Fundamentals of Electrical Engineering
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Lecture - 15
Methods of Circuit Analysis (Contd.)

We will come to the next example right. So, using the node voltage method, determine the currents of the circuit as shown. Now we are thinking about super node later we will see after few examples again we will see after one or two example we will see now super mesh right. This is not a node voltage analysis we will see mesh analysis also and then here we will apply mesh and we will apply node we will discuss those things right.

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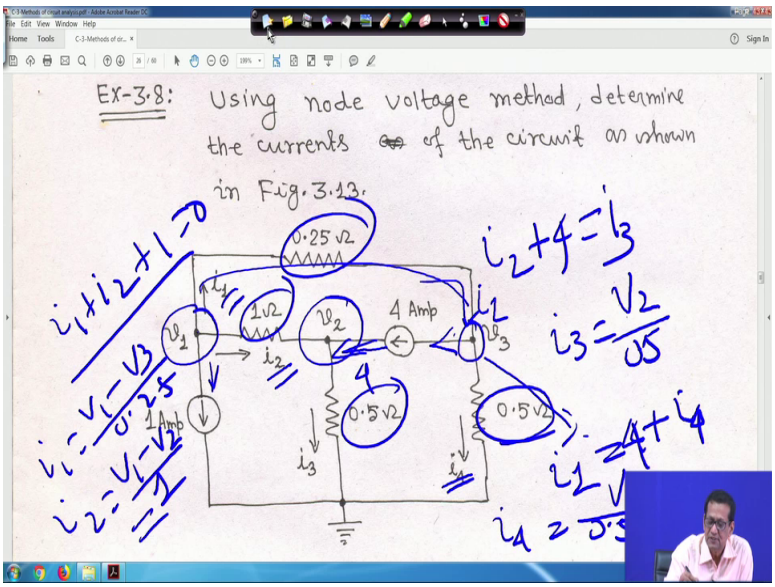

So, if this circuit is given right you have to find out the currents of these whatever is given right. So, you are using the node voltage method, you have been asked to find out the current.

So, this is actually one current source is here, a 4 ampere current source is here, another 1 ampere current source is here and rest all the resistive circuit and this is your reference node potential is 0. So, again and again I will not write that v 2 minus 0 or something it is understandable right. So, you have node 1, you have node 2 and you have node 3 and v 1 v 2 v 3 voltages are there, but you have to using node voltage method you have to find out the current that is i 1, i 2, i 3 then your i 4 right.

So, first is you apply your what you call KCL at node 1, first let me clear it right. So, first you apply KCL at node 1. So, if you apply KCL at node 1, look this i 1 current and i 2 current and 1 ampere current all are leaving this node. So, your equation should be your i 1 plus i 2 plus 1 equal to 0, this is one equation right later we will and if you see what is i 1; i 1 will be this i 1 is flowing like this it is going like this. So, i 1 will be v 1 minus v 3 by 0.25. So, i 1 is equal to v 1 minus v 3 by 0.25 because this 2.25 ohm right.

Now, similarly i 2 is equal to i 2 is here. So, i 2 is equal to v 1 minus v 2 by 1 because it is 1 ohm right. So, if you substitute we will come later we will see the solution how thing, but this is the equation. Now similarly if you apply at node 2 that KCL then this 4 ampere current is entering into the node 2 right; that means, this i 2 plus this 4 because this is a current source independent current source i 2 plus 4 is equal to i 3 right.

So, i 2 expression is given here right and i 3 and i 3 is equal to your v 2 upon 0.5, v 2 upon 0.5. Again v 2 minus 0 I am not writing because the resistance is 0.5 that is your i 3 right. So, next is you apply here that KCL here at node 3. So, this current 4 ampere current is leaving right and this current this your i 1 current this is your i 1 current entering into the node, because this is your i 1 entering into the node. So, this is your i 1 right and is equal to other 2 currents are leaving.

So, it is equal to 4 plus your i 4, 4 plus i 4 right i 1 i 2 i 3 all is going to i 4 is equal to your this i 4 is equal to write here I am writing i 4 is equal to this is v 3 divided by 0.5 because the resistance is 0.5 ohm. So, all is given next we go to the solution let me clear it right. So, all this things are written at node 1 I wrote you substitute all in terms of these right.

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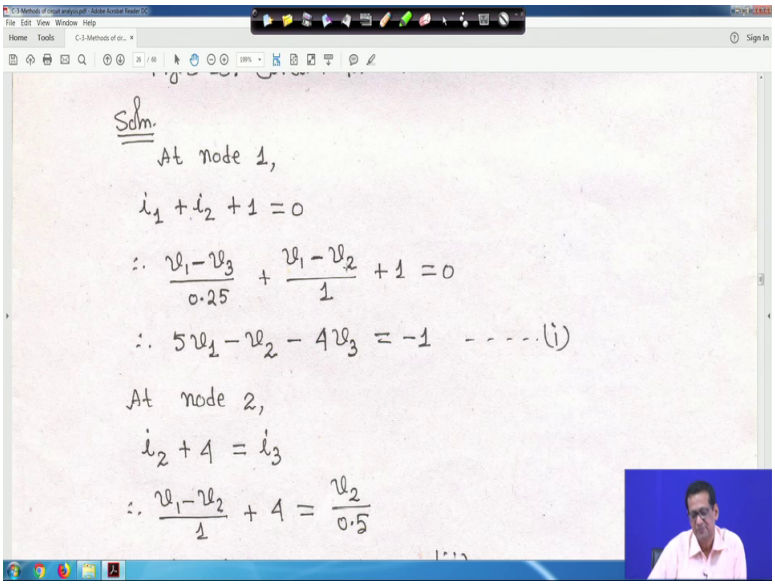

Similarly, at node 2, I this things I wrote. So, you put all these things, all these things I told right similarly at node 3 I wrote this thing, you put all these things right all this things you put right here also and simplify this your this one you put it and simplify you will get 5 v 1 minus v 2 minus 4 v 3 is equal to minus 1. This is equation 1; this at node 2 also I wrote for you, now you substitute here, you will get v 1 minus 3 v 2 is equal to minus 4, this is equation 2, at node 3 also i 1 is equal to 4 plus i 4.

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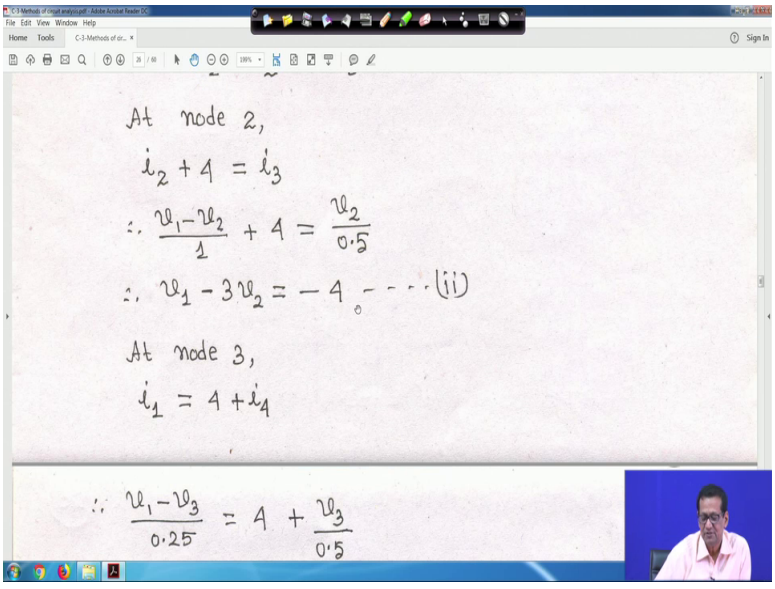

So, you substitute all i 1 and i 4 simplify you will get 2 v 1 minus 3 v 3 is equal to 2.

