Fundamentals of Electrical Engineering
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Lecture – 11
Methods of Circuit Analysis

So, welcome (Refer Time: 00:14) to what you call that another problem, right. So, it is you have to find out that equivalent resistance Rab some circuit is given you find out.

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So, previously, previously you have you have solve this star delta transformation.

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This we have seen in just now just now, right. So, let us find out that what will be first let me let me mark it by paint, right. So, you have this terminal, the terminal a and terminal b, you have to find out the what is Rab, Rab is equal to what for this circuit? Now this is the problem before going to the problem look this c and d it is connected by a wire; that means, c and d basically this is a common point, because no electrical element is connected here.

That means, similarly if you if c and d is a common element, then in the circuit I will show you; that means this 5 ohm and 20 ohm, they will be in parallel. Similarly, 6 ohm and 3 ohm they are also in parallel. And this your a to e it will be taken out, with 10 ohm and your b to f it is 8 ohm. So, if we draw that equivalent circuit of this circuit, if we try to make the equivalent circuit of this one, first let me clean it, right. Then it will be then it will be your something like this, look at that.

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That a to e actually 10 ohm, that a to e it is 10 ohm here it is 10 ohm, and b to f 8-ohm b to f it is 8 ohm. Now c and d it is a short circuit, c and d it is a short circuit, it is a common terminal because c and d connected like this, basically if you make the just for your understanding, if we make the circuit like this.

It is this suppose this a I am taking out, suppose this is my a and this is your 10 ohm, that is a e say this point is your e, and this point is a.

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And this is your 10 ohm, right. And c and d this is actually short circuit point, because c and d it is a it is a it is a common, actually may have been we can make it like this. So, this c and d is a common terminal. So, if you make it; that means, your this point is e, that means, this is actually this is say 5 ohm, right. That is e to c and similarly e to d this is your what you call it is 20 ohm. So, this is actually common point c to d, this is a common point. Similarly, I making it here similarly, your c to f that is your if this point is f say c to f, this is your say 6 ohm.

And similarly this one if you take this value your 3 ohm, right. This is 3 ohm, and this point is a, and this then another thing is that this point your this point is b, and your if b to f this point is your say f point, right. Where this is c d, this is f point. So, this is your 8 ohm, right. So, this is actually series parallel combination of the circuit. So, this circuit actually the whole circuit actually I have drawn in the your next page.

So, let me let me your let me clean it. So, that is why this we have made it a to a, a to e 10 ohm, then 5 and 20 are in parallel see these common point, 6 ohm 3 ohm are in parallel 8 ohm this is that your what you call that is different circuit. So, find out equivalent one Rab so, you have to find out your Rab; that means, this point right?

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That means, this you have to find out from here what is your Rab, right. So, 5 and 20 are in parallel so, this 10 ohm is in series.

So, this 10, then 5 and 20 are in parallel. So, this part is 5 into 20 by 5 plus 20 equivalent, plus this parts 6 into 3 upon 6 plus 3 this part plus 8 this part, right. And total R, then equivalent Rab is equal to 24 ohm, I mean if you simplify it will be 24 ohm. So, this is the answer for this problem, just simple problem, only thing is that let me clear it, only thing is that that if you look at the problem, that you to see that this c and d actually it is short circuit. It is actually bunched together, it is a common point, because no all are your electrical elements are there, right. So, that is why the answer is 24, now next problem.

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Here you have to find out the resistance between points A and D in this figure.

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That means, right this is your point A, and this is your point D, you have to find out what is the equivalent resistance R A D, write that is I mean you have to find out that equivalent resistance, that is your R A D, right.

So, that is that is been asked in the problem so, let me clean it.

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So now, in this case, what you can do is look, if you if you take here the triangle BCD that is your this thing, if you see just hold on if see triangle BCD; that means, B C and D, right? And all are 20-ohm resistance, this is 20, this is 20, all are 20-ohm resistance, right. So, you have to find this BCD it is a delta, delta your delta formation it is there, you have to converted to star first, right. And all are equal 20, 20, 20. So, things are simple so, first let me clean it.

So, if you make star, then it will be like this, it will be like this, and it will be like this. So, all are equal. So, this part, this part and this part you have to first find it out, that how it will be; that means, as soon as you will make this one, this one will not be there, this one will not be there and this one will be not be there.

