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

Lecture - 16
Methods of Circuit Analysis (Contd.)

So we are back again, just before going to the next problem let me tell you for DC circuits, I have solving so many problems and I give for you, but it is DC circuits so, it does not take much time to solve, but when we will come to the single phase and 3 phases AC circuits, at that time number of examples will be less because their complex number will be involved right. So, that is why, but all, but theory, but whatever theories and your theorems, then laws whatever you are applying all this theorems we will see later right. So, all this things similarly applicable to AC circuits, but at that time examples will be small sorry number of examples will be less, but in DC circuit varieties of problem I am showing such that you should not have any confusion or any sort of problem. So, let us come to this problem right.

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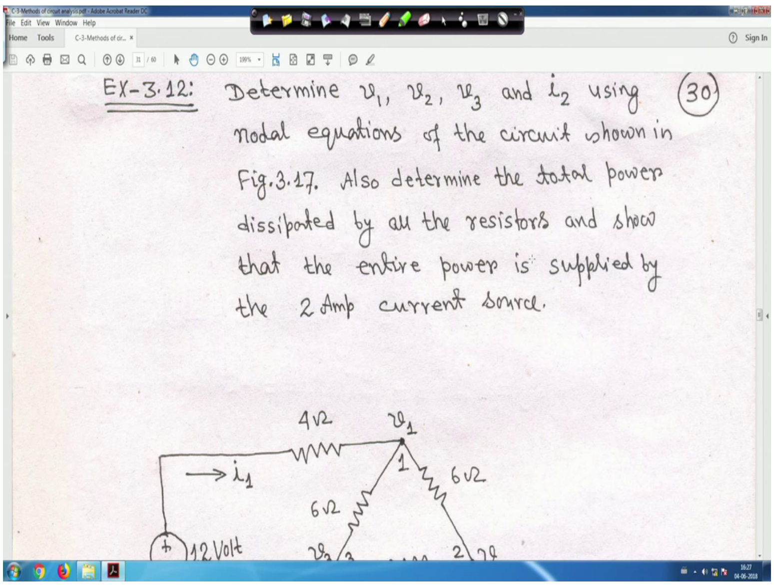

So, this circuit is like this. So, this is your example 12 right.

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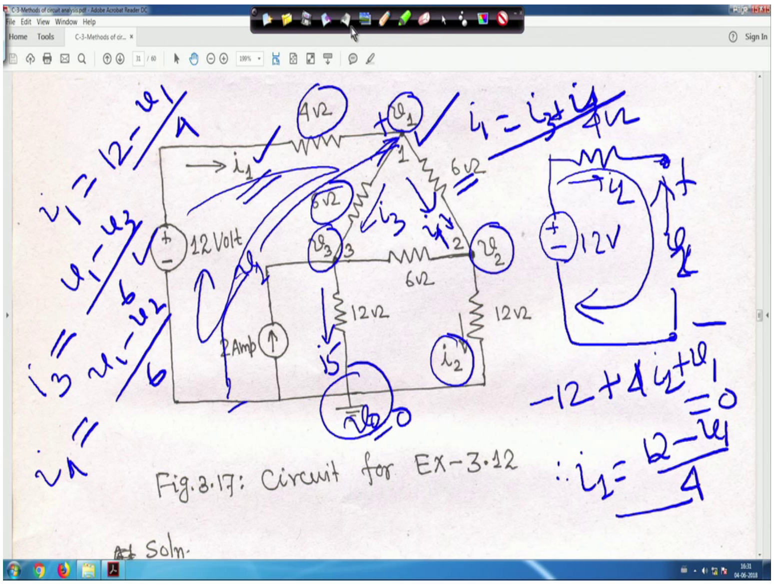

In this problem it has been asked, that just hold on it has been asked that you have to find out v 1 this is node 1 v 2 that is node 2 and then node 3 v 3 these 3 nodal voltages and then you have to find out this current i 2 right. These are the 4 quantities that we have to solve for this circuit right and here current is given i 1 other branches currents are not given, but we have to assume right some current and according to we have to solve.

For example suppose if this branch current is i 3, say I am taking in this direction, and this current say i 4 right and this current say if we take i 5 for example, right because later because so, many examples we have solved. So, later actually we did not write all i 3 i 4 i 5 anything in the problem directly we have written, but when we will make such things first thing is what will be the i 1, we have to understand look. At the beginning we have told any node voltage with respect to this reference node, this is ground. So, reference node voltage say v 0 is equal to 0 this we know.

So, first we have to find out the your what we call expression for v 1, just for your understanding looking at the circuit you may have some kind of thing, but if I make it separately actually this v 1 with respect to the ground; that means, suppose this is my v 1 and it is from here to here, it is from here to here right this is negative and this is your positive right. So, this way so, what you can do is first you apply your KVL like this. So, you apply your KVL like these right, you have apply KVL like this, if you have any confusion I can draw a different neat same diagram, but in different way. Say this is my plus minus; this is my 12 volt source; that means this one right.

And this is actually 4 ohm resistance this is 4 ohm; that means, this one right and this is your current i 1 and here this is your node 1 this point this point after 4 ohm this is your node 1, so, this point with respect to the reference ground that is why I have made it from here from here to here. So, this is actually your v 1 this is v 1 say plus minus.

Now, you apply this way you apply your what you call that KVL. So, it is encountering minus a terminal plus. So, minus 12 right plus 4 into i 1 this is 4 into i 1 this is 4 ohm and this current is i 1 then plus v 1 equal to 0; that means, my i 1 current will be your 12 minus v 1 divided by 4 right so; that means, here this current again rewriting here. So, i 1 is equal to your 12 minus v 1 by 4 this is my i 1 right.

So, first you have to apply your what you call that your KCL at node 1 this is node 1. So, if you take i 3, i 3 I 3 will be v 1 minus v 3 and this resistance is 6. So, it is v 1 minus v 3 by 6 this is your i 3; similarly for i 4 I mean here in this branch i 4 the resistance is 6. So, i 4 is equal to your v 1 minus v 2 v 1 minus v 2 upon 6 right. So, at this node 1, I am putting it here look i 1, this is the incoming current and i 3 i 4 is outgoing currents so, i 3 plus i 4 if you apply KCL right. Actually on this making all this exercise here itself, such that things will be understandable for you right.

So, now let me clean it. Therefore, I mean your just hold on if you.

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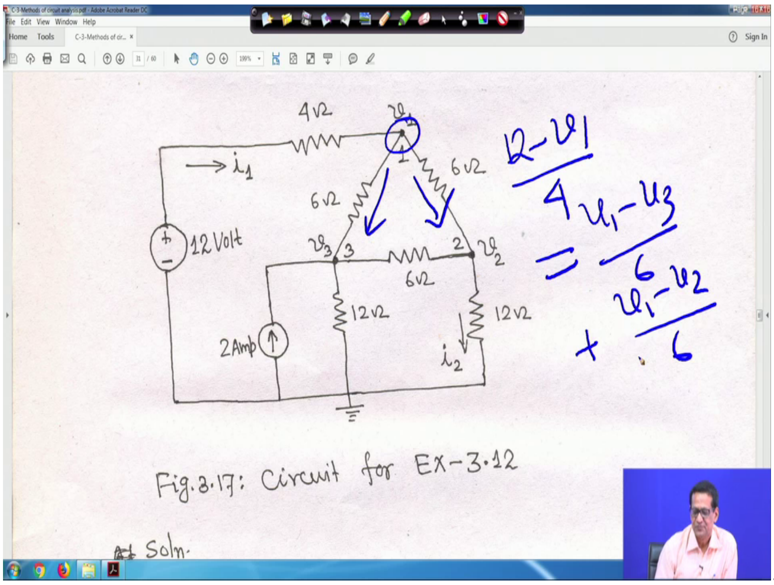

That means, if you apply your what you call KCL at node 1, so whatever we wrote it will be 12 minus v 1 upon 4 is equal to this v 1 minus v 3, directly you can write by 6 this direction is the current and this direction whatever just I wrote i 3 and i 4. So, this is i 3 and i 4 is actually plus your v 1 minus v 2 upon 6 right. So, this is your what you call that is KCL at node 1.

