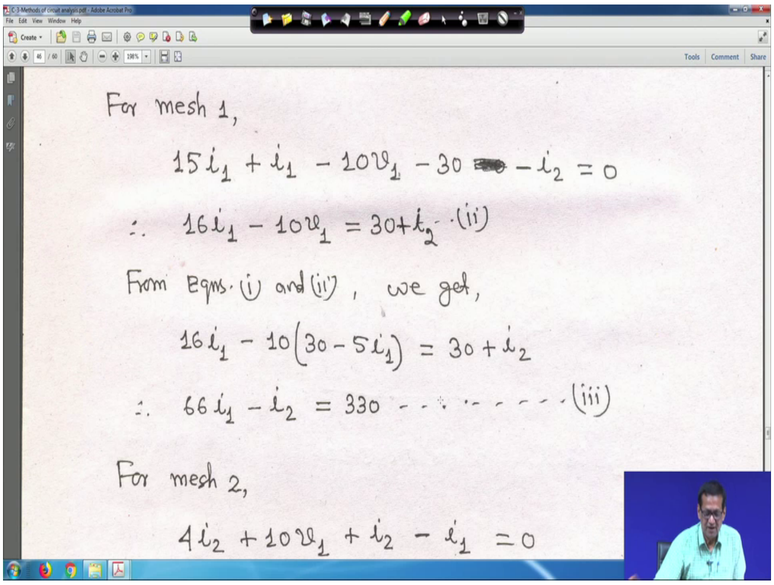

This is your second equation so, let us clear it right. So, if we move like these, so this way mesh 1 will get this equation, mesh 1 your for mesh 1, if you write I wrote you, I wrote it for you, so this is the equation right, I wrote something after simplification is like this, so this is equation 2 say. And here you have to substitute v 1 is equal to that v 1 is equal to your 30 minus 5 i 1 there you substitute such that you will get any equation in terms of i 1 and i 2 right.

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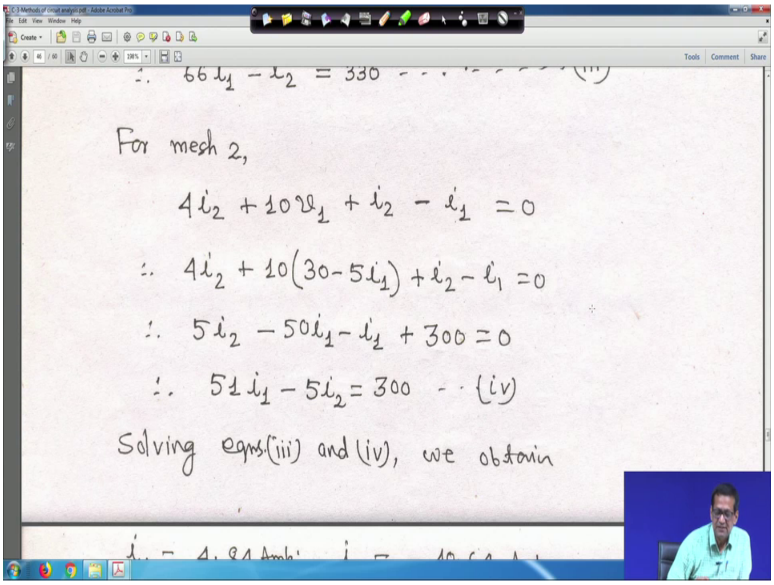

Similarly, if you clear it, if you if you go to your sorry, if you go to for mesh 2 i, I wrote for you that this is also the mesh 2 KVL you apply. And finally, here also you put v 1 is equal to 30 minus 51. So, another equation you will get 51 minus i 1 minus 5 by 2 is equal to 300. And solve these two that equation 3 and 4 you solve it right.

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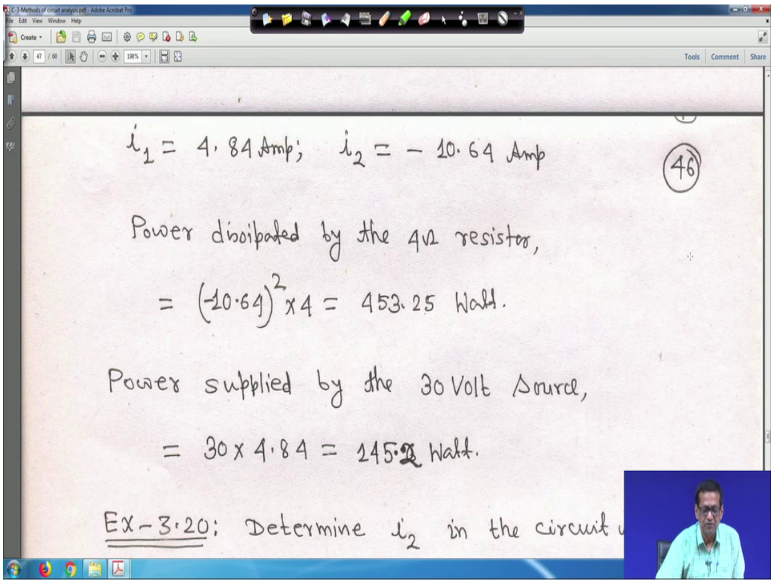

If you solve it, so you will get i 1 is equal to 4.8 4 ampere; and i 2 is equal to minus 10.64 ampere. And power dissipated by the 4 ohm resistor is minus 10.64 square into 4, so 453.25 watt. And power supplied by the 30 volt source, it is 30 into 4.84, so 145.2 watt. Because, from the source that i 1 source supplying i 1 current, so it is 30 into 4 point and basically 30 volt into i 1; i 1 is 4.84, so what are they 45.2 watt right.