Then whatever will come here that will be in series with 20 ohm, whatever will come here 10 and 20 that will be in series 10 ohm, and whatever will come here, that will be in series with that and whatever will come here there with 10 ohm, it will be in series with that, right so, let me clean it, right. So, if will do so, so this is that that delta star transformation actually every branch, it is coming 20 by 3, 20 by 3, 20 by 3.

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So, so this is also 20 by 3, this is also 20 by 3, this is also 20 by 3. You have to find out the equivalent resistance across the here, it is you have to find out R A D is equal to how much, right. So, this if you look into that this 10 and 20 by 3, they are actually in your what you call series. So, 10 plus 20 by 3 it is 50 by 3 ohm here it is, right.

Similarly, here also 10 and 20 by 3, that is also 50 by 3 ohm. And this terminal and your what you call this terminal, it is across this here also 10 your 10 plus 20 by this side 50 by 3, and this side they are connected across the same terminal; that means, these 2 are in parallel, right. And then you are, what you call the you have to find out that you have to find out that your resistance R A D across R A D so, it cannot be in series.

Here if you if you do not find just hold on, I am cleaning it, just hold on, right if you do not try to find out resistance here I mean if it is ask for R A D that is why this when you converge it to star, when you sorry, when you converge it to star right like this so, if d point, if it is asked for something else then this one this one will be in series.

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But as R A D you have to find it. So, naturally your this 20 by 3, it will be taken in different way, because our objective is we have to find out what is your R A D, right so, let me clean it. So, when I was telling it that I told it is in series because, but our objective is R A D had it been something else except this point, then it should have been series anywhere.

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So, here it is 20 by 3 and we have to find out R A D. So, ultimately what will happen that these 2 are in parallel 50 by 3, 50 by 3. So, it is equivalent actually will become 25 by 3, these 2 these 2 are parallel. So, it is R 1, R 2 upon R 1 plus R 3 if you do this, this will be actually 25 by 3 ohm, right. And with that this 20 by 3 ohm will be series; that means, if you if you draw the equivalent circuit farther of this one farther of this one so, it will be your it looks like this, it look like this. This is your D point and this is your A point right.

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So, this will be your 25 by 3 ohm and this one also 20 by 3 ohm, and this is your 20 ohm. So, if you make 20 these 2 are in series, 25 by 3 and 25 by 20 by 3. So, if you add 25 3 plus 20 by 3, that is actually 45 by 3. So, it is coming actually 15 ohm, right. So, that is why this 50, that means, this 15 ohm and 20 ohm now are in parallel so, let me clean it, right. So, this 15 and 20 ohm are in parallel, this 2 and it is equivalent to find out that 15 into 20 upon 15, 15 plus 20. So, R AD will be 8.57 ohm, this is your answer, right?

So, with this what look for each chapter we are solved (Refer Time: 10:08) this one problem number 25. So, each chapter for varieties of circuit we are trying to solve such that it will you know that your concept will be completely clear, I mean varieties of problem so, you will be knowing how to solve this one, right. Now few exercise I am giving you that you will do it after that we will go to the next topic.

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So, this is a or exercise 2 of problem 1, that circuit is shown you have to find out v 2. So, what is your a 1 depending current source is there, and this is your v 2. You have to find out v 2 answer is given answer everywhere; answer is given here, right.

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Next problem you will solve find the voltages v 1 and v 4 in figure this figure, right. You have to find out v 1 and v 4, right. Simple a simple series circuit is given. So, answer is given, answer is here, answer is given.

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Then next problem that your in this it is it is your what to you call your series parallel circuit 2 loops are there, right. You have to find out that v x i s and i 3, right. This is this voltage is v x this voltage is v x, right. This is your i x and by voltage source independent source is there 100 volt, right. And you have to find out v x i x and i 3 so, i 3 is here. Flowing through the 60-ohm resistance answer is given 25 volt 1.25 ampere, and 0.417 ampere. So, answers are given, but if you find during solving any error or anything you just you just let me know then I can rectify myself, right. Hope all these things are correct, but still then problem 4.

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In the circuit you have to find out equivalent resistance Rab. So, this is your a and this is v, from here you have to find out Rab, right. Equivalent this things, only thing is that this node and this node is a common node, just when you will solve this one, just a for this thing this is a wire connected this is actually common node, right?