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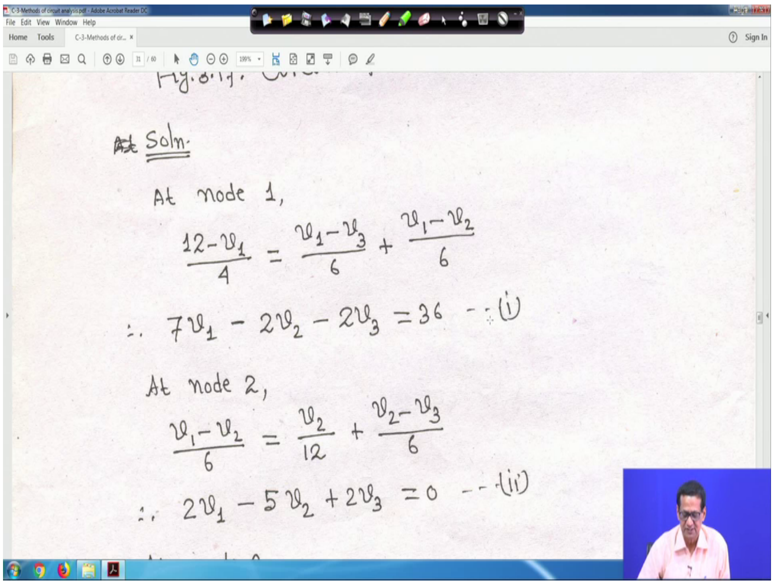

So, let me clear it right; that means, at node 1 this is the equation is written 12 minus v 1 upon 4 is equal to v 1 minus v 3 upon 6, right. Upon simplification 7 v 1 minus 2 v 2 minus 2 v 3 is equal to 36, this is equation 1. Similarly you apply your what you call that your KCL.

Student: Sir.

At just hold on, at KCL at node 2 here you apply right.

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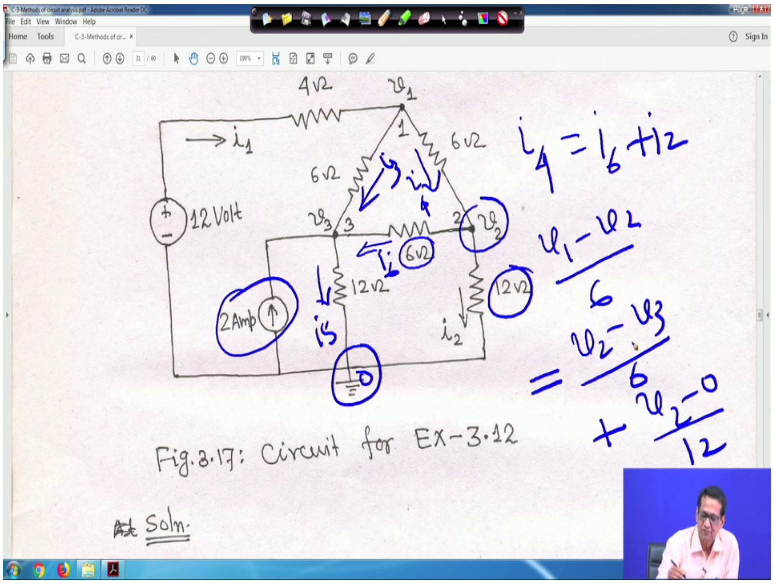

So, this current we took of this current we took of i 4 and this current we took i 3 right and this one we took i 5, one current source is there 2 ampere current source is there.

So, if you apply you have what you call this and it is i 1 i 5 another current here you can take here. So, if this current is here i 6, previously I did not see because it is becoming clumsy. So, if you apply your KCL at node 2, then this i 4 is incoming, so, this current is incoming that is i 4 right, but other current that i 6 and i 2 it is living the terminal is equal to your i 6 plus i 2 right.

So, because we are applying your what you call KCL at node 2.

So, in this case, so, i 4 is equal to your v 1 minus v 2 upon 6 is equal to your i 6 that is this branch current is i 6. So, it is v 2 minus v 3 upon 6 plus this is your ground potential 0 right. So, it will be and this is your what you call v 2 minus 0 divided by 12, because this is 12 ohm resistor. So, this is your if you apply your what you call that KCL at node 2 this is the equation. So, let me clear it.

So; that means, this is at node 2 this is the equation right. So, v 1 minus v 2 upon 6 is equal to v 2 upon 12 plus v 2 minus v 3 upon 6, we upon simplification you will get 2 v 1 plus 5 v 2 plus v 2 which is equal to 0 this is equation 2.

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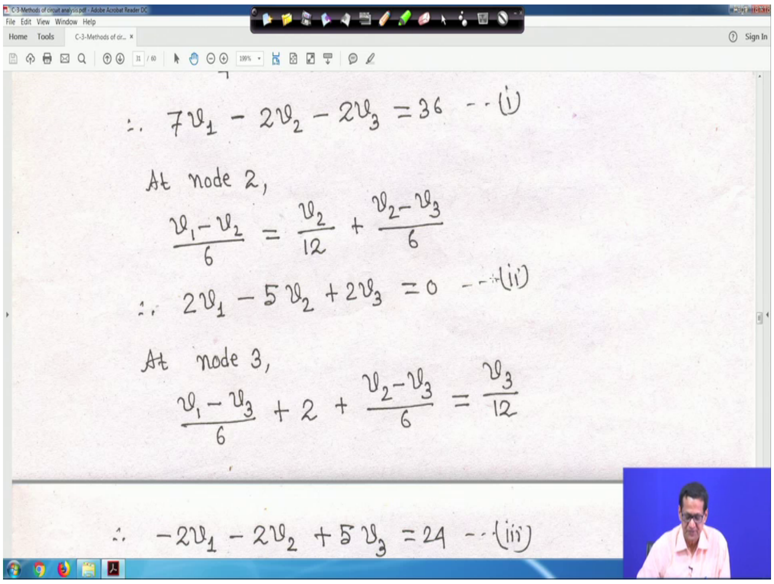

Similarly, at node 3 if you come at node 3, this is your this is your node 3. So, similar way you can apply your KCL so, not so beneath here because this 2 ampere current is entering right.

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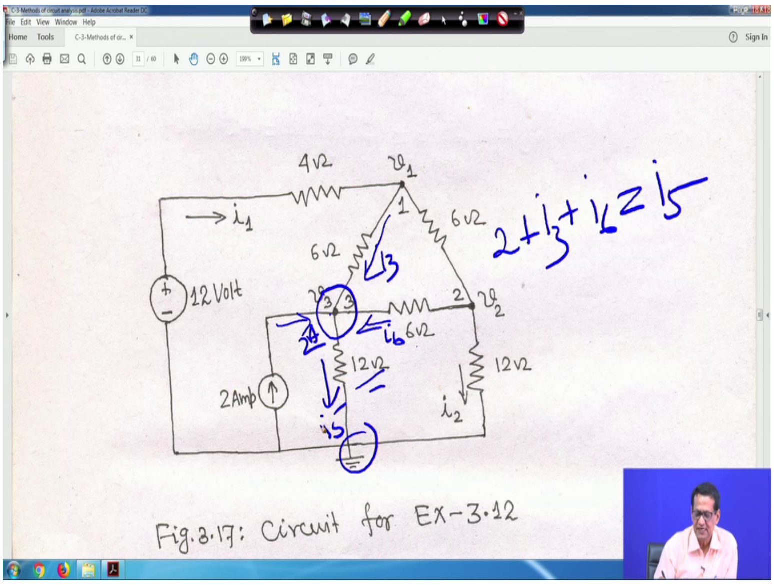

This is this 2 ampere current is entering into the node, and this one also that is your i 2 i 3 this i 3 is entering here right and another thing is this current i 6 also entering here and this current i 5 it is leaving this terminal.