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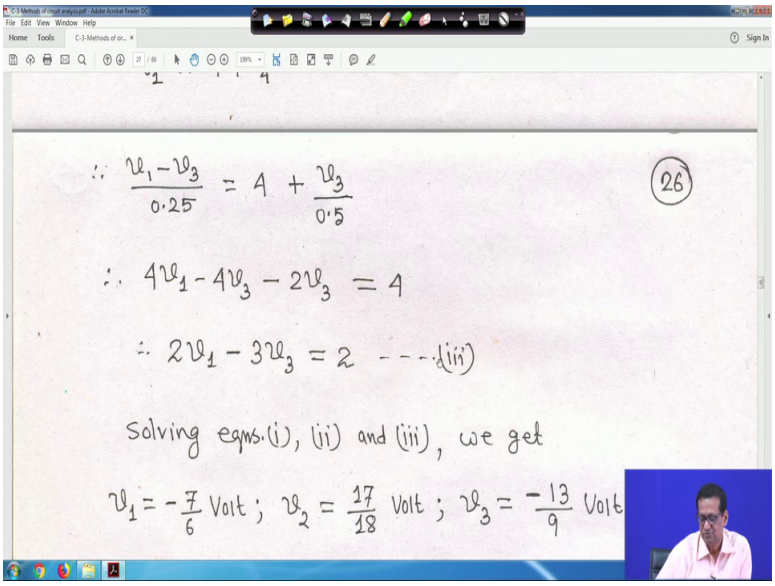

Now, the way you want you solve solving equation 1 2 and 3 you will get v 1 is equal to minus 7 by 6 volt, v 2 is equal to 17 by 18 volt, v 3 is equal to minus 13 by 9 volt.

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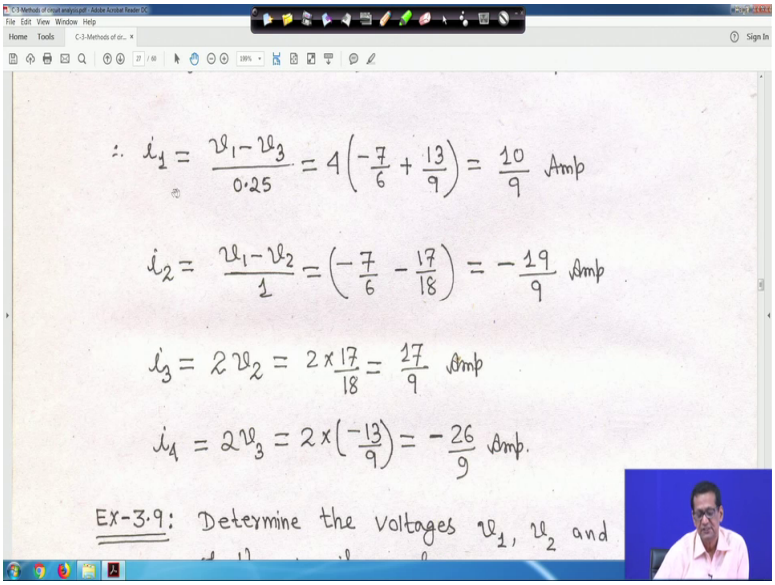

Then you calculate all the current i 1 is equal to v 1 minus v 3 by 0.25 all these things I have told, it is 10 by 9 ampere; i 2 is equal to v 1 minus v 2 upon 1 it coming minus 19 by 9 ampere i 3 is equal to 2 v 2. So, it is coming 2 into your 7 by 17 by 18. So, 17 by 9 ampere and i 4 is equal to 2 v 3 so, 2 into minus 13 by 9, so, minus 26 by 9 ampere right.

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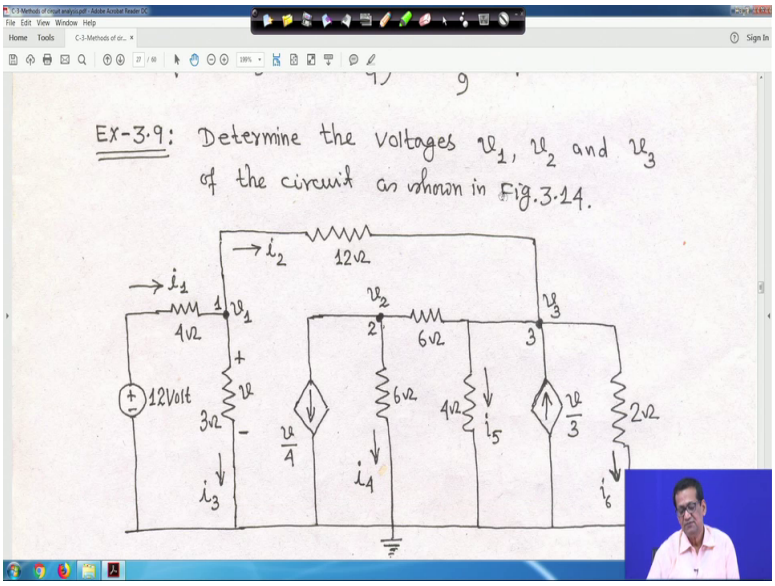

Next is another example, here determine the voltages v 1 v 2 and v 3 of the circuit shown in this figure right. So, little bit you know complicated circuit to we will observe right. So, all this is you have find out v 1 v 2 and v 3. So, listen this is your node 1 this voltage is v 1 right and this is your node 2 voltage is v 2, this is your node 3 voltage is v 3 and volt this one voltage v is here, v actually is equal to 3 into i 3 from Ohms law, because the resistance is 3 ohm this voltage is v right.

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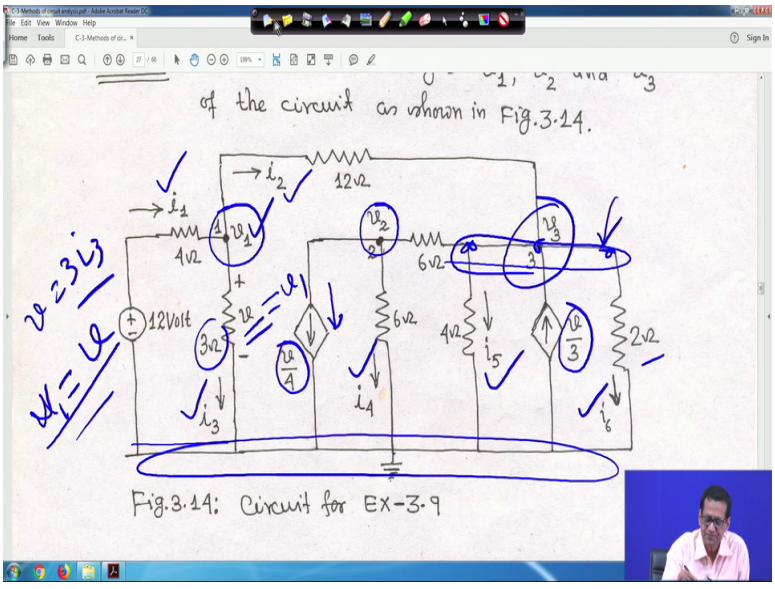

And as this voltage is v and this volt this is your reference node right this is your reference

one this ground, potential is 0, right. So, v 1 actually v 1 actually is equal to v. So, this is your v 1 and this voltage is given v. So, basically v 1 is equal to also 3 i 3 so, is equal to v. So, v 1 is equal to v. First thing we have to understand this right. So, v 1 is equal to v and 2 your dependent current sources are there based on this v 1 is this is one dependent current source, current is flowing this direction is v by 4.

Another dependent current source is there the current is here v by 3, right and second thing is at there is no electrical element here and nothing. So, basically these are at this is a single node that is node 3 right, either this point either this point or this point or this point this is node 3 because it is a common thing; that means, this 4 ohm then this dependent your what you call that current source and this is 2 ohm all are in actually connected parallel and right they are connected to node 3 to the reference point right.