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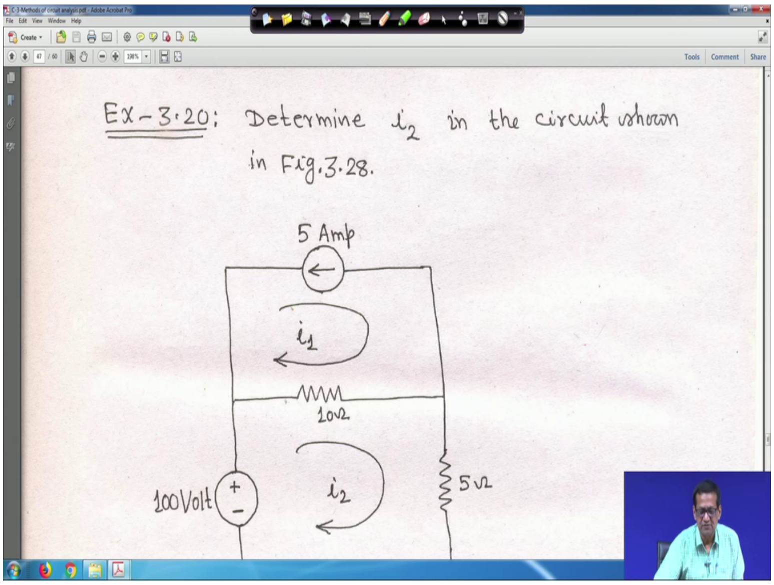

So, next take this simple example. Determine i 2 in the circuit shown in figure this 3.2. So, this is the circuit you have to find out your i 2 look this current actually this current 5 ampere, this is it is this direction it is there right, but we have taken your this way we have taken right that means i 1 actually is equal to minus 5 ampere. Because when they move i 1 like these i 1 is going like this, this i 1 this going like these clockwise and this is coming out, so just opposite direction, so i 1 is equal to minus 5 the nothing else that is all.

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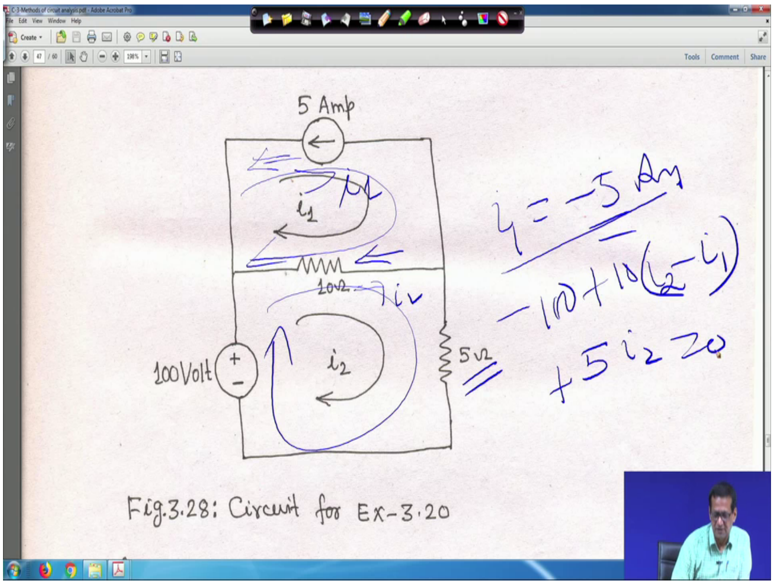

After that you apply your what you call KVL in this in this mesh. So, if you move like this, so I move like this, I move like this, so it will be minus 100. Now, no need to repeat again and again. Now, you understood so minus 100 plus 10 right into you this is the current i 2 this direction, this is the current i 2. And i 1 is in this direction, so it will be 10 into i 2 minus i 1 right plus 5 into i 2, because this 5 ohm resistance is there this 5 i 2 is equal to 0.

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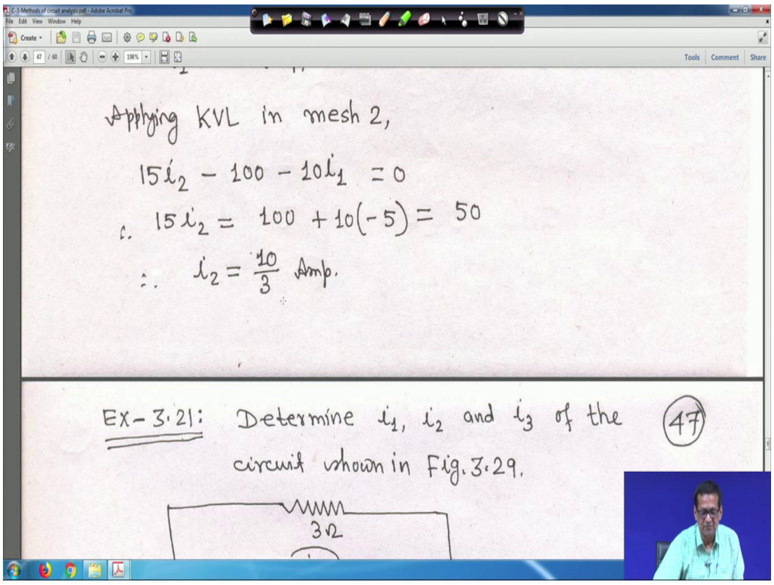

But i 1 is equal to minus 5 ampere, if you substitute i, i 1 is equal to minus 5, then it will become minus 100 plus 10 into i 2 plus 5 plus 5 by 2 is equal to 0 from which you have to compute i 2. So, that is calculations your; it given here right, so this is a simple things. So, i 2 is equal to actually 10 by 3 ampere right. This is the answer.

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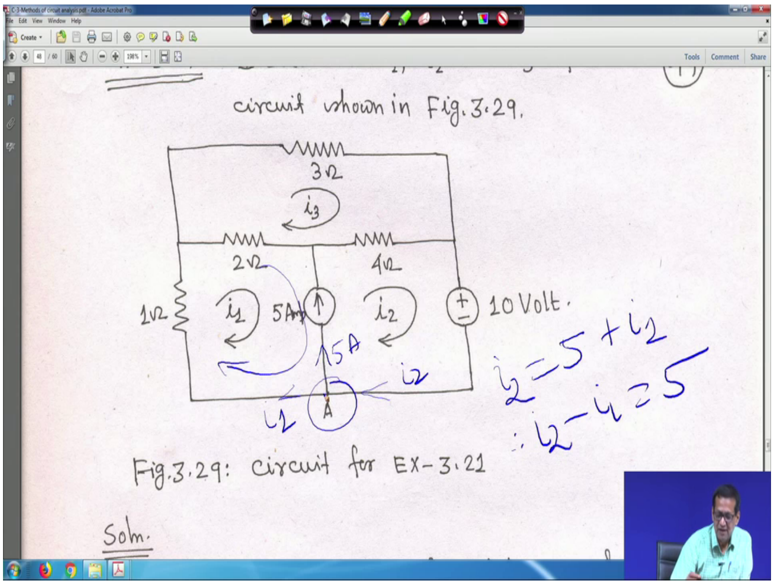

So, similarly, for this one, determine i 1, i 2 and i 3 of the circuit shown in figure this right. So, in this case, if you look into that for this problem, you have to find out your you have to find out your i 1, then i 2, then i 3 right. And if you look into that, then this is mesh and this is 1 mesh and in between 2 mesh 1 current source is there right. So, so accordingly you have to you have to see that this creating a super mesh right. Because, one this is mesh this is, mesh and these two mesh in between one current source is there. So, it is computing with beginning with a super mesh.