So, basically it will be 2 because this 2 ampere current entering the terminal you has i 3 this entering plus i 6 is equal to your i 5 at you apply KCL at node 3. So, similarly; that means, you know i 3 is equal to your what you call v 1 minus v 2 upon i 6, and i 6 is equal to v 2 minus v 3 upon 6 i 5 is equal to your v 3 upon 12 right because here it is at ground potential. So, you put it and let me clear it accordingly you will get this one.

Right that is your at node 3. So, at node 3 this is your this is the equation right whatever I wrote. So, upon simplification you will get this equation 3, right. So, solve equation 1 2 and 3 the way you want clamors rule or anything you will get here.

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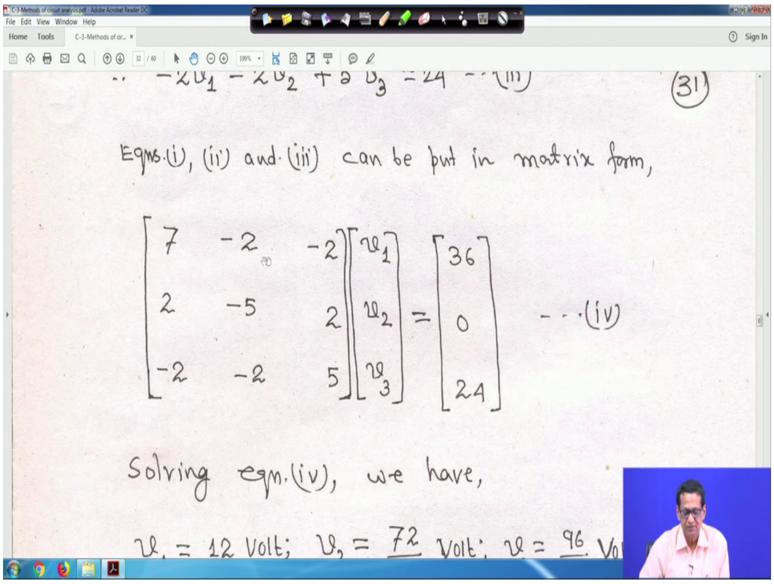

You have solve using the you can write in this forms, that your ax that is your x is equal to v, v 1 v 2 v 3 is equal to this equation. So, and you solve it the; however, you want Clamors rule.

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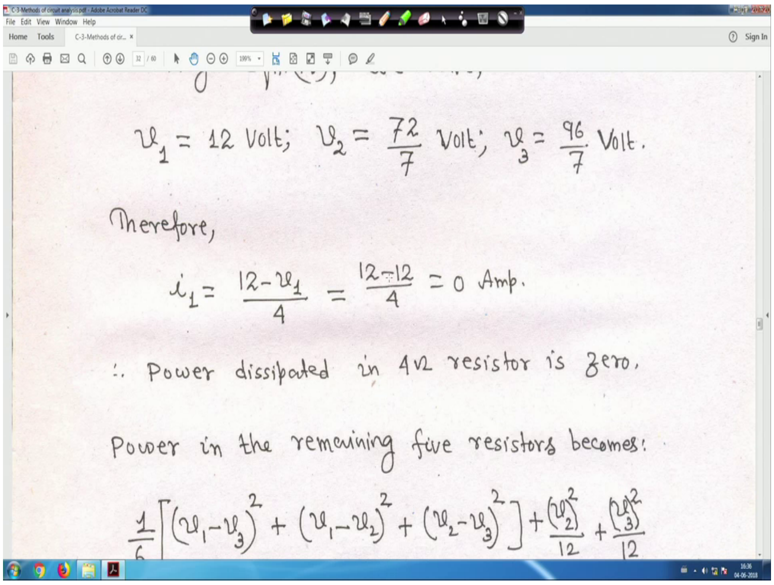

So, you will get v 1 is equal to 12 volt, v 2 is equal to your 72 by 7 volt this is your v 1 a just hold on this is your v 1 this is your v 2 72 by 7 volt and this is your v 3 and the current i 1 is 12 minus v 1 upon 4. So, basically it is 0 ampere current, and you have to find out power dissipated in 4 ohm resistor that is 0 right and second thing is that your what you call power in the remaining 5 resistor right

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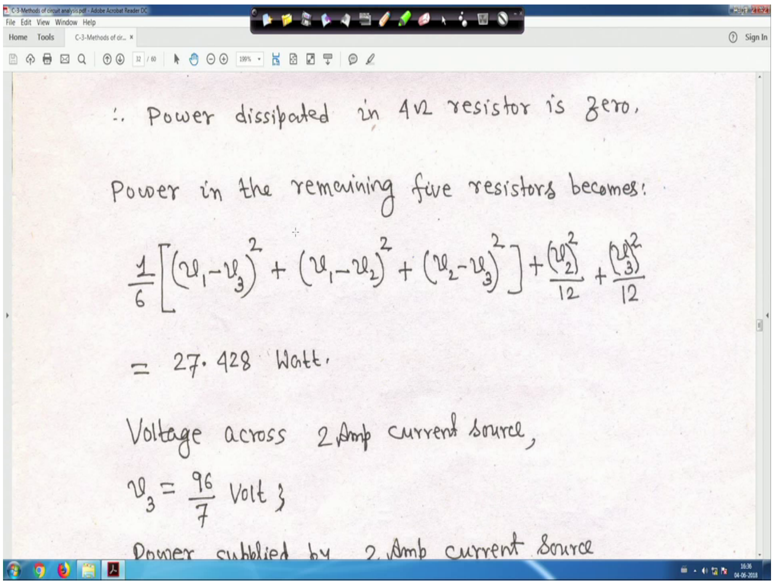

So, power in the remaining 5 resistor is your is your this I have written right just hold on. So, this there are 5 resistor 4 ohm 6 ohm 6 ohm 6 ohm and one you told that across that power because this i 1 current is becoming 0 so, i 1 is becoming 0 so, power dissipated here is 0 right. So, i 1 is 0 so, rest is 1 2 3 4 and 5 right the 5 resistors are there. So, this is and exercise for you I have written, but little bit you also do, this is an exercise for you this is the power in the remaining 5 resistor this is coming actually this the rest you please do it this is very simple things you please you please do this one right a very simple thing. Find out current in terms of your basically its i square r you find out general in general that v 1 minus v 2 upon whatever i is come and multiply by that I take is square and multiplied that r of that branch right. So, ultimately we will find that this way it will come. So, it is exercise for you and answer will be 27 point your 4 2 watts. So, volt is across 2 ampere current source also 96 upon 7 volt right and let me clear it.

And power supplied by 2 ampere current source is 90 it is v into i. So, v 3 is the voltage across the current source, this is your because if you look into the circuit that this v 3 this v 3 actually this actually this voltage is v 3 right.

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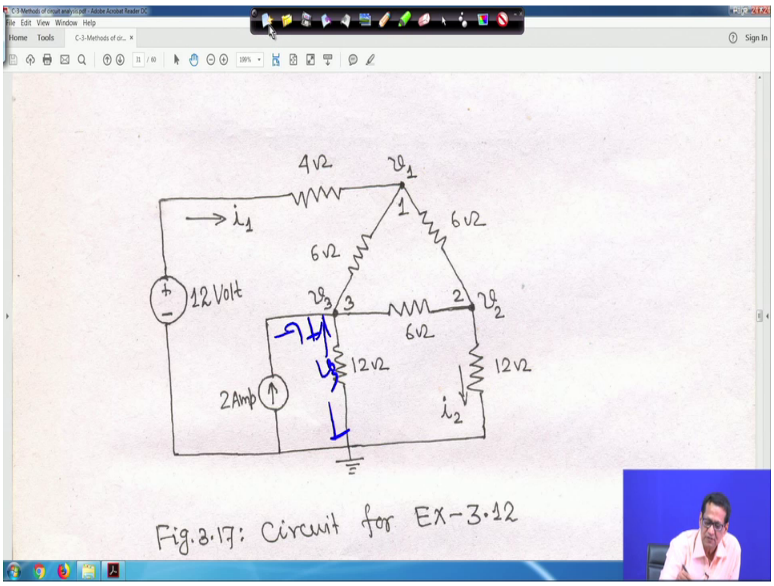

The way we write that let we clear it actually this voltage it is v 3, right so and 2 ampere current is entering. So, power supplied by the current v 3 into 2, right whatever it comes.