And therefore, what we have to do is, that look this is the current i 1 right, this is current i 2, this is current i 3, this is i 4, this is current i 5 and this is current i 6 right, so, you have to solve this circuit. Now first is to get your what to call the expression of your what you call i 1, I told you earlier also let me clean it this. So, this, whatever I have mentioned I hope this things are understandable to you know. So, v 1 actually is equal to this v, v 1 is equal to v I told you there right.

So, now, we have to solve this circuit. So, let me clear it. So, first thing is that you have to obtain i 1 first you have to obtain i 1 and before sorry before applying KCL before applying KCL, first you obtain i 1 so, same philosophy.

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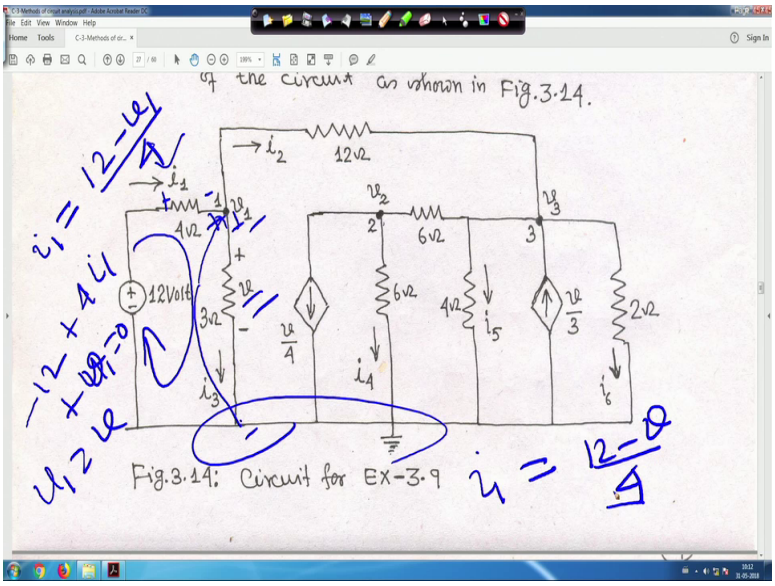

So, this is a plus, this is your what you call this is your ground right. So, you apply clockwise say your what you call that KCL. So, it will be if I write here it will be minus 12 right then it will be plus 4 i 1 right, I am not putting polarities this is the thing resistor plus 4 i 1, then encountering plus terminal first I told you several time right. So, plus v 1 is equal 0 right.

That means here I am putting on top that is your i 1 is equal to it is 12 minus v 1 by 4 right, but v 1 is equal to v 1 is equal to v; that means, I am making it somewhere here; that means, my i 1 is equal to 12 minus v by 4 right. So, you take KVL that is minus 12 plus 4 i 1, then plus v 1 is equal to 0, but put v 1 is equal to v right because earlier I told you that here v 1 is equal to v, because this is v this is v 1. So, same thing so, it is 12 minus v by 4 that is your i 1, this is the first thing rest are simple right.

Now, at node 1, node 2 and node 3, but remember that here it is a dependent current source in terms of v so, automatically your problem will be easily solved. For example, i 6 will be your v 3, for example, here i 6 will be sorry.

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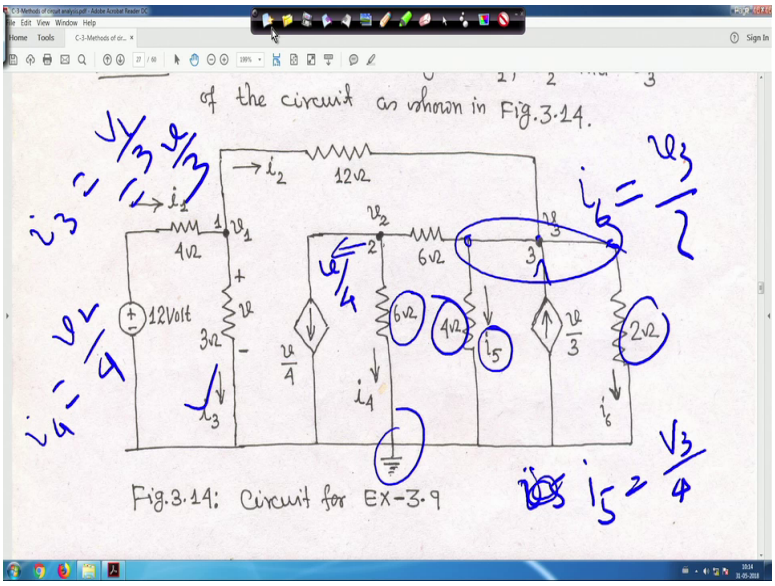

So, i 6 will be is equal to v 3 by 2 easily you can make it because this 2 ohm resistor reference, this is ground reference potential is 0 so, v 3 by 2 that is your i 6 right. Similarly if you your what you call, if you try to find out what will be your i 5 right.

So, i 5 this is a common node, this is all this node this node this node the same thing node 3. So, your i 5 making it here i 5 that will be is equal to v 3 by 4 because this is your 4 ohm resistance is there, that will be your i 5 is equal to v 3 by 4 right and this v by 3 current it is entering right when we will apply KCL, accordingly it can understand. Similarly this from this v by 4 this current dependent source is leaving right. Similarly when you try to find out i 4 when you try to find out i 4 it is actually v 2 by 6 because 6 ohm resistance is here.

So, it will be v 2 by 4 right similarly if you try to your find out i 3, i 3 will be actually is equal to it is v 1 by your 3 that is nothing, but v by 3 that is your i 3 because this is your i 3 right because v 3 v 1 is equal to your v. So, and similarly your i 2 if you just let me clear it, I hope this things are easy now understandable to you right.

And similarly if I let me clear it right and similarly if you see the i 2 this flowing from node 1 to node 3 this is your i 2 it will be actually v 1 minus v 3 by 12 because this is 12 ohm resistor right.

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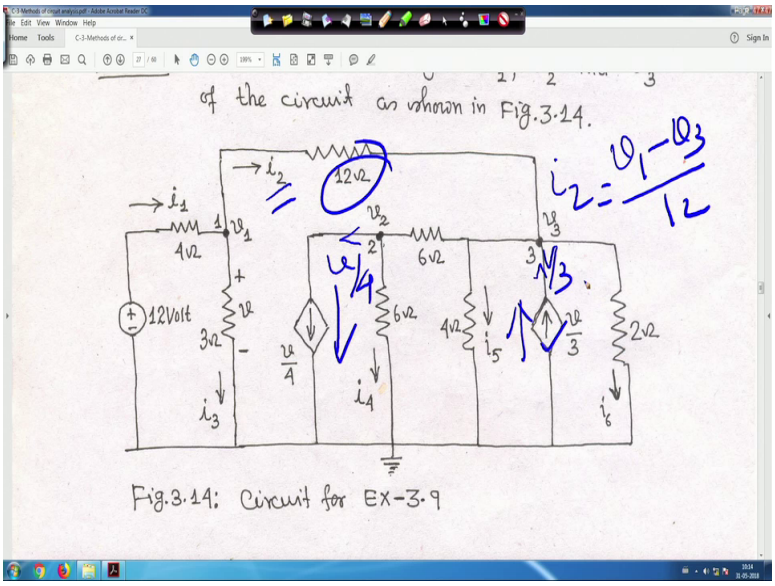

So, all these things i 1 i 2 i 3 i 4 i 5 i 6 all I have told and now apply your KCL remember, this v by 3 actually current dependent current source.

So, this current is entering here and this is dependent current source, so this current actually leaving this terminal because direction is this way and this direction is upward this v by 3; now you apply and next come to the your what you call the problem. So, all these things I have told you for this circuit, everything had been told right everything has been told.