So, and, if you look into that this current, this current, we are taking actually this way this way if you take the loop it is i 2 and this way, we are taking this is your this direction is i 1 and 5 ampere shown it is upwards right. So, now we from that we have to see that how we can we can solve this one that because this is this is creating a super mesh. So, what we can do is first and because of that some constant equation will come. So, how one can do is look before because it is a super mesh. So, one constant equation will be there. So, let me let me clear it first.

So, before right from the KVL, so this is this is one node is there node a right. So, this i 2 current is coming, so this is actually your i 2, because, you are moving clock wise this is i 2 right. And this is your 5 ampere current moving upwards. And this actually i 1 goes like these this is i 1, so this is i 1 right. So, if you look into that, therefore this i 2 current entering at node a, so the and 5 ampere and i 1 both are leaving.

So, i 2 is equal to actually 5 plus i 1 right or i 2 minus i 1 is equal to 5 ampere right. This is one easily you can apply your what you call that your KCL at node a. Another thing is simple thing. Another thing is this i i 2 is moving this way; and this i 1 is moving this way this is your i 1. And this 5 ampere direction is upward, so upward direction current is actually i 2 minus i 1 this i 2 and minus a i 1 right.

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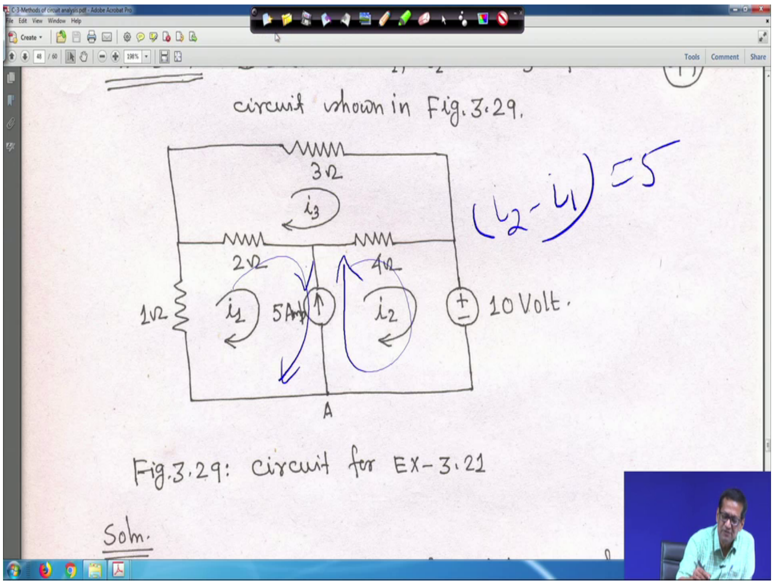

So, this is upward 5 ampere that is also directly you can write 5 ampere the way you want right. So, let me clear it, equation will see later. First, we have to understand. And this as this as this creating a super mesh; that means, what we have what basically we have to do, you have to you have to apply the KVL like this right. Because, the this you can exclude, and then make a dash line the way I showed and you can do it, so that we have gone there right. So, let me clear it.

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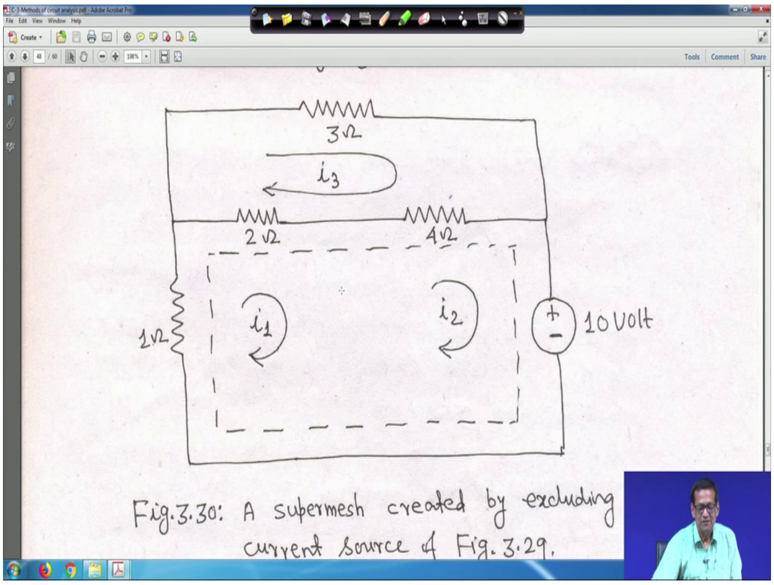

So, so for this is a super mesh I told you. So, write down those write easily you can write down the equation, it will be now from my mouth I am telling you can understand, it will be if i move like these it will be 2 into i 1 minus i 3, because this is your resultant in the in this direction sorry, so just hold on. So, resultant in this direction right, so it is your i 1 i 1 minus i 3. Here, it will be your i 2 minus your i 3 right, so 2 into i 1 minus i 3 plus 4 into your i 2 minus i 3 plus 1. And if you come like this plus, your i 1 into 1 is equal to 0 right. So, let me clear it, so. So, if this way similarly for the other this mesh 3, you can apply mesh 3; also you can apply KVL.

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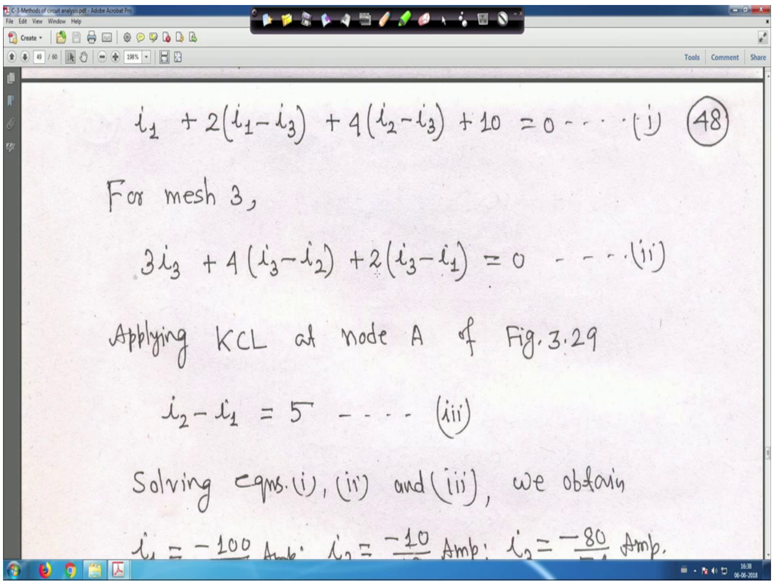

So, if you apply this KVL, so your in the super mesh, so this is the equation I wrote for you right. And for, if you for mesh 3, you apply KVL again this is your equation, this is for mesh super mesh 1, the equation 1; and for mesh 3 equation 2. So, apply KCL at node A, I told you earlier that i 2 minus i 1 is equal to 5 this is equation 3 right.