So, let me clear it. So, that is why that is why it is 96 by 7 into 2. So, 27.42 watt I look 227.42 watt here also. So, if you if you see that that all the power supplied by the current source, because in the circuit i 1 is equal to 0 i 1 is equal to 0; that means, power supplied by voltage source is 12 into i 1 but i 1 is equal to 0; that means, this voltage source is not supplied any power as per this circuit configuration is concerned right.

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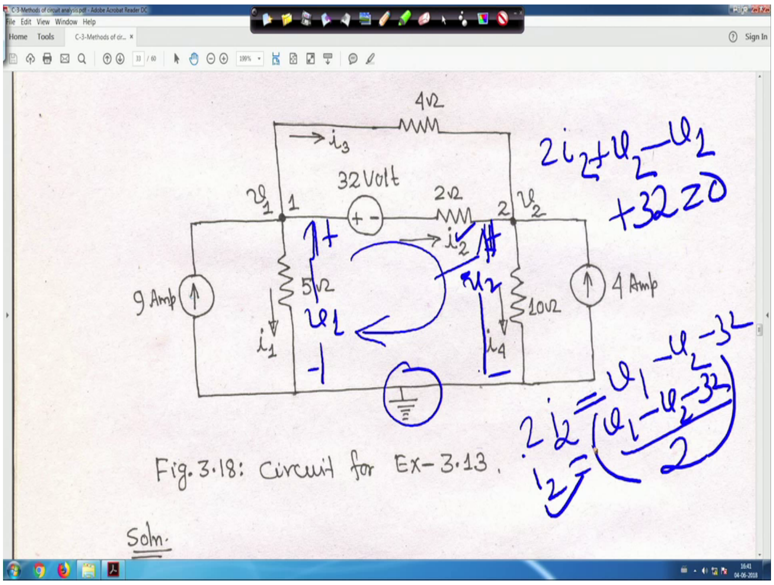

So, all the power supplied by the current source only right. So, this one now next you come to this problem using nodal analysis you determine v 1 v 2 i 1 i 2 i 3 and i 4 of the circuit as shown in figure 18 right this figure. So, here you have to find out that what is your what you call that your i 1 i 2 i 3 i 4 and v 1 and v 2. So, question is how to solve it look one voltage source is there eh in between you have 2 non reference node v 1 v 2 and one resistance is also here 2 ohm resistance right.

First you have to find out before moving that first we have to find out I have told you earlier also, first you have to find out that what is your what is your i 2 right. So, if you look into that this is reference voltage, this voltage any way is 0 v 0 0 and this is your v 1 and this is your v 2; that means, this voltage these voltage actually v 1 right this will take plus this is minus and this voltage this is another voltage is there this is v 2 right. So, this voltage v 2 right so, this is plus this is minus.

So, this voltage actually v 1 v 2 the nodal voltage with respect to the your with reference to the ground right. So, in this first you have to find out i 2 so, here you first apply KVL. So, we have taken clock wise you take clock wise or anti clock wise does not matter answer will remain same right. So, if you do so, if you do so, this way then look how things are coming first it will be your I am making it here say 2 into i 2, 2 into i 2 because this is the current i 2 here plus terminal here this is plus. So, it is plus v 2 plus v 2, then here it is minus it is encountering minus plus minus v 1 right then it is moving like this.

So, again encountering clock wise it is going encountering plus terminal plus. So, plus 32 is equal to 0 right; that means, here l am writing for you; that means, my 2 i 2 is equal to right it will be v 1 minus v 2 minus 32 right that is 2 i 2; that means, my i 2 is equal to v 1 minus v 2 minus 32 by 2 this is my expression for i 2 the first we have to understand that what will be the what will be the i 2. So, i 2 will be v 1 minus I previously also couple of such example are known we have taken. So, from that you can find out there should not be any scope of confusion right so; that means, i 2 expression because i 2 is needed, because we will apply KCL at node 1 and KCL at node 2 so, i 2 is needed. So, this is expression for i 2 v 1 minus v 2 minus 32 by 2, right.

So, let me clear it. So,; that means, now you have to apply your what you call that your KCL at node 1 see if we apply right if we app if we apply your KCL at node 1 node 1 right.

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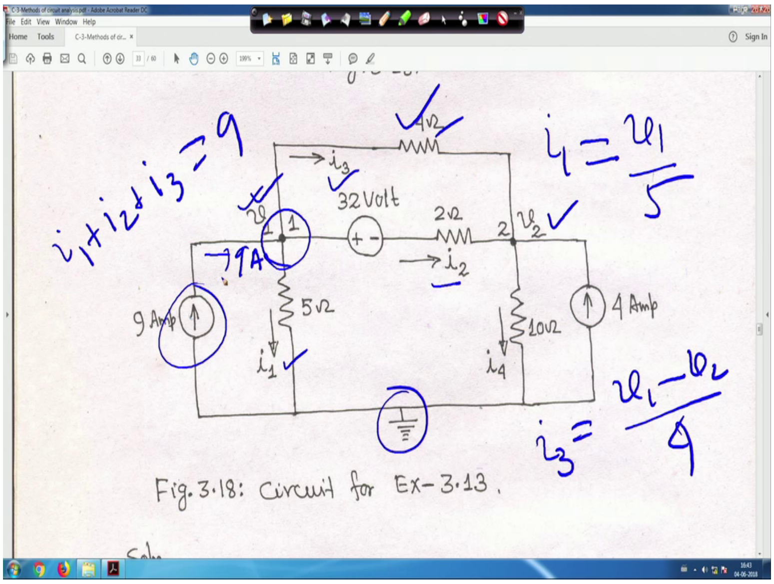

So, 9 ampere this is the 9 ampere current source. So, 9 ampere current is entering here this is 9 ampere right.

Now, you have to right down i 1 i i 2 we wrote right. So, basically if you apply this 9 ampere current is entering into the node. So, and other this i 3 then i 2 and i 1 all are leaving the node so; that means, it if you write it should be i 1 plus i 2 plus i 3 is equal to 9 right. So, because we are applying this 9 ampere is entering this i 1 i 2 i 3 are leaving the node 1; that means, i 1 i 2 I told you therefore, i 1 i 1 is equal to this is v 1 this voltage reference ground potential 0 so, basically i 1, I writing here for you. So, i 1 is equal to your v 1 upon 5 right this is v 1 upon 5 and then your i 3 i 3 is flowing like this it is v 1 4 ohm it is v 1 to v 2, the 4 ohm resistance is connected. So, here I am writing your i 3 is equal to v 1 minus v 2 v 1 minus v 2 divided by this 4 right. So, put i 2 expression I have told you then put i 1 i 2 i 3 everything is equal to 9 this will be the first equation right in terms of your what you call that your v 1 and v 2 right then. So, let clear it right.