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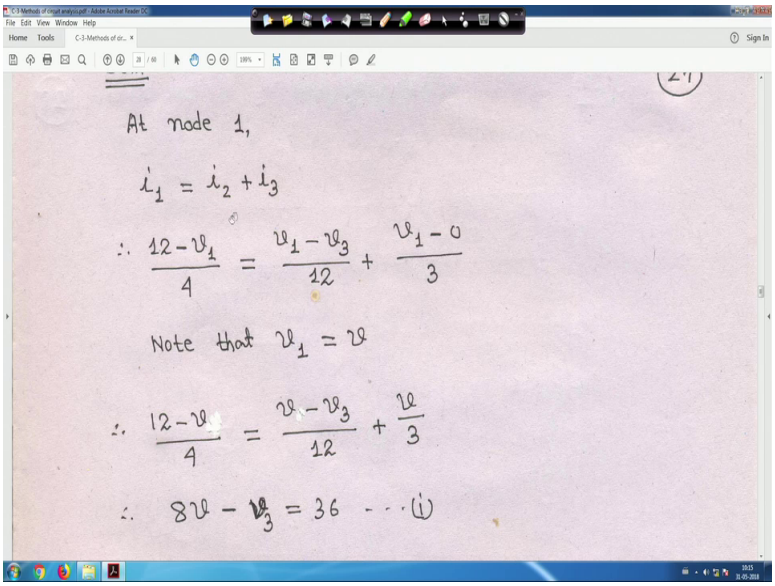

So, at node 1 you apply you will get i 1 is equal to i 2 plus i 3, i 1 is equal I 2. So, i 1 I told

you right then v 1 is equal to v that also I told you is equal to v 1 minus v 3 by 12 plus v 1 by 0 by 3, 0 is need not write again and again, but I have written for your understanding defined that reference node potential is 0 right unless and otherwise something is stated right.

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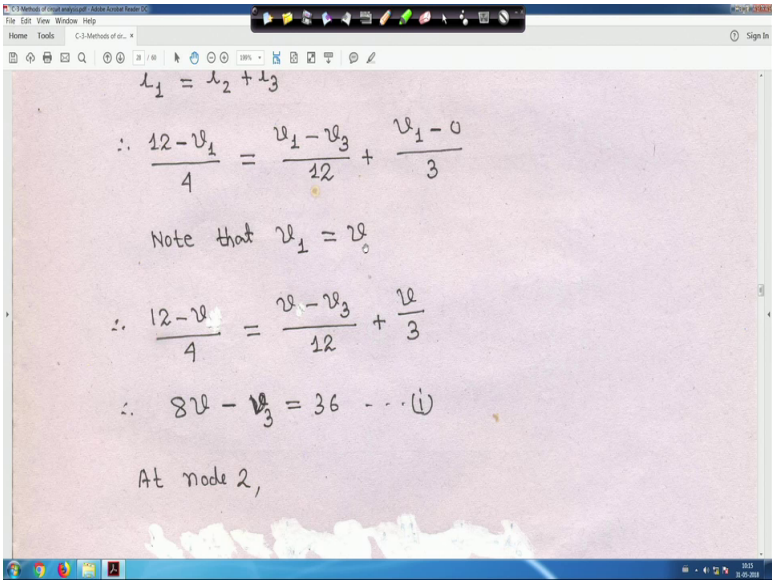

So, at note that v 1 is equal to v that also I told you. So, you put that in this equation you put v 1 is equal to v, v 1 then you simplify it will be 8 v minus v 3 is equal to 36 it is equation 1.

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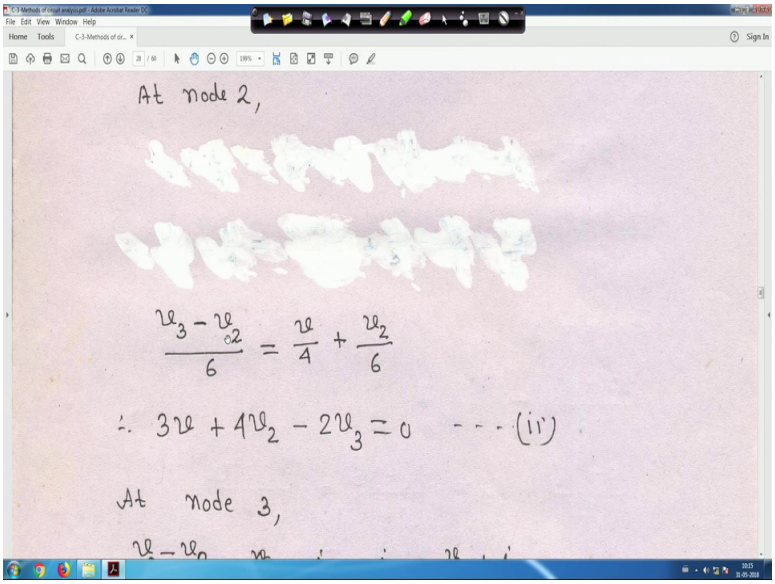

Similarly at node 2 here directly I am writing at node 2 that v 3 minus v 2 upon 6 is equal to v by 4 that is v 2 upon 6; that means, at node 2 this is actually this is actually node 2 right, this

is node 2. So, here if you apply your what you call this your this thing your KCL right. So, what we will what you will get that this is also node 3 this is a common node, this is node because this is a common node right.

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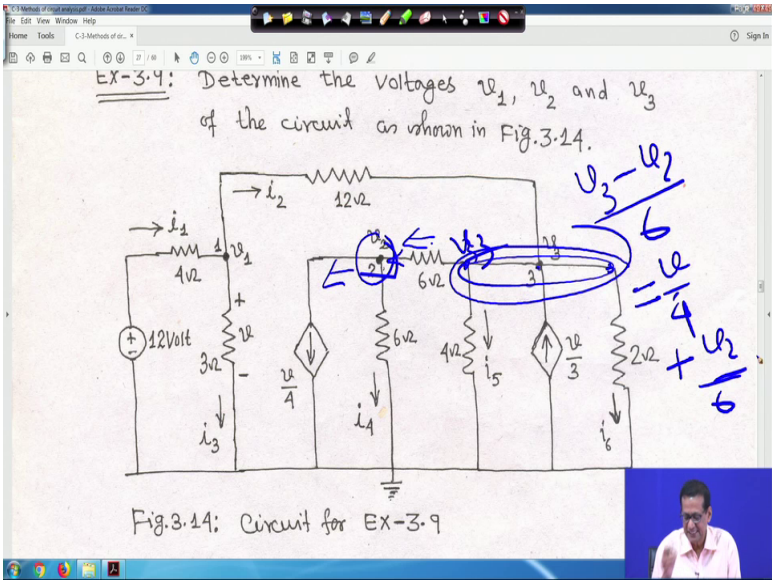

So, if you try to; that means, this voltage v 3 this is also 3. So, this is basically voltage v 3, right. So, in this case that if you say that current is for this branch the current is flowing from node 3 to node 2 say, then it will be your this current is entering into the node and other two are leaving at node 2. So, it will be v 3 minus v 2 by 6, this current is entering because current here flowing from this to that. So, instead of writing any current it is v 3 minus v 2 by 6 is equal to this current is v by 4 leaving. So, it is v by 4 right and plus your this v 2 by 6 plus this v 2 by 6 right.

So, this thing I am writing there. So, let me clear it. So, that is why I am not written any current thing directly it is understandable. So, that is why it is writing v 3 minus v 2 by 6 is equal to v by 4 plus v 2 by 6, right. So, upon simplification 3 v, because v 1 is your what you call v 1 is equal to v we are putting it right. So, here right. So, this is actually v by 4. So, in this case you are upon simplification you will get 3 v plus 4 v 2 minus 2 v 3 is equal to 0.