Solve equation 1, 2 and 3, so you will get your i 1 is equal to minus 100 upon 18 ampere; i 2 is equal to minus 10 upon 18 ampere; and i 3 is equal to minus 80 upon 54 ampere. So, this is the answer right. So, one thing I can give you give you as an exercise, so you also find out what is the what is the power your supplied or absorbed by this current and the voltage source this is not done here, but it is an exercise for you. You please do it.

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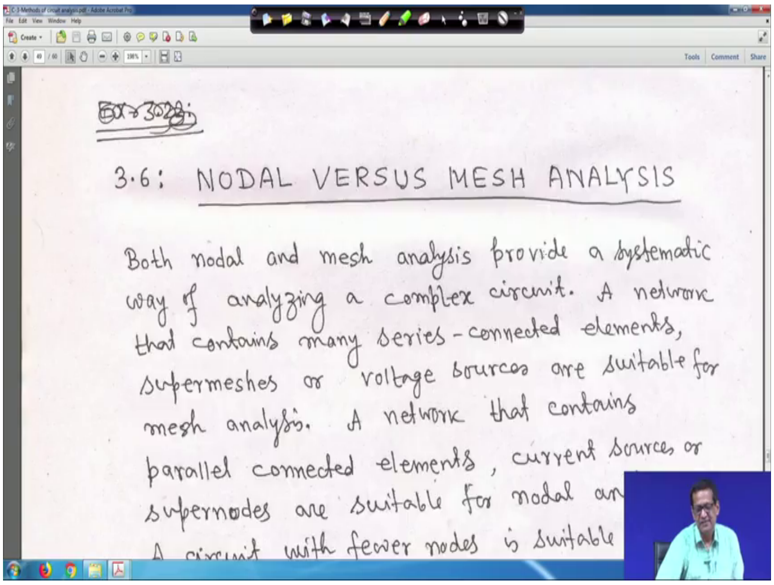

Next is that your nodal verses mesh analysis. So, where you will go for nodal analysis and where will go for mesh analysis look. This is actually generally for both nodal and mesh analysis provide a systematic way of analysis and complex circuit right. So, if you have for example, just hold on. For example, in network right in network that contains many series connected elements right super meshes or voltage sources are suitable for mesh analysis right. And similarly, a network that contains parallel connected elements, current sources or super nodes are suitable for nodal analysis right, but this is actually something we are giving.

Actually question is that you have to see that where you have a minimum number of equation. If you see that you for nodal analysis, if you have a minimum number of equation, because if minimum number of equation means your competition time is less right; we have to see that why whether nodal analysis or mesh analysis, which one will be suitable such that you can have minimum number of equation that is the that is that idea for your what you call for nodal or mesh analysis right.

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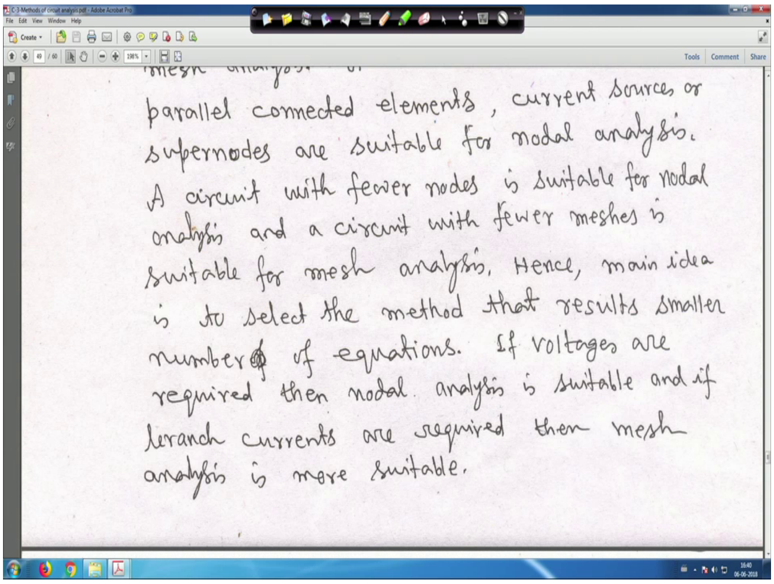

So, ultimate thing is, if voltage are required, then you go for nodal analysis. If currents are required, better you go for mesh analysis, but both the cases you please see that whether you need for nodal analysis whether where you have a minimum number of equations right, this is the idea. So, this is the difference between nodal and your what you call mesh analysis.

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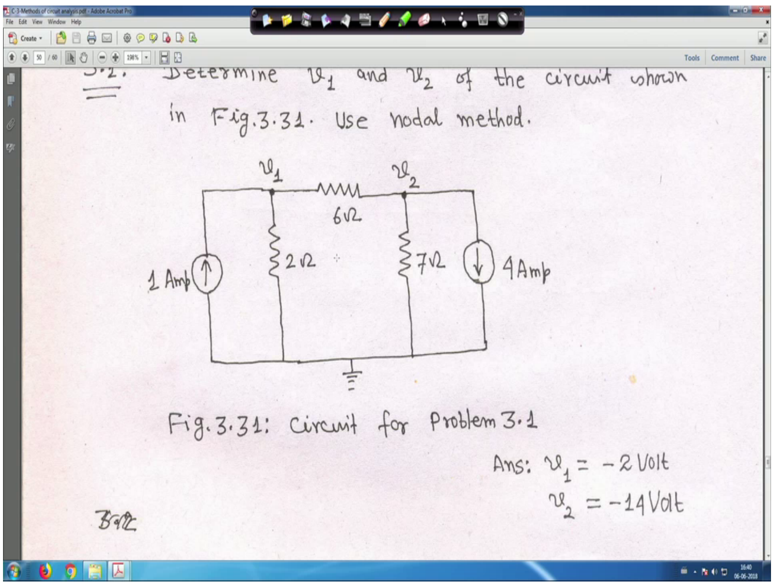

Now, some exercise you will do at least 10 problems I am giving you. So, here you have to find out v 1 and v 2 right using nodal method. Answers are given everywhere right hand side you see v 1 is equal to minus 2 volt, and v 2 is equal to minus 14 volt this will do.