So, accordingly we will solve it, and these 6 ohm 14 ohm are in series so, accordingly we will solve it so, I am cleaning it. So, this is your answer is given, answer is answer is your 27 ohm, and also given power delivered by the source; that means, that 144-volt source is there how much power is being delivered. So, here it is 760-watt 68-watt answer, right.

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Then this one, that this another problem, I will in every chapter I will try to give you some 5 to 10 problem, that in this circuit switch s is open, right? The voltage divider is operating at no load when the switch is closed. The divider is said to be loaded. So, calculate, a the no load value of v 0, b load value of v 0, and c ratio of v 0 by 25 at 20 v 0 by 25 at no load, and d ratio of v 0 by 25 under load.

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Then when it was open it is no load and when it closed it is load. So, it is a voltage divider circuit at 25-volt source is there.

So, please this is simple one please solve it. So, answer is given 20 volt 15 volt another ration is 0.80, 0.60 answer is given.

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Next problem is determine the equivalent resistance at the terminals of the circuit. Of 4 circuits are given one is 2.61, a another is 2.61 b, another is 2.61 c, another is 2.61 d. This is for the practice, this is for the practice, 4 problems are given, this is for first problem, this circuit is for the second problem.

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This circuit is for the third problem, all answers a b c d are given, all answers ab 4 problems are there a b c d. So, these are given and this is the 4th problem.

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So, all the 4 answers are given, right. Last problem answer is 30.333 ohm so; all answers are given.

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So, in this one you have to find this circuit you have to find out v and i, right. So, this is the current i, right and you have to find out this voltage your what you call your this voltage is given that v, right? So, you have to and voltage across this stain over resistance it is 20 volt, right. So, just for your this thing just should not be any confusion this voltage across this 10-ohm resistance is given 20 volt, you have to find out v, you have to find out i answer is given for v is it is 39.5 volt, and current is point 5 ampere.

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So, right and then one more, here in this figure the first one we have to find out the equivalent resistance offered by the network to the voltage source, and the current i drawn from the source. So, that means, you have to find out your what you call that you know R a v, you have to find out the R a v, that is the or that is the or the your what you call that resistance offered by the voltage source, it is given equivalent resistance offered by the network sorry to the voltage source and the current i drawn from the voltage source.

So, you have to find out basically R a v so, a equivalent is how much, right. And here answer is given 2.5 ohm and 16 your what you call that your a 16 ampere.

So, similarly here also here it is a some kind of star delta formation is given.

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You have to determine R and i, if the current through r is 0; that means, capital R; that means, you have to find out the capital R. This is capital R, and this is small r, that determine R and i and this is the current i, this is the current i and this is the capital R, you have to find out if the current through R is 0 the small r if the current through small r is 0 if current flowing through this, if current flowing to this is 0, right. You have to answer is given R is 8 ohm, and i is equal to 0.8 ampere. So, you have to solve this an exercise.

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Last one, one more, right one more what is the resistance across the terminal ab of the network shown in figure. Also calculate the voltage across the terminal ac if a 36-volt battery is connected across the terminal ab. Read carefully, and you have to find out what is R ab, and what is Vac answer is given; 4 ohm and Vac is equal to 18 volt so, this 10 problem. In fact, many are there, may be many more are there, but I have given you this 10 problem as an exercise. With this, this your this chapter is closed next will go for methods for circuit analysis, right.

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So, next is your methods of circuit analysis. So, so far whatever we have your analyzed relative simple circuit by applying Kirchhoff's laws in combination with ohms law, right.

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So, KCL, KVL in combination with the Ohms law, these approach your these approach can be used for all circuits, but as they become more complicated, actually and involve more element this direct method become very cumbersome. Just KCL and KVL and Ohms law sometime, it will be your little bit cumbersome.

So, in this in this chapter, we will apply these laws to develop 2 powerful technique that aid in the analysis of the complex circuit structure, right just hold on. So, in this case first thing is the nodal analysis.

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So, it is a based on your, what you call? A systematic application of KCL, and mesh analysis it is systematic analysis of KVL. So, KCL and KVL and using these of course, we have to use Ohms law of course, required every time, right?

So, using these 2 techniques so, we can analyze any linear circuit by obtaining a set of simultaneous equations.