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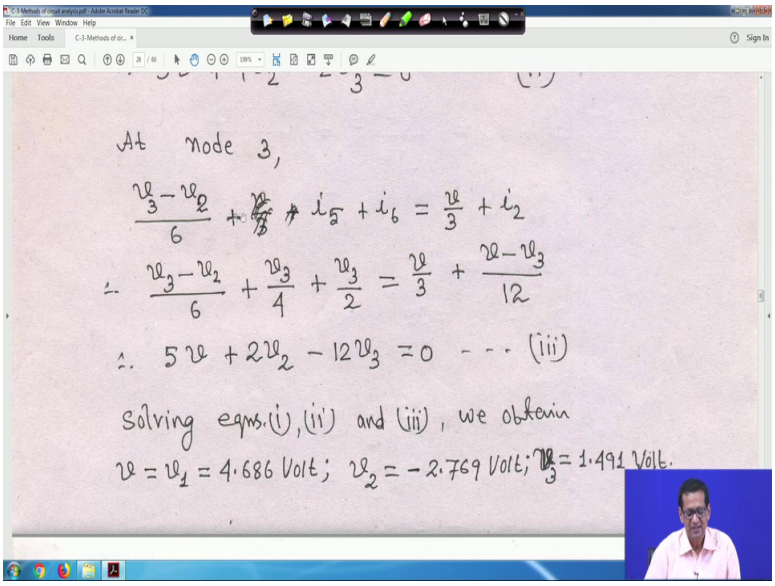

Similarly, at node 3 directly I am writing at node 3 if you come to at node 3 this is your node 3. So, these 3 things are in parallel and another current i 2 is also entering into the node. So, just apply you are what to call this is this is another one right. So, 1 2 3 4 5 different currents will either leave or will this thing this i 2 current is entering into the node, then i 6 current leaving this node, v by 3 dependent source are entering into the node, i 5 current leaving this node, another current that is if you take v 3 minus v 2 by 6 also in this direction leaving the node right so; that means, that means just for your understanding. So, this is actually this is node 3 right.

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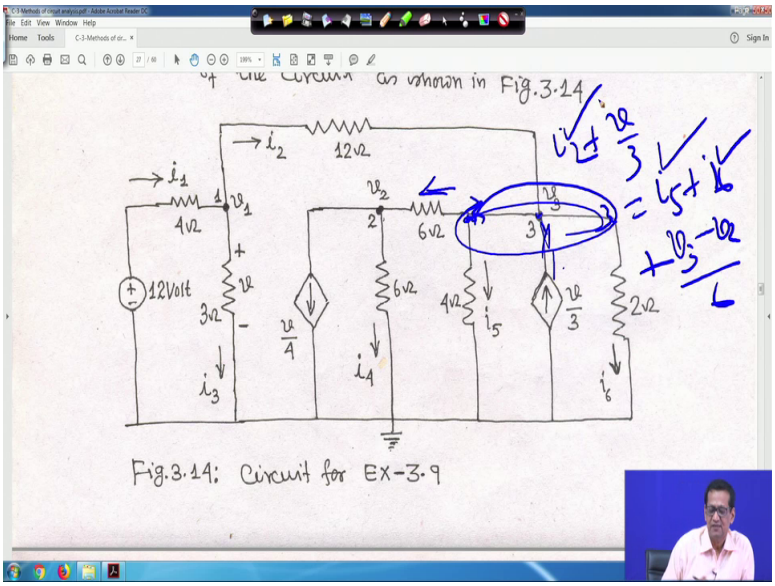

So, basically this is a common node this is a common node right this is 3 this is whatever it is this is a common node. So, in this i 2 current is entering this current i 2 is equal to v 1 minus v 3 by 12 this current is entering.

Then another current although not marked right this current is entering then another current is dependent source current also entering. So, plus v by 3 this current is entering and other currents are leaving right. This 2 current are entering other current is leaving one is i 5 another is i 6 plus this is a common node right; that means, another current also if you take leaving this node. So, it will be actually v 3 minus v 2 by 6 so, i 2 plus v by 3 is equal to i 5 plus i 6 plus v 3 minus v 2 by 6.

I 5 we know i 6 we know and i 2 also we know put everything in terms of v right. So, that is why after making so, many examples, I did not write again i i i right. So, just written this at node 3 these are the equations

So, you make it right. So, and simplify you will get 5 v plus 2 v 2 minus 12 v 3 is equal to 0. So, solve this your what we call equation 1 2 and 3 and for v you will get v is equal to v 1 is equal to 4.686 volt, v 2 is equal to 2.769 volt and v 3 is equal to 1.491 volt right.

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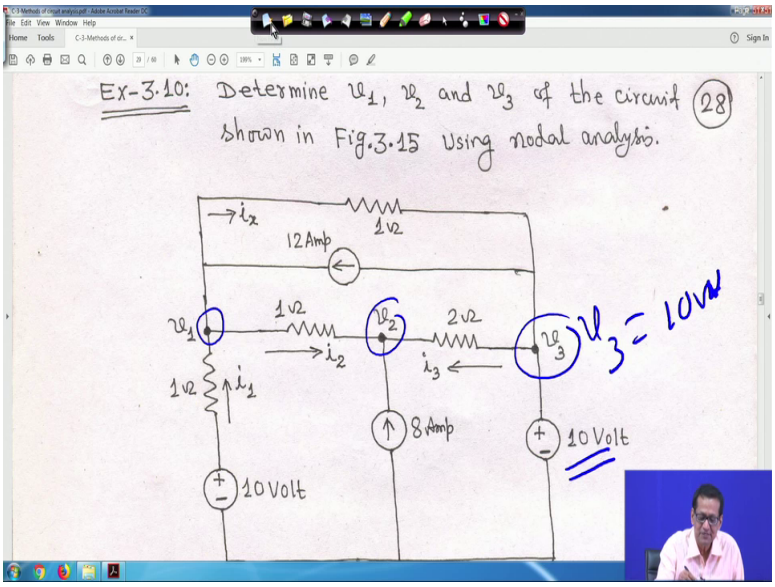

Next is this problem; here after making so, many examples, so, here directly you will write something right. So, for this problem that you have to find out v 1 v 2 and v 3 of this right so, this is v 1, this is v 2 and this is v 3 right.

So, v 3 directly you will get v 3 is equal to 10 volt right v 3 is equal to 10 volt directly you will get it because this is the only your what you call that voltage source here, but here you will you will not get the things directly right because here one ohm resistance is there.

So, let me clear it right. So, in this case that you are what you call in this case you have to find out that what is your v 1 so, first before that this all these thing sorry. So, this one this is a common node right so; that means, this i 2 current; that means, at node 1 if you take node 1 it will be something like this is if this is suppose my node 1 right.

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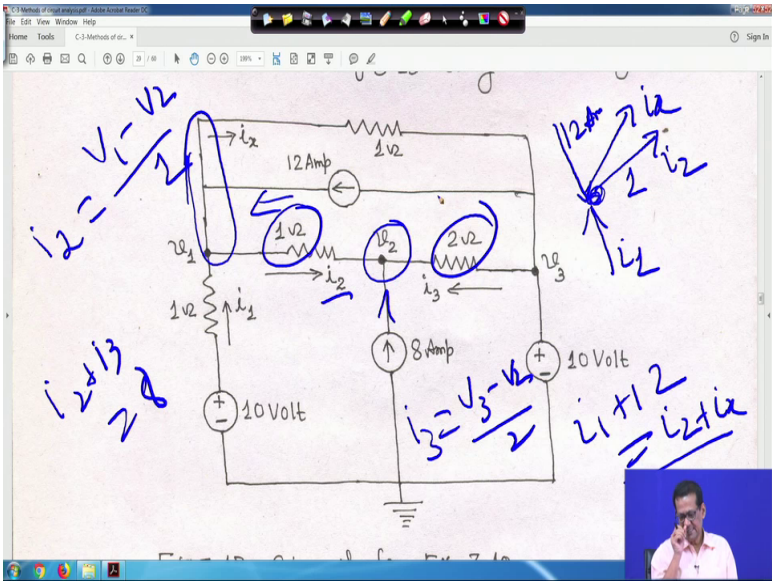

So, this i 1 current entering into the node so, this current is i 1 this is entering into the node, then i 2 current emitting like this the way we explain that KCL this is your i 2 current it is leaving the node then this is a common node then 12 ampere current it is entering into the node because direction is this way entering into the node. So, this is 12 ampere current right.