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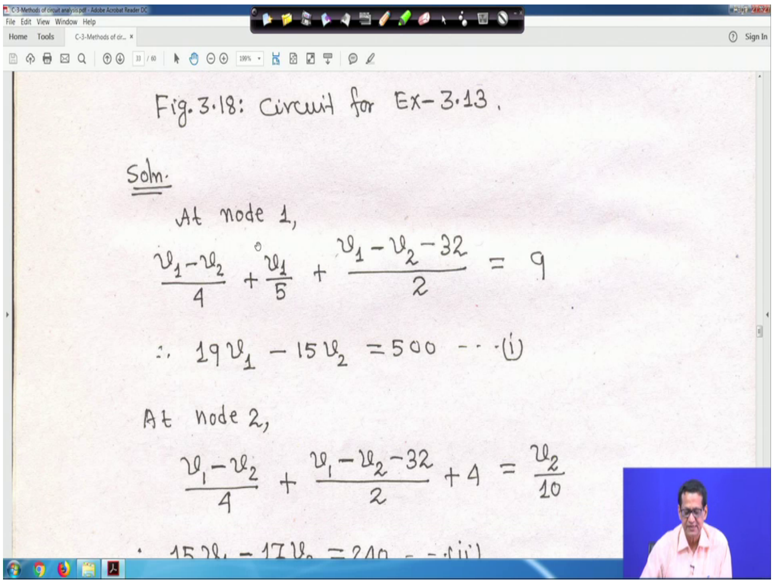

So, if you do so, then this is your at node 1 and this equation right whatever I said right and this is your what you call, this is your this is that equation this is that equation right is equal to 9. So, I i 2 I told you v 1 minus v 2 minus 32 by 2.

So, if you simplify. So, this is your equation 1 right similarly you apply KCL at node 2 let me clear it, right now I am little bit slow, but later we have to you know increase just increase the speed otherwise it will difficult to acquire the time now next one is your node 2. So, this is your what you call that 4 ampere current is entering into this node.

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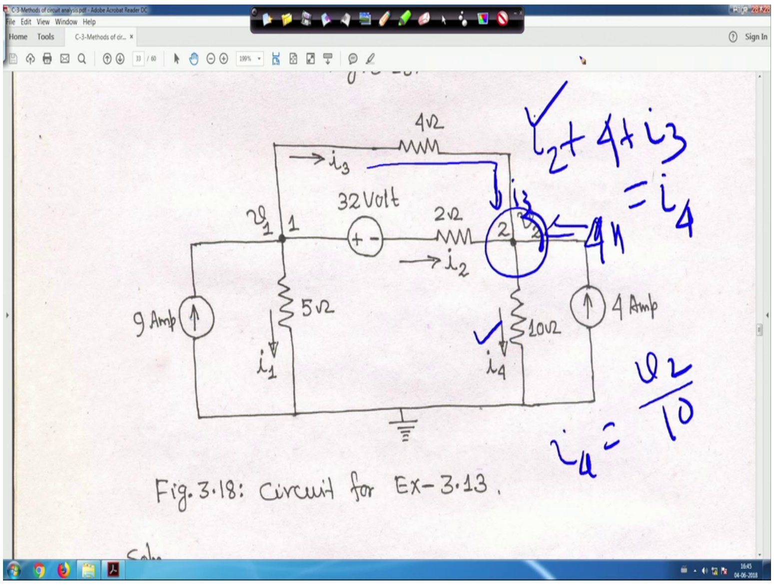

This is 4, right and after that you apply your what you call that your KCL look 4 and i 2 I 2 and 4 ampere this 2 are entering into the node. So, i 2 plus 4 this 2 are entering right now another one is there i 3 also entering this current i 3 is also entering I three. So, plus i 3 right is equal to this i 4 is leaving is equal to i 4. So, 4 plus i 2 plus i 3 is equal to i 4. So, i 3 we have written v 1 minus v 2 upon v 4 right and your i 4 is equal to your i 4 is equal to it is simply you can write v 2 minus 0 upon 10 basically it is 0 upon 10 this is i 4 right and your i 2 expression already we have got v 1 minus v 2 minus 32 by 2 right. So, substitute all then you will get this things. So, let me clear it right.

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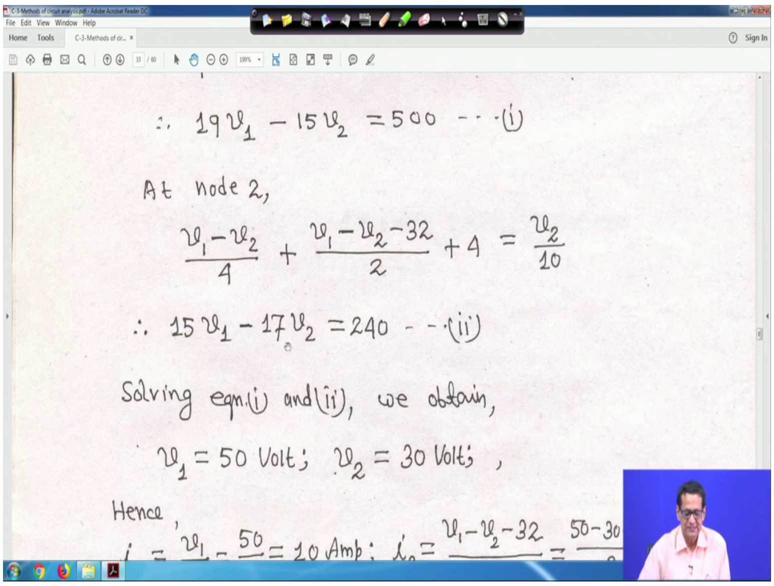

So, at node 2 this is that equation right. So, after simplification you will get 15 v 1 minus 17 v 2 is equal to 40.

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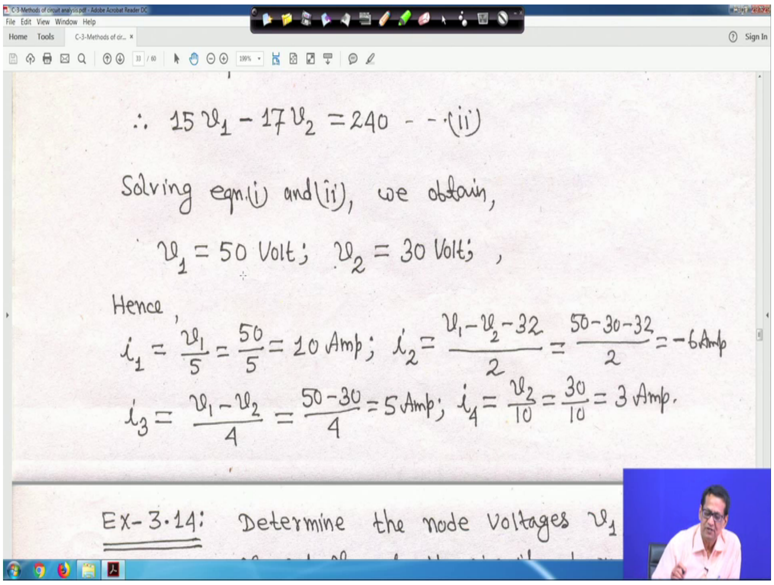

And you solve equations 1 and 2 you solve because only 2 unknown v 1 and v 2, if you solve you will get v 1 is equal to your what you call this 50 volt right v 2 is equal to 30 volt and i 1 is v 1 by 5. So, we solve i 1 10 ampere, i 2 v 1 minus v 2 minus 32 by 2 so, it is i 2 is equal to minus 6 ampere; that means, current is actually flowing in other direction whatever direction shown in the circuit, it is shown in the other direction then i 3 is equal to 5 ampere and i 4 is equal to 3 ampere right. So, there is nothing your a what you call there should not be any confusion solving the this you get whenever, also deriving difficult problem simple problem all set of things we are considering so, let me clear this right.