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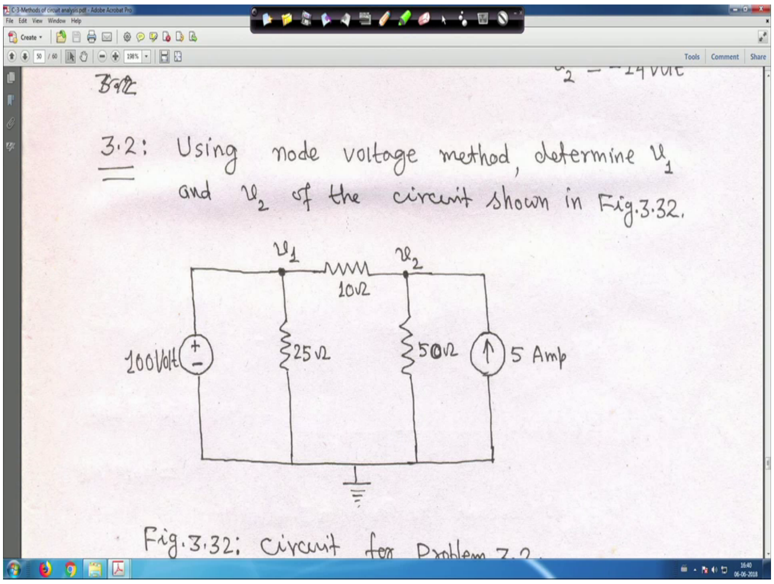

Similarly, you take a example 2. So, using node voltage method determine v 1 and v 2 of the circuit shown in figure 32 the chapter 3.32, so figure 3.2. So, this is another one this will solve. Then another one the figure 3.3 using nodal analysis, find the power delivered by each source in the circuits shown in figure your 33. So, this is the figure right. So, you have to find out the power delivered by each source of the circuit right.

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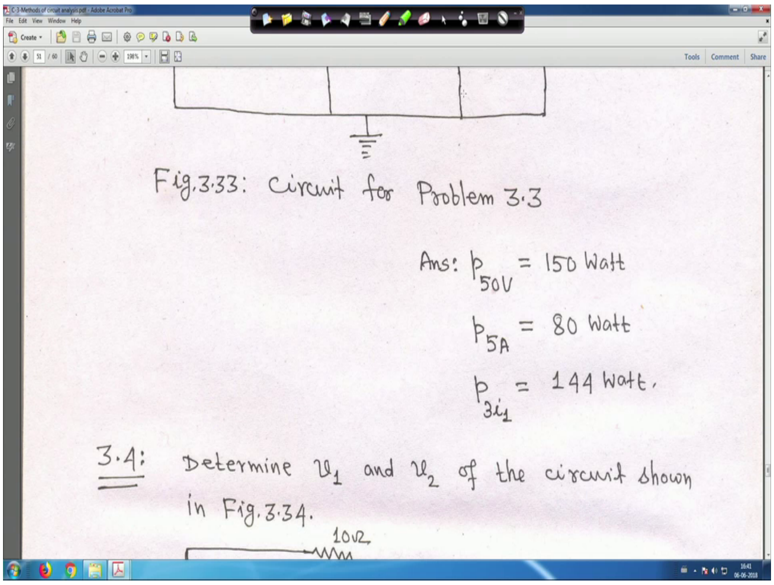

Next, these answers are given 150 watt; 80 watt; and 144 watt respectively answers are given. So, determine v 1 and v 2 of the circuit shown in figure 34.

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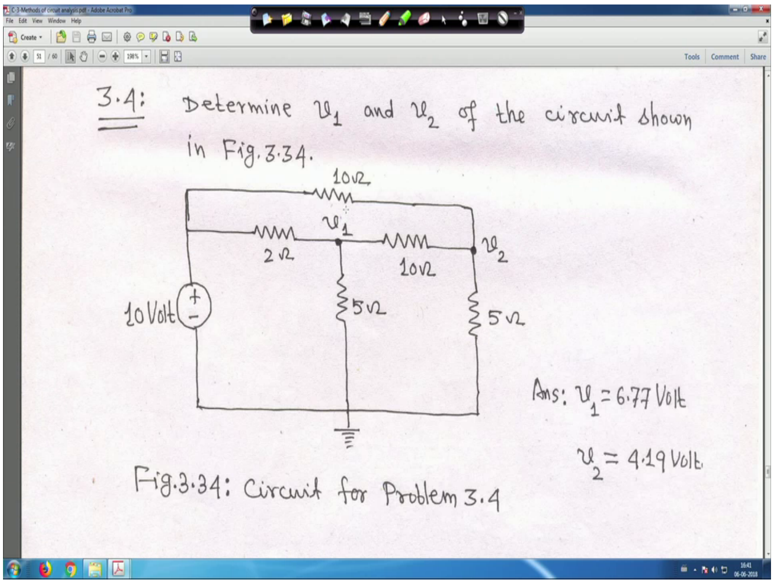

So, here also v 1 and v 2 you have to find out right answers are given. Hope all answers are correct. But, I suggest, if you find any error of these things, you please let me know such that, I can rectify answer right.

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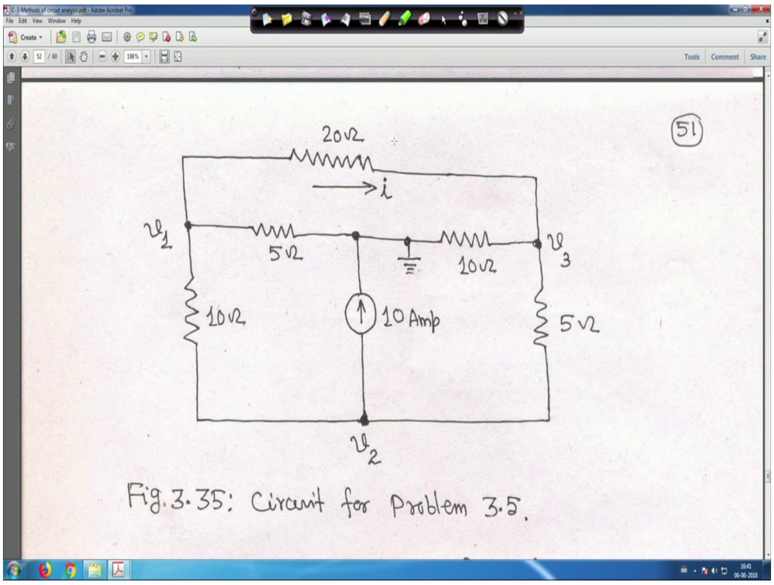

So, as example 5 you have to find out v 1, v 2, and v 3, and i of this circuit shown in figure 35. So, this is the 35 figure, you have to find out v 1 your v 2 here, I have asking v 1, v 2, v 3 and I, v 3, v 2 is here. Hold on v 2 do not over loop this, this is actually v 2 right. Here, it is given v 2. You have to find out v 1 v 1, v 2 and v 3 right, and i this i for this problem right. So, let me clear it.