And another thing is that i x current leaving this node. So, this is your i x current leaving the node right. So, if you look into that 1 2 3 4 four branches are there. So, 2 current are entering into the node that is i 1 plus your 12 is equal to 2 currents are leaving that is your i 2 plus your i x right. So, this is your KCL for this node right.

And similarly voltage will come later similarly if you come to node 2, then i 2 plus i 3 plus 8 is equal to 0 because all current are entering into the node. So, i 2 plus i 3 is equal to 8 right. So, all current are entering into the node right.

So, let me clear it and i 3 is equal to now you know i 3 equal to v 3 minus v 2 upon 3 upon 2. So, if you first take i 2 i 2 is equal to this current will be v 1 minus v 2 upon 1 v 1 minus v 2 upon one because one ohm resistance is here right. Similarly if you take your what you call that your i 3 i 3 is equal to v 3 minus v 2 by 2, because it is 2 ohm resistance is there and another thing is I x let me clear it then I will do it.

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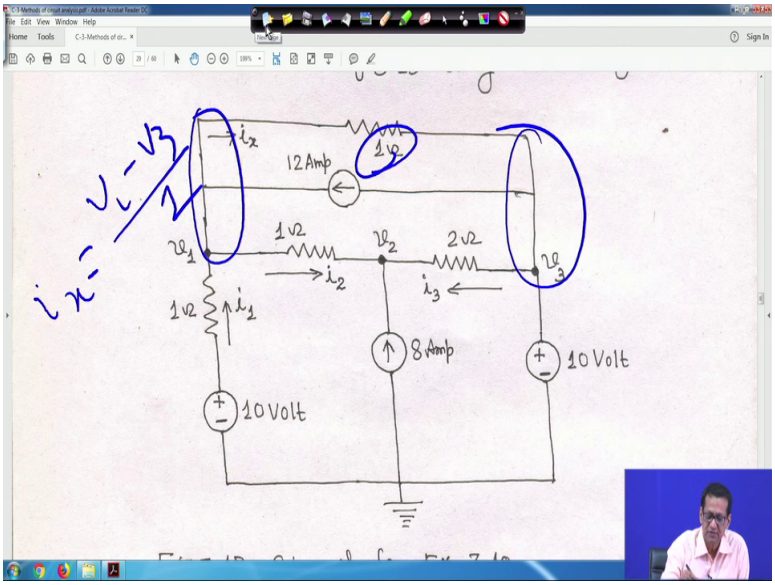

Another thing is i x this is a common node v 1 and this is your also common node v 3 right. So, i x actually v 1 minus v 3 right divided by this 1 ohm resistance, divided by one that is your i x right. Now only thing that all i x is got, now question is i,1 how to get i 1 right? So, because here 1 ohm resistance is there, so, how to do it? Look first come to your node 1 right.

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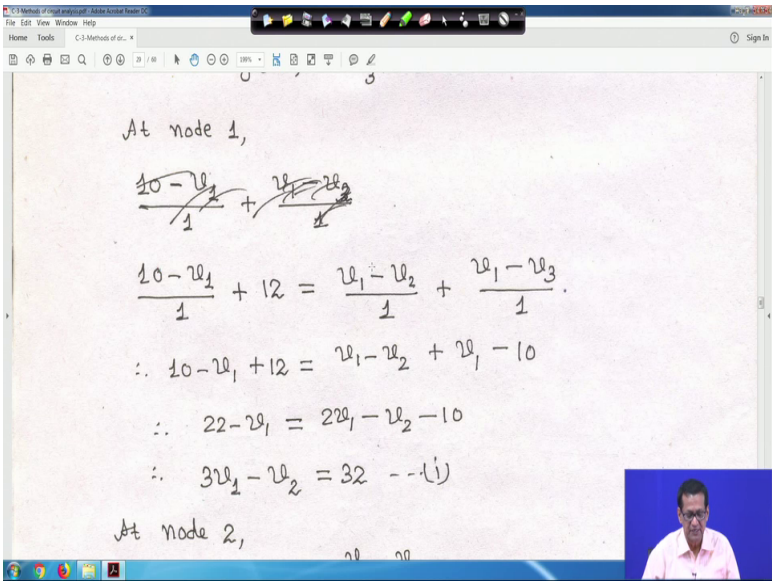

So, if you if you look into this your here that this one though what we have to do is this is your voltage reference voltage v 1 right. So, if you make like this sorry if you make like this.

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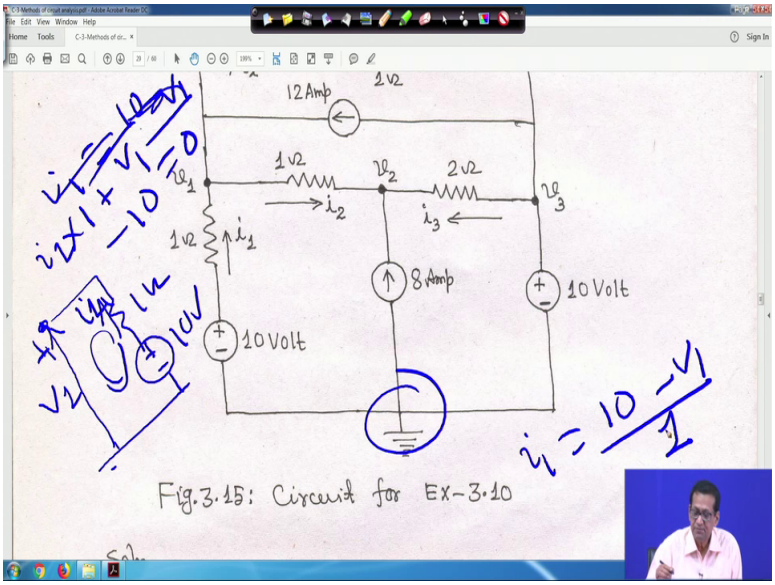

Suppose this is my voltage v 1 right and then because voltage v 1 means with respect to this your reference node right and then if I make it like this, this is 1 ohm this is my 10 volt right and direction of the your what we call the current this is say i 1 like this right.

So, if I move by if I move like this, if I move like this right then it will be i 1 into 1 because this is one ohm then this plus terminal plus v 1 minus 10 is equal to 0; that means, my i 1 will

be 10 minus v 1 making it here that forget about this thing, that mean my i 1 is equal to 10 minus v 1 divided by 1 right. So, if let me let me clear it.

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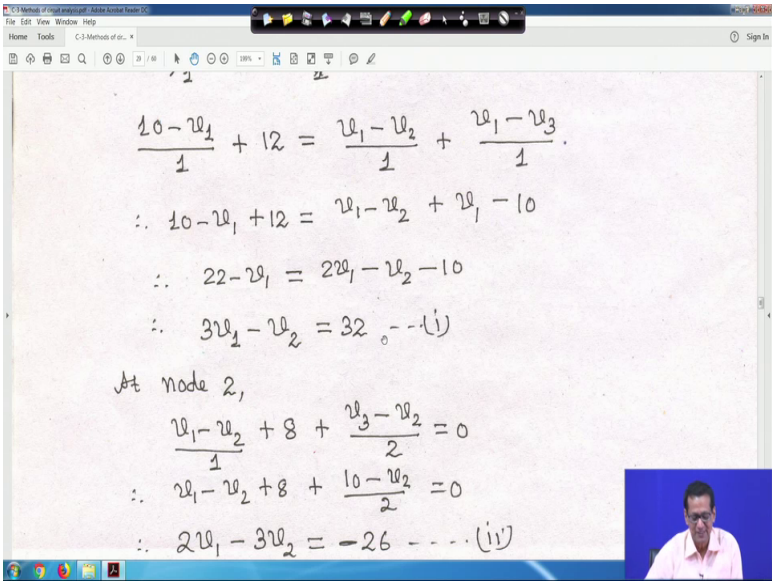

So, that is why I am writing here 10 sorry I am writing here 10 minus v 1 i 1 plus 12 this all this equations KCL I have told you to. So, 10 minus v 1 upon 1 so, this way you have to make it, you have to see you have to understand that how to make your what to call how to compute this right.