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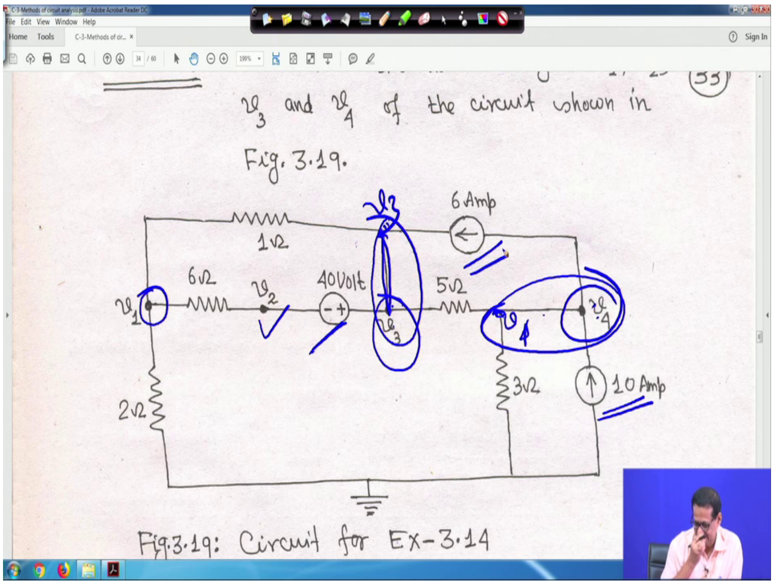

So, next one is determine the node voltages v 1 v 2 v 3 v 4 of the circuit shown in figure this 19 right. So, we have to find out v 1 v 2 v 3 v 4, listen. This is there are certain thing that you have to little bit. Before you solve the problem look at the problem carefully before doing anything this is actually a common node because its basically these 2 are connected together if it is v 3 this is also v 3 right.

Similarly, these 2 nodes are common node, because there is no electrical element in between this 2 similarly this point and this point it is same right because no electrical element is there. So, basically here it is 4 means here also it is v 4, if it is node number 4 means this is also 4, right. Another thing is that an intermediate point v 2 also it has been asked you find out right. So, v 2 later we find out basically we have to see the how many nodes are there basically we have 3 node; one is here first we look into this one is here and another is here v 3, another is the v 4 all these things we apply KCL right. So, then after solving this you when you find out the current another thing then you can easily compute v 2 that will see. So, basically if these nodes are common this 2 are it is a common node, similarly these is common node little bit you have to first understand looking at the circuit and the you can solve it because no electrical element is involve between in this wire and here also right.

With this let me clear it and of course, here you have a one voltage source here and here you have 1 current source here also you have one independent current source right. So, let me clear it so let us go to the next one or directly I am writing, then here actually because we have solved so, many problems. So, here we are writing that apply KCL at node 1 like look if you apply KCL at node 1 right first thing is this is your ground potential just let me add just it little bit hope it is right.

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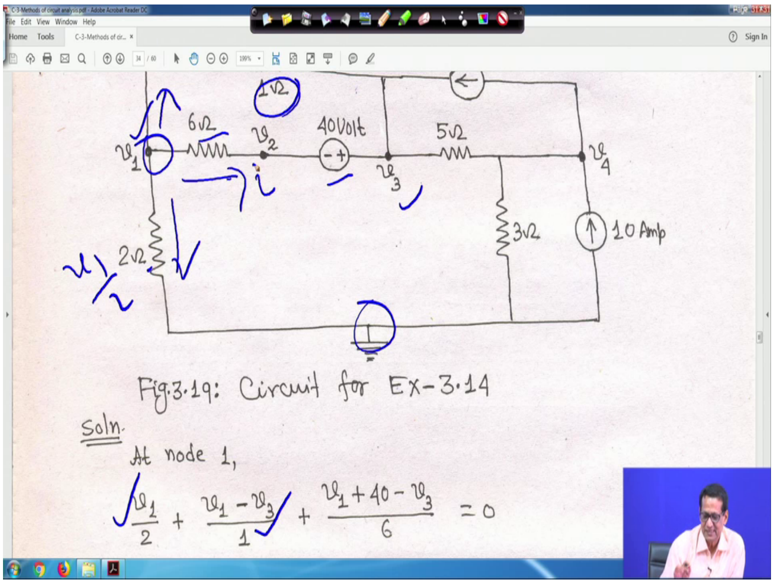

So, now no question of i 1 i 2 nothing is written. So, if you look into that that this is your ground potential. So, at node 1 this is your node 1 you apply this thing. So, one is that your v 1 your upon 2. So, this current is leaving say this current is v 1 upon 2 this is 2 ohm resistance this is v 1 upon 2, right. Another thing is this v 1 and v 3 and here you have one ohm resistance, it is it is g 1 up, but you bring down the circuit will one ohm resistance. So, if the current is going out here also right it will be your what we call that your v 1 minus v 3 upon 1. So, this is v 1 minus v 3 upon 1 right plus another current is going right.

Similarly, like previous one you have here also one 6 ohm resistance and 140 volt source is there so in this case similarly you find out what is your this current for example, if I take current flowing this thing is i if it is a i right let me clear it a clean this thing then it will easier for you right.

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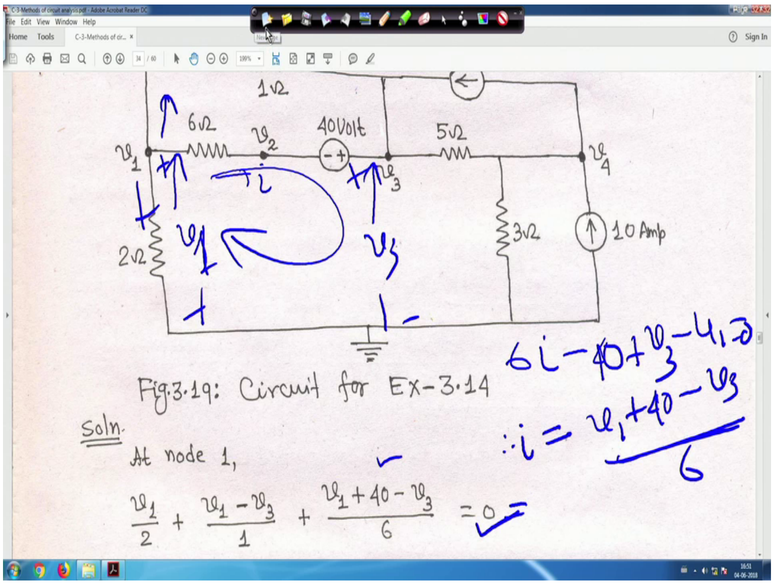

Suppose this current this current is i and this is respect to ground; that means, that means this voltage actually v 1 this is v 1 right plus minus and similarly this voltage your plus and this is v 3 this is minus right just hold on this plus means this voltage plus this is the voltage source is there.

Now, what you do? You apply KVL in the clockwise direction if you do so, then it will be 6 into i 6 into i then minus it is encountering minus for a terminal plus that is your minus 40 then minus 40right plus v 3, because it is encountering plus terminal plus v 3 then here it will be minus v 1 minus v 1 is equal to 0; that means, your I is equal to it will be v 1 plus 40 minus v 3 divided by 6 this is your i. So, all this current this current this current and this current leaving the terminal so, that is v 1 by 2 plus v 1 minus v 3 by 1 plus this i we have taken, v 1 plus 40 minus v 3 upon 6 that is equal to this is equal to 0 I hope you have understood this right. So, let me clear it. So, similarly at node 3 and node 3 and node for listen this is not here should not apply this is actually just intermediate point you have been asked this is v 1 v 3 and v 4 this 3 nodes are there.

Similarly, v 3 and v 4 you please apply your what we call that your KCL right and then accordingly you please your you please solve it. So, I have explained everything to you.