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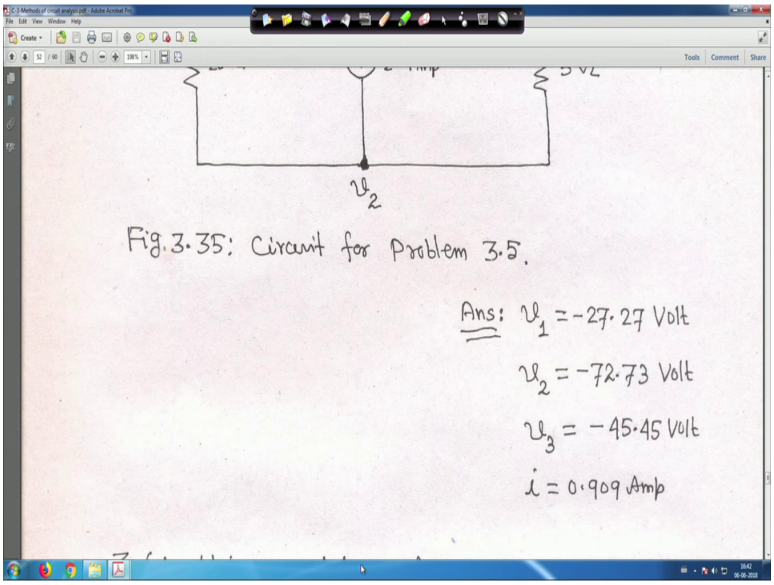

Here, something different, because generally (Refer Time: 21:52) but here it is given you find out. Answers are given, v 1 but note that v 2 is not a reference node that 0 potential nothing v 2 is equal to minus 72.73 volt, answers are given.

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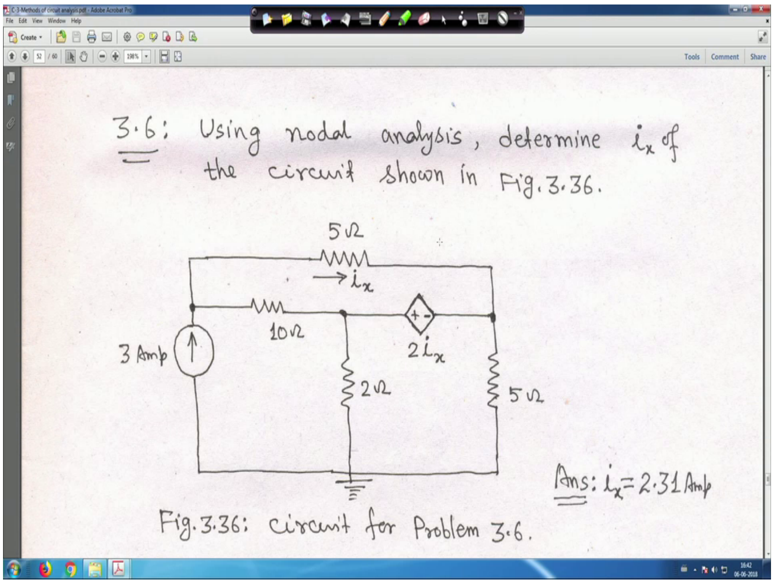

Then example 6 are using nodal analysis, you have to determine i x right of the circuit. So, i x is a dependent voltage source is there; and answer is given i x is equal to 2.31 ampere.

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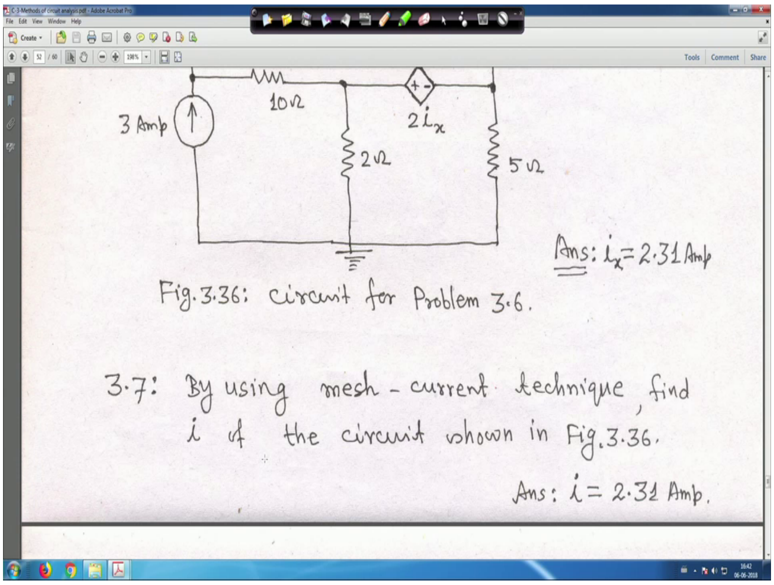

Similarly, for problem 7, the that example 7 find by using mesh current technique find i. Actually, it should be i x right, that is a nodal analysis actually this should be your i x right.

So, here it is a correction, this is should be suffix is i x right find i x. So, same figure that figure 36 means this figure same figure, and you have to find out and this is also your i x right. So, i x because it is also 2.3 answer has to be same, so 2.3 ampere. So, this is correction only right.