Otherwise for example, otherwise you know just arbitrary or keeping something in memory do not try, better we should try to understand the things rather than keeping something like this if it comes like this, I will keep it in memory that will not give as a no this thing understanding that will be a problem, better understand and then we should do it right, then everything every problem you can solve 100 percent accuracy you can solve right.

So, this is at node 1 whatever I told you all the equations. So, this is at node 1 you will get this equation, finally, is it coming 3 v 1 minus v 2 is equal to 32.

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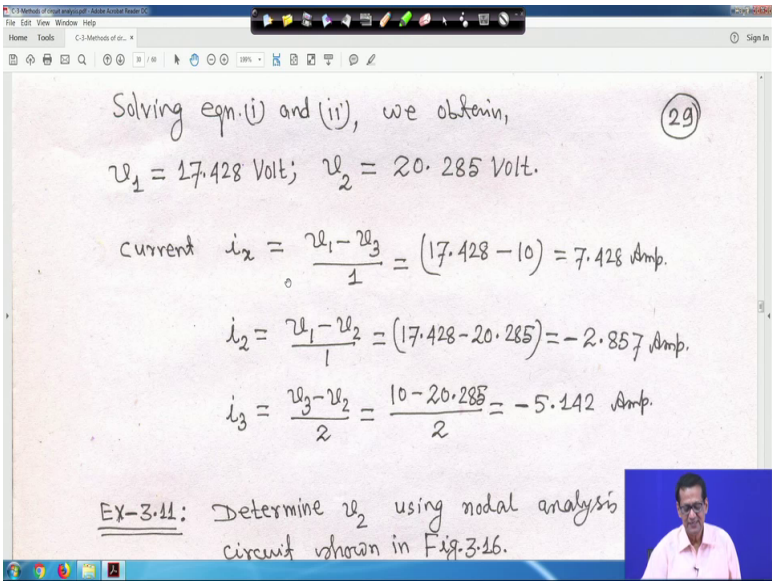

Similarly at node 2 I told you all the equations incoming outgoing everything so, it is also write down v 1 minus b 2 upon 1 plus 8 plus v 3 minus v 2 upon 2 just you substitute those in this equations i right.

And that is why I am not writing again KCL is here all this things on the problem itself I have explained. So, to save sometime so, I have directly now writing. So, hopefully it is understandable to you right. So, finally, it will be 2 v 1 minus 3 v 2 is equal to minus 26.

You solve equation 1 and 2. So, you will get v 1 is equal to 17.428 volt and v 2 will be 20.285 volt and current now you calculate i x v 1 minus v 3 upon 1. So, it will be 7.428 ampere sorry i 2 you will get v 1 minus v 2 upon 1. So, it will come minus 2 point when minus sign is coming means the direction of the current will be reverse right.

And i 3 is equal to v 3 minus v 2 upon 2 it is also coming minus 5.142 ampere right. So, this problem this problem hope everything is understandable to you and when nothing is there v 3 is equal to 10 volt, but if some resistance is here or here, that do not write v 1 is equal to 10 never write you apply the way I showed you apply KVL and then you find out what is v 1 right. So, this way you should what is i 1 that we should write right. So, do not write your directly, then there will be then it will be an error mistake.

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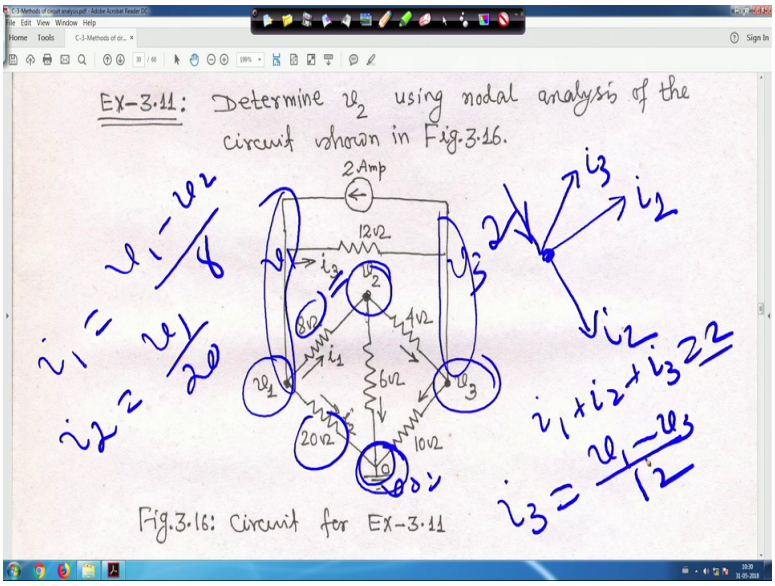

Next one is determine v 2 using node analysis of the circuit shown in figure this thing right here also directly I write those equations, but this is a bridge circuit right. So, here this is your reference node and you have this is node 1, this is voltage v 1, this is voltage v 2 and this is voltage v 3 right and 1 2 ampere source is connected basically this this is a common node right.

So, it is therefore, this is your node 1, this is your node 1 one current is leaving just putting like KCL the way we explained before, this is i 1 this current is also leaving this is i 2 right another current is there this is a common node. So, another current is also there this current is leaving this current is i 3 and this 2 ampere current entering actually. So, this 2 ampere current is entering right so, there early 1 2 then 3 4 4 branches are there.

So; that means, one current is entering other are leaving. So, i 1 plus i 2 plus i 3 is equal to 2 this equation is we can easily write right at now i 1 is equal to your i 1 is equal to your v 1 minus v 2 by 8 because it is 8 ohm, similarly i 2 is equal to your v 1 this reference node voltage is 0 v 0 is 0 this is your i 2; that means, it will be directly v 1 by 20 because this 20 ohm resistance is there.

Next is your i 3 i 3 is equal to this is a common node. So, this voltage actually v 1 and this is also a common node. So, this voltage is v 3, right. So, making it here therefore, your i 3 is equal to v 1 minus v 3 by 12 right so; that means, if you say it i 1 i 2 i 3 if you put it here, then you will get into equation in terms of v 1 v 2 and v 3. So, this is understandable later we

will we have given the solution that, but first we have to we have to try to understand this right.

So, let us clear this. So, for node 1 this is done right now for node 2 for node 2. So, this is node 2 also you apply your KCL right. So, directly what you can what you can do is that here i 1 i 2 other branches I have not made any your what you call you have to find out v 1 v 2 v 3 other branches I have not shown the current, but direction of the current here all this shown right.

For example if you apply your what you call directly I am writing that apply suppose this is node 2 suppose this is node 2 this is your node 2 right.

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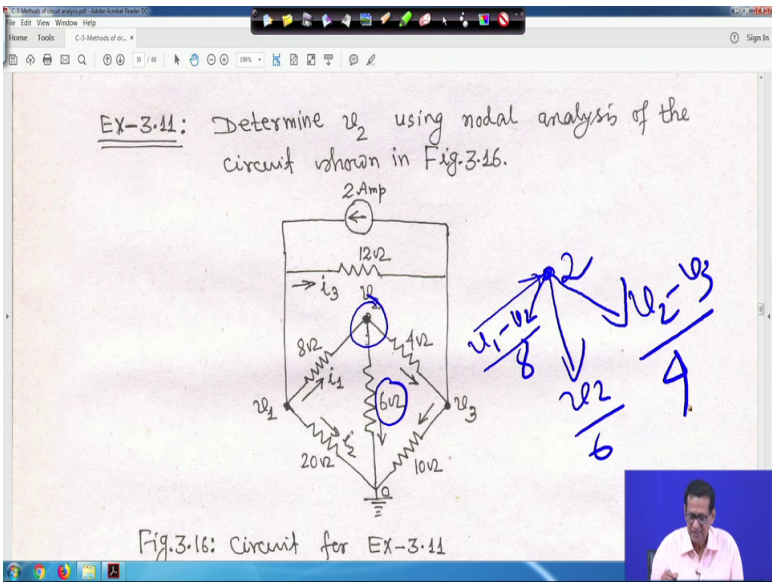

Then this current i 1 actually entering this current i 1 is actually entering this current will be v 1 minus this current will be v 1 minus v 2 divided by 8; this current is entering then at node 2 other 2 currents are leaving; that means, this is entering and another current this 2 2 your datum node reference node reference voltage is 0; that means, these 2 will be v 2 by 6 because this is 6 ohm right.