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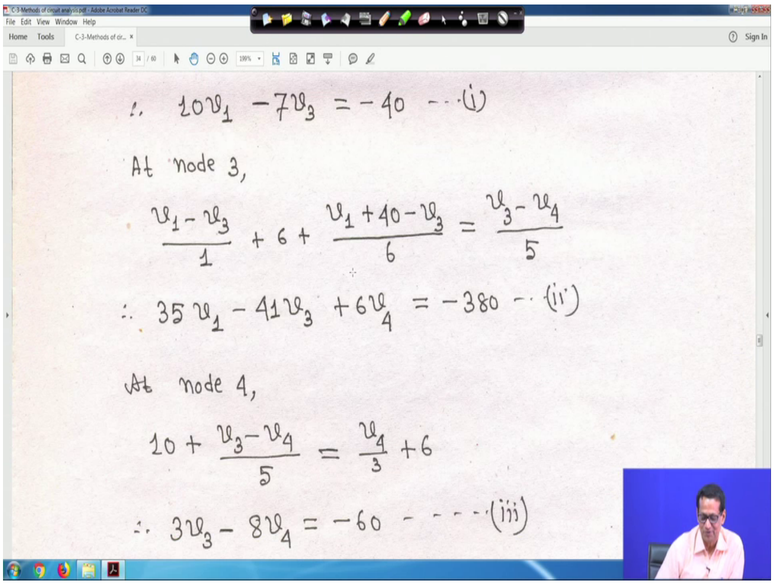

So, similarly if you write at node 3 and node 4, then you will get this equation right, node 3 if you write you will get this equation, and node 4 if you apply you will get these equation right. So, finally, upon simplification this one this is equation 1 this equation 2 and this is equation 3. So, at node 3 you will apply let node 4 you apply KCL, I am not writing further I hope you have understood everything and please do it right. So, because so, many examples similar type and different how to take it have been explained so, this way you can take it. So, if you solve this one if you solve this one then you will get your v 1 is equal to 10 volt v 3 is equal to 20 volt and v 4 is equal to 15 volt.

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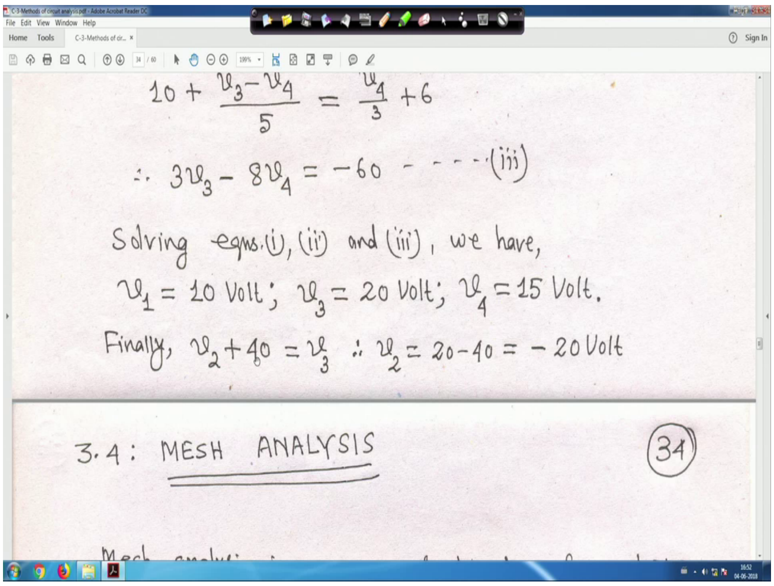

Finally, you have to find out that what is your v 3 v 2 has been asked to find out right, this v 2 has been asked to find out your find out. So, if you try to find out your v 2 say this one.

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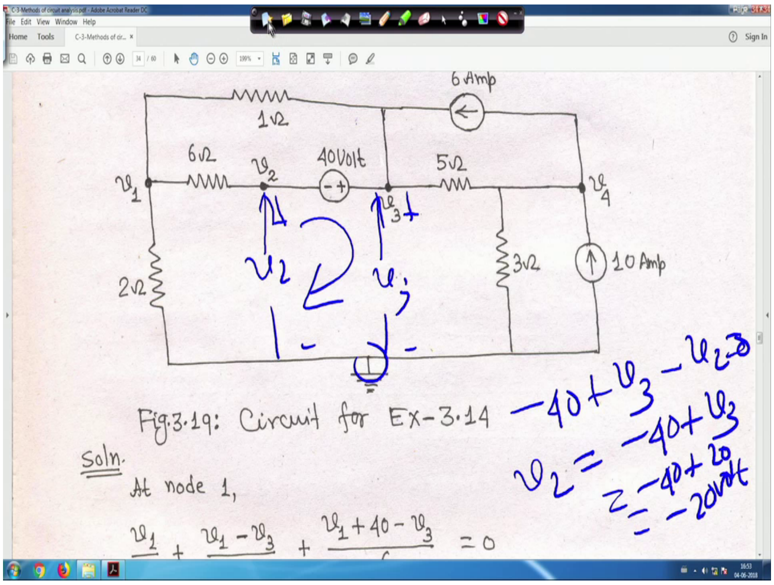

So, if you if you try to find out v 2 say this is my v 2. So, plus minus you take and this is your v 3 say plus minus this is ground potential right and you take KVL like this. So, it will be minus 40 because it is if you go clock wise, minus terminal encountering plus v 3 minus your v 2 minus v 2 is equal to 0 right because we have to find out v 2 therefore v 2 is equal to your minus 40 plus v 3 right. So, I think v 3 will might have got 20. So, it is 20. So, it is minus 20 volt that is v 2, right. So, let me clear it right.

So, here your v 2 is equal to 20 minus 40 minus 20 volt because v 2 we got your what you call v 3 you got 20 volt because I told you that v 3 you got 20 volt. So, ultimately it is minus 20 volt hope you understood how to compute the voltage at any point right. So, what you will do is for your just for your own practice suppose if it is suppose something is here it is given these volt or that volt right what you can do is, for your this thing you find out how much power is supplied by the this is not given in the problem I have also, but I have also not solved let find out how much power is supplied by this 6 this 6 ampere current source, this 10 ampere current source, and this 40 volt voltage source right.

So, you find out that how much power and then power absorb in the each resistor you see, then you make that your power absorbs is equal to power supplied whether it is correct or not if you get matching, then your answer is correct otherwise somewhere some calculation error is there. So, this is an exercise for you should do it right. So, with this node voltage analysis is over, next will go for mesh analysis right.

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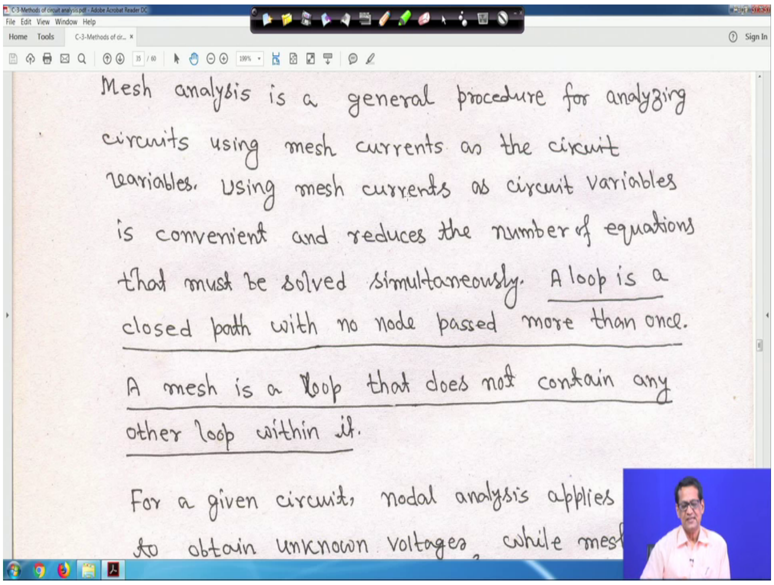

So, mesh analysis is a general proceed your for analyzing circuit using mesh current as the circuit variables. Actually whether you use nodal analysis or mesh analysis actually it depends on your what you call that in probably observation you have see that where number of equation will be less such that your competition (Refer Time: 29:59) will be less right. As the circuits variables using mesh current as circuit variables it is convenient and reduces the number of equations that must be solved simultaneously.