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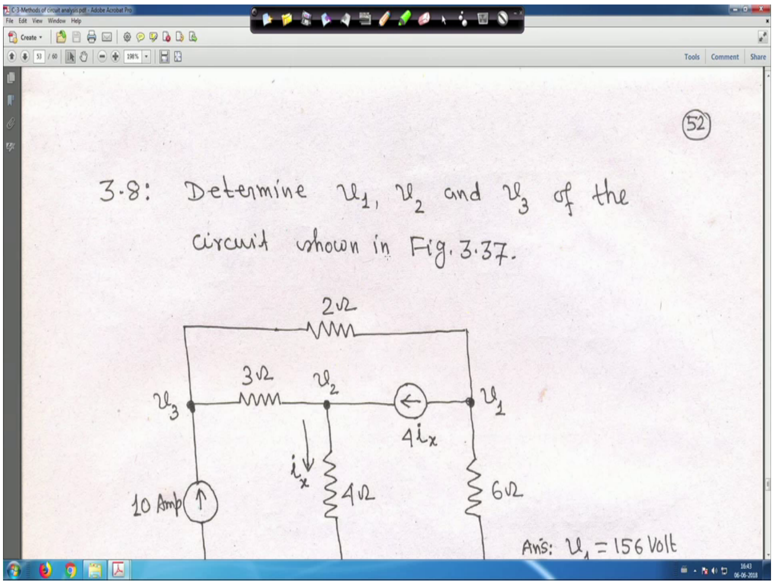

So, these you will this you will do it, so let me clear it right. So, this is your asking for your nodal analysis. And same thing is asking for mesh analysis right, both you will do. Then, 3.8 you have to find out v 1, v 2, v 3 of the circuit shown in figure this, so you have v 1, v 2, v 3 all marked.

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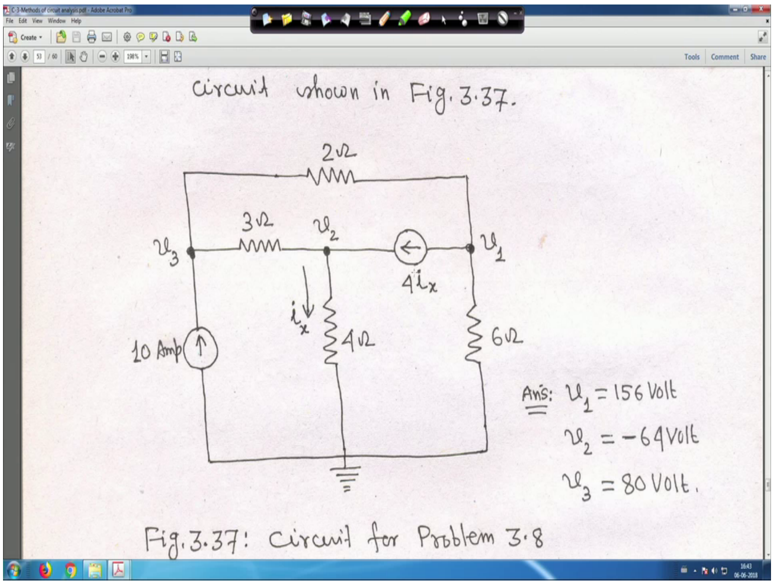

So, and a dependent and a independent your this thing 4 i x that is your 10 ampere thing is there, and a 4 i x your dependent current source is there right. So, just you all answers are given right. So, another thing is just hold on just hold on it is ok. And another thing is that your problem 3.9 using mesh analysis, you determine i x of the circuit right.

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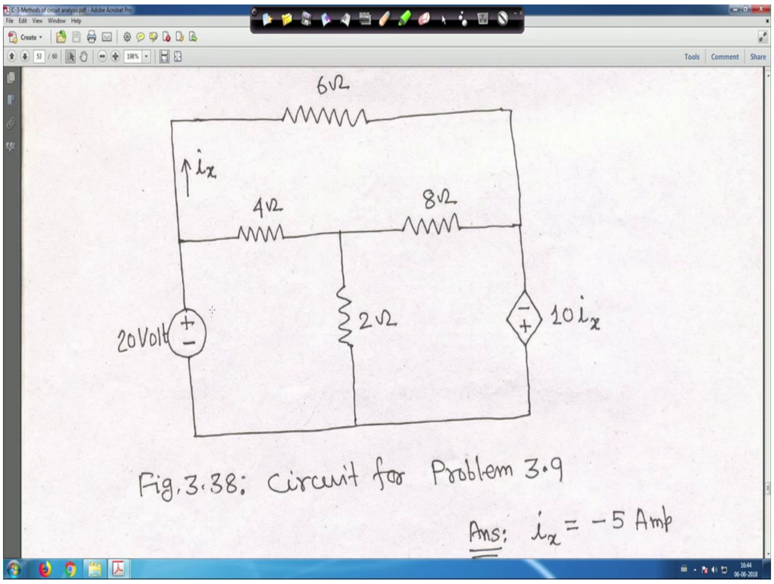

So, there is so dependent voltage source is there, and this current is i x. So, you find out this one. And answer is given i x is equal to minus 5 ampere it is given. A last problem I actually have many problems, but only this 10 I am giving for dc circuit only ac circuit problem will be reduce. So, using mesh current method determine power delivered to the 2, 2 ohm register in the circuit.

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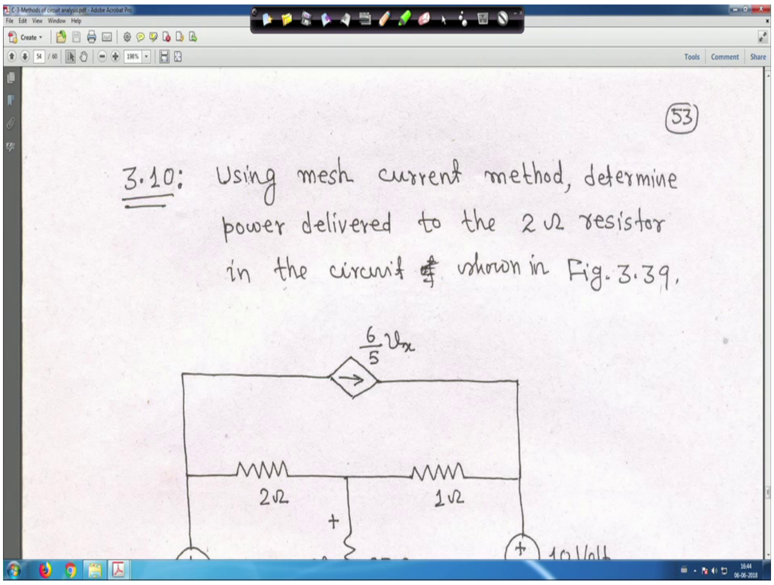

So, this is your what you call that your last problem 10. You have to using mesh current method; you have to determine that power delivered to the 2 ohm resistor in the circuit shown in figure this.