Similarly, another current is also leaving because we have taken in this direction. So, another current it is also leaving that is v 2 minus v 3 divided by 4 right so; that means, v 1 minus v 2 upon 8 there is current is entering is equal to v 2 upon 6 plus v 2 minus v 3 upon 4 that show later.

But this is your what we call at node 2 similarly you let us let us clear it, similarly at node sorry similarly at node 3 node 3. So, here also this is a this is actually is a common node at node 3 if you take this is my node 3 that if you look into that this is also common node; that means, this 2 ampere current is there.

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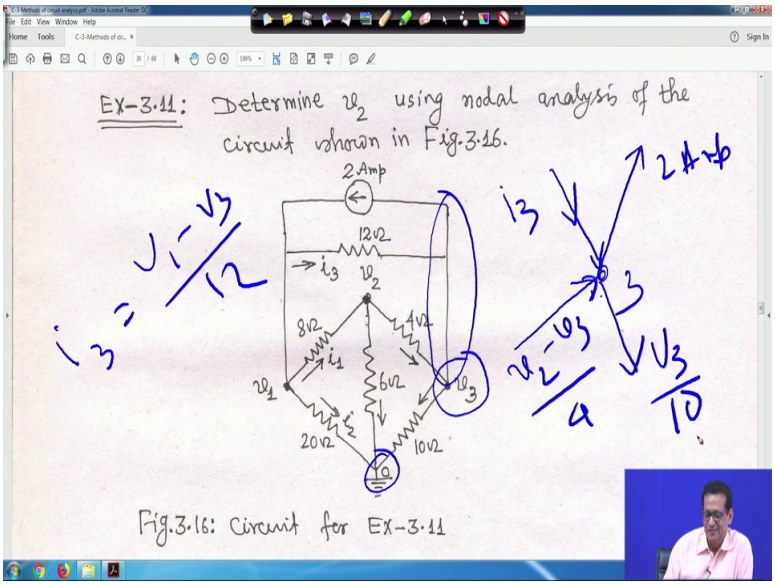

So, this 2 ampere current is you are leaving this node right there another thing is that that i 3 current this is that i 3 is marked here. So, this i 3 current actually entering into the node and i 3 I told you earlier that i 3 is equal to v 1 minus v 3 v 1 minus v 3 by 12 these 2 currents are entering right.

And another current your v 2 minus v 3 upon 4 is entering into the node 3. So, this is your this is your node 3 and this current is v 2 minus v 3 by 4, this current is entering into the node right, but another current here direction is taken this way. So, reference voltage is 0 so, another current actually leaving this terminal. So, it will be v 3 by 10 right; that means, and i 3 as I told you; that means, i 3 right this current is entering. So, i 3 that is your v 1 minus v 3 upon 12, then another current is entering that is v 2 minus v 3 upon 4 this one this 2 current are entering is equal to 2 plus v 3 upon 10 this way you can write the equation those things are there later. So, this way you will have to understand certain things right.

So, let us clear it. So, next if you write now at node 1, I given you everything right.

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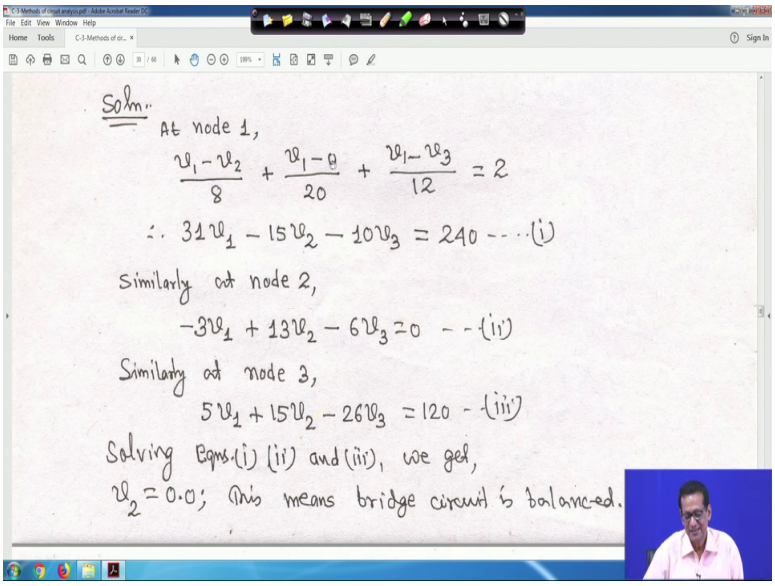

So, hope I have not missed any branch or anything hope everything is correct I believe right.

So, this is actually your at node 1 you apply your KCL the way I showed you, all these things I told, here I am writing now right. So, v 1 minus v 2 upon 8 plus v 1 minus 0 I am writing, but v 1 by 20 reference node, but for your understanding just every time I have writing v 1 minus 0 the reference node and v 1 minus v 3 upon 12 is equal to 2.

So, if you simplify it will become 31 v 1 minus 15 v 2 minus 10 v 3 is equal to 2 40. Similarly at node 2 you the way I told you make and simplify, you will get minus 3 v 1 plus 13 v 2 minus 6 v 3 is equal to 0 this is equation 2. Similarly at node 3 I told you please do it of your own because this is example 11. So, many exp[lain]- examples are varieties of examples are given. So, can simplify the way I told just now I wrote everything for you just you do it and simplify it will be 5 v 1 plus 15, v 2 minus 26, v 3 is equal to 120 this is equation 3.

You solved one 2 and 3 for v 1 v 2 v 3 you will get v 2 is equal to 0, this means this circuit is balanced this circuit anyhow will show will not study in this course right. So, anyway so, one voltage you are getting that v 2 is equal to 0, right.

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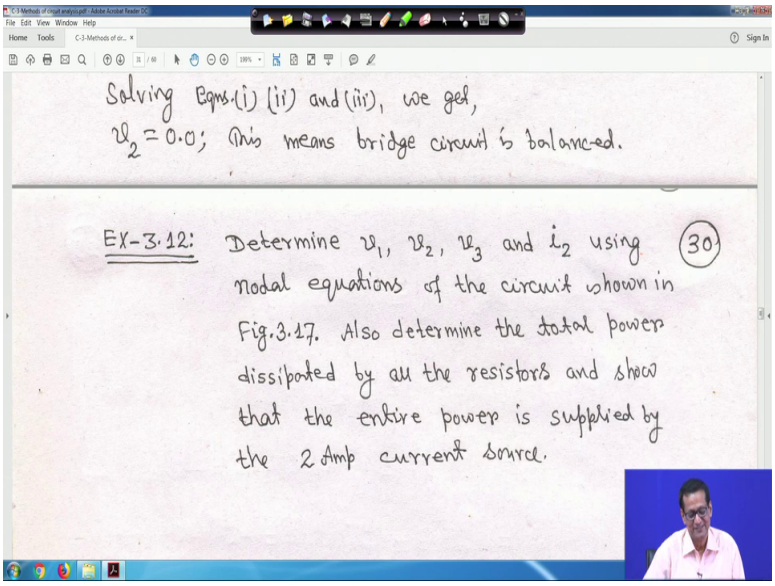

This means these circuit is balanced in the problem it is said determine v 2 using node analysis. So, already you solve for v 2 and it is. So, v 2 is equals to 0 right 0 potential; that means, nodal circuit is balanced right; so with this.

Thank you very much we will be back again.