So, a loop is a close path with no node I have underlined this, a loop is a close path with no node passed more than once. If mesh is a loop it does not cut any other loop within it right. So, later I will tell you what is the loop sometime loosely we talk mesh are loop, but slight difference is there right. A mesh itself is a single loop right, but in a loop there may be other loop also right, but whenever the mesh is a single loop there may not be any other loop inside it, but in a loop there may be other loops also later will see that.

So, that is why a loop is a close path with no node pass more than once. If mesh is a loop it does not contain any other loop within it right. So, this there is a slight difference between your loop and then node right loop and the mesh. So, this is mesh and this is loop right so, just let me clear it.

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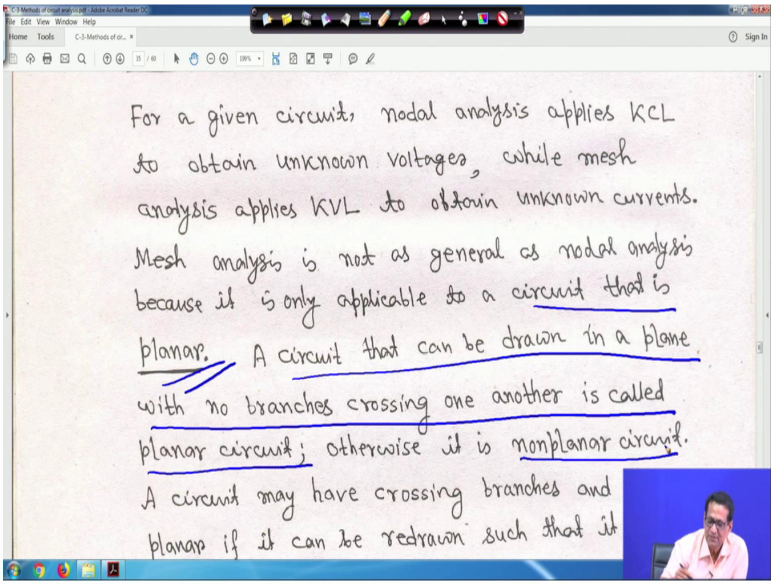

So, for a given circuit nodal analysis actually we apply KCL, to obtain unknown voltage while mesh apply KVL. So, nodal analysis also we have seen we have applied KCL, for mesh analysis we go for KVL to obtain the unknown currents.

So, mesh analysis is not as a general as nodal analysis because it is only applicable to circuits, that is actually planar right that is actually applicable to a circuit that is actually planar circuit right. The circuit that can be draw in a plane actually that can be drawn in a plane actually with no branches crossing one another is called planar circuit right. So, a circuit you can draw it in plane and with no branches crossing one another is called planar circuit otherwise it is non planar circuit you cannot apply your mesh analysis right.

So, let me clear it we move little bit up right. So, in circuit so, just one minute. So, is. So, circuit your what you call we have crossing branches, may have crossing branches, but still if planar if it can be redrawn such that, it has no crossing branches. Suppose diagram is given it is crossing branches, but you can if you can redraw such that there is no crossing branches, then circuit may be planar right.

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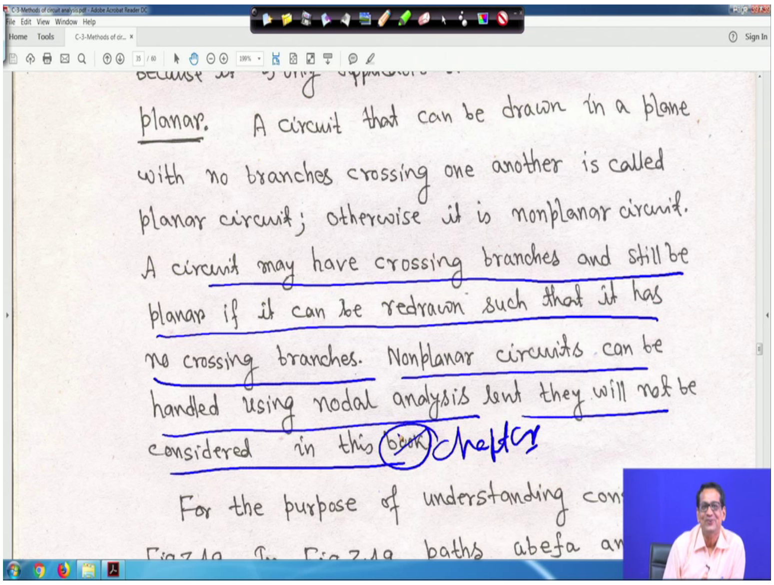

So, non planar circuits can be handled using nodal analysis, but they will not be considered here, it is written book actually book is not written it is actually you read it as a chapter, few places you will get it is a book, but book is not there not completed right. So, you read it as a chapter, do not treat as a book right.

So, analysis that will not be consider in this chapter right.

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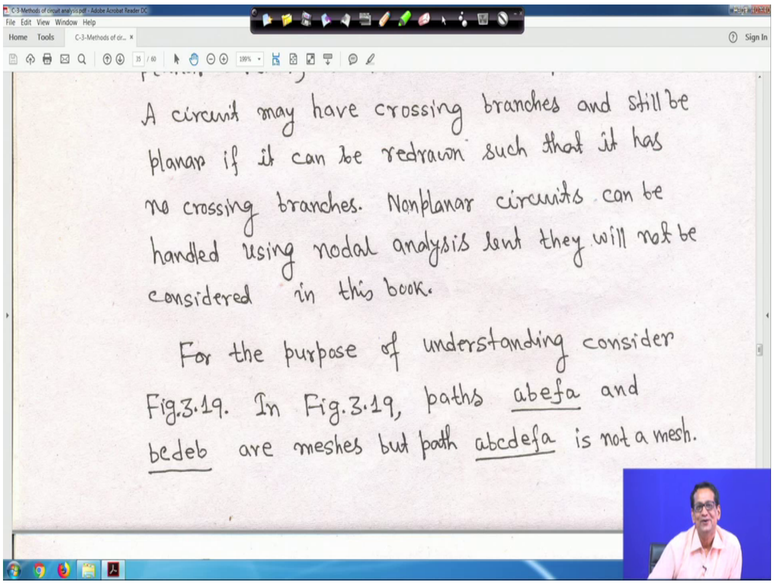

So, for the purpose of just one minute for the purpose of understanding, so, books should not be written many places you may find, but please read it as a chapter. For the purpose of understanding, consider you have to consider these the path right.

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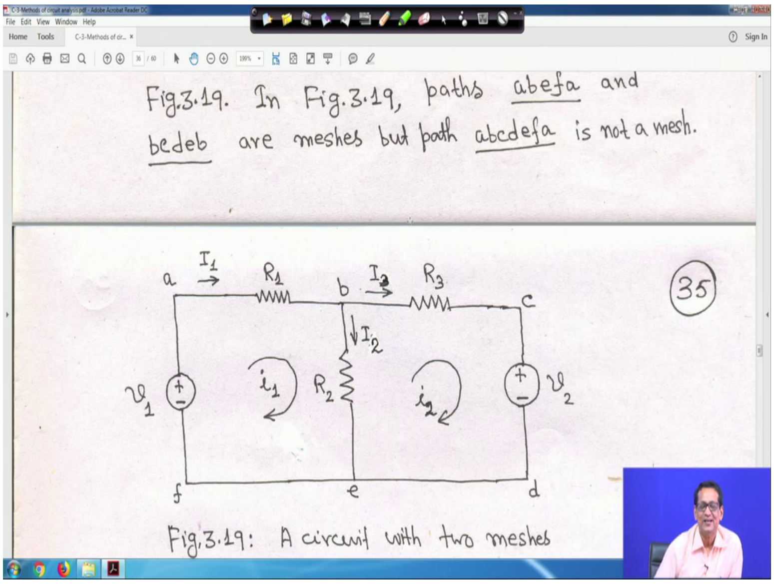

And then we will see the difference between mesh and loop but.

Thank you very much we will be back again.