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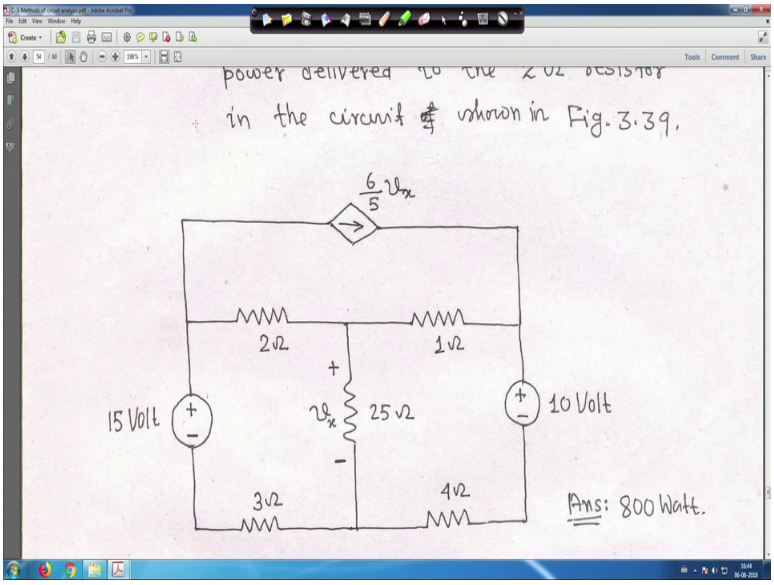

So, this is that figure right, so 2 independent your voltage sources are there one dependent your current source is there right. So, all these things I think here 1, just 1, just hold on I think here 1, this one your a sorry. Here, it is a dependent current source i because this i x, here you change the here you change these things thus it should be it should be 4 i x right. So this is the correction right so anyway.

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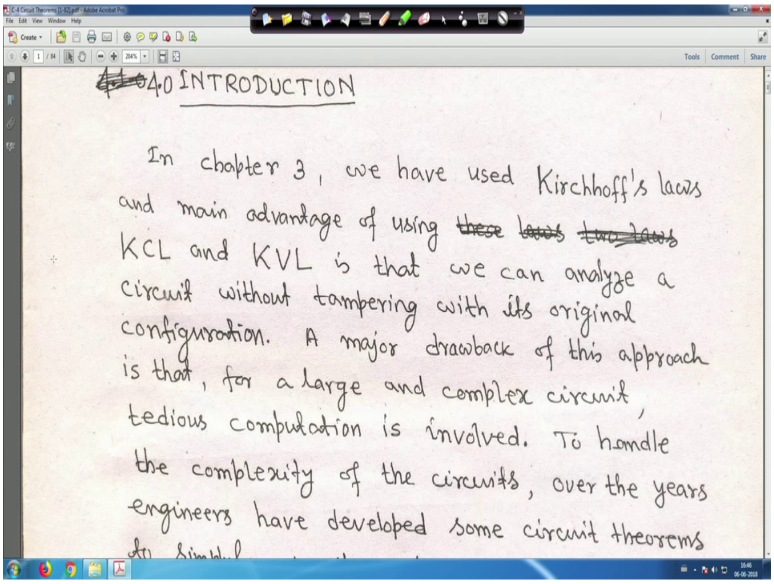

So, with this your this a this chapter will be close, so we will go to the next one right. So, hope detail have been made, so many examples have been solved. And I do believe that you have you have understood all these all these things right. So, next one will be your circuit theorem right. So, circuit theorems actually in chapter 3, we have seen that sometime we have used KCL and KVL right, and circuit analysis and you are tampering with this original your what you call without tampering its original configuration right.

But, in major drawback of this circuit user of this analysis your KC, your KCL, KVL there we are going for nodal and mesh analysis right, you have to a this thing you have to solve very large complex circuit right. So, over the years, and it is a tedious computation is involved; so handle the complexity of the circuit over the years engineers have developed some circuit theorems right.

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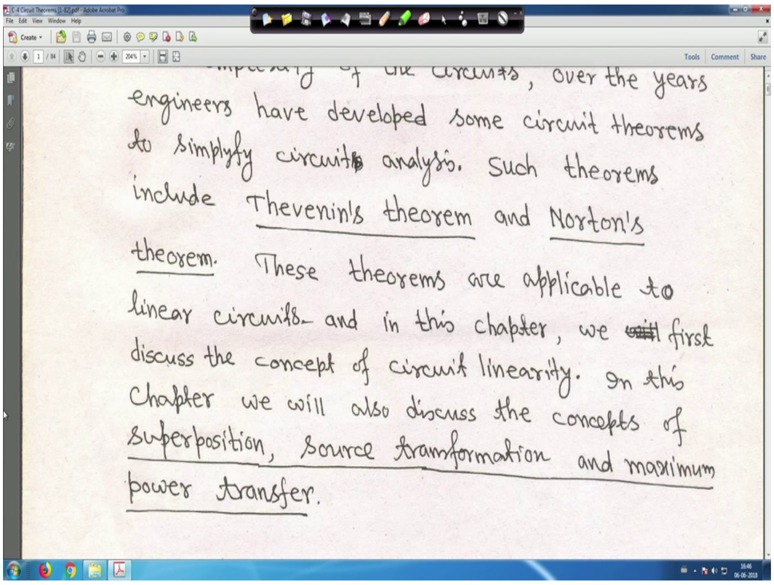

And, so such theorems are called sometime Thevenin's theorem and Norton's theorem right. So, these theorems are applicable to linear circuit. And in this chapter right, we first discuss the concept of circuit linearity and in also will discuss the concept of super position source transformation and maximum power transfer, I have underlined those things. So, here circuit theorem will learn Thevenin's theorem and Norton's theorem. Apart from that will learn super position theorem then your source transformation and the maximum power transfer condition right for the your for the dc circuit first.

So, whenever, we go for linearity property, so basically it is the property of an element describe a linear relationship between cause and effect. This you this you know even from your higher secondary physics this you know that is a property of an element describing a linear relationship between cause and effect right.

So, although linear property applies to many circuit elements right, but in this chapter, we will restrict it to the registers only because we have handling only dc circuit. So, the linearity property the combination of both the homogeneity property that is your scaling, the homogeneity property that is the scaling and the additivity property right. So, one is homogeneity, another is additivity right. So, this linearity property is a combination of both. So, just let me let me let me clear it right.

So, homogeneity property it requires that if the inputs it is called excitation. If the input your called excitation, here it is just you mark this one. If the input is excitation, and it is multiplied by constant, then output is also multiplied by the same constant. For example, where you make v is equal to i R say in ohms law right, then if you multiplied by constant k way increase way decrease, so KV is equal to K I R, so will come to that.

Thank you, we will again come to that.