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That are that are then solved to obtain the required values of the current or voltage. So, Cramer's rule is used for solving simultaneous equation which allows to calculate circuit your variables as a quotient, right of determinants. So, we will see little bit of Cramer's rule also. So, first thing is a nodal analysis. So, nodal analysis actually is a very powerful tool for circuit solving circuit later we will see the difference between nodal and mesh analysis, and where we can go for nodal analysis, and which type of circuit will go for mesh analysis that will be see in later.

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So, nodal analysis gives a general technique for analyzing circuit using the node voltages as the circuit variables. In this section, we will assume that circuits do not contain voltage sources. First what we will do? First will assume the circuits do not contain your voltage source, right. There is no voltage source will assume, right. So, the circuit that contain the voltage source will discuss in the next section, right.

So, that is why first we will consider a circuit without voltage source, but current source maybe there, but not no voltage source, right So, our interest is to find the node voltages. Now consider just in generally, you consider a circuit just hold on, a consider a circuit, right with n nodes, with n nodes, you consider a circuit with n nodes without voltage sources, right?

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So, the nodal voltage analysis of a circuit involves the following 3 steps. First thing is select one node as the reference node. That is called that term node. You have to select one node as a reference node, and the potential of the reference node we will take it as a 0, unless and until it is specified we will take it as a 0, right. So, what will happen? You take one node as a reference node.

So, you have to assign voltages were remaining n minus 1 nodes. I mean just suppose your n node so, one node is reference node. So, assign the voltage for the rest n minus 1 node by say v 1 v 2 up to v n minus 1, because one node is a reference node.

So, the voltages are referenced with respect to the reference node, right. So, this is step one, next is just hold let me clean it, now next is that you are apply KCL to each of the n minus 1 no reference node.

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That means, you have to apply you apply KCL to each of the n minus 1, no reference node, right so, express the branch current in terms of you have to express the branch current in terms of node voltages by using Ohms law. This is the second step. And third step third step, you have to solve the simultaneous equations to obtain the unknown node voltages, you will get those equations in terms of node voltages, then you have to solve this one. So, this is actually node voltage analysis without any voltage source. So, let me clean it, right.

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So, first step in the nodal analysis is a select to a reference node or datum node. Sometimes we call it is a reference node or datum node. The reference node is assumed to be assumed to have 0 potential and is commonly known as a ground. So, this is ground reference node is a ground node, right? So, reference node is indicated by any of the 3 symbols, I will show you the figure as shown in figure 3.1, right.

So, just let me clean it. So, so if you look into that the 3 symbols, right. The type of ground the type of ground is shown in figure 3.1 a is known as chassis ground and is used in devices, there are chassis case or enclosure act as a reference point, right.

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So, this is one symbol for the your reference node, right?

Just let me clean it.

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Similarly, right similarly, common ground that b and c also may be a is a common ground point, right.

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Suppose circuit when the potential of the earth is used as reference I mean these 2, these 2 symbols, this is this is for your grounding for chassis case or body of the your devices something like this. So, this symbol will be used and (Refer Time: 22:29) if the earth is earth, or (Refer Time: 22:31) your ground is a your what you call reference point that either this symbol or this either of this symbol can be used, right. So, let me clean it.

So, this b and c it is common, right. So, that is why your, what you call the earth ground is shown in figure 3.1 b or 3.1 c. So, this is earth ground, b or c b or c, right.

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So, this is actually symbol you will use after selecting reference node assign voltage, your designation to non-reference node. For example, do just hold on just hold on let me move it little bit up just hold on. So now, take for example this one, right?

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So, this circuit first now here we have 2 current sources, one current source is here and another current source is here, right? And 2 resistance are there R 1, R 2 sorry 3 resistance are there R 1, R 2 and R 3, and you have here it is marked as voltage v 1, right? And here it is marked as voltage v 2 and this is your reference point, this is actually Vo, this is Vo this is a reference node or datum node and potential of these is always is equal to 0 volt, right. This is a first thing unless and until is mentioned then v 0 is equal to generally taken as a 0 volt.

And this is 2 nodes are given 1 and 2, right. So, we and this voltage actually this voltage v 1 is given. So, at nodal analysis actually this voltage v 1 means this is node 1; that means, this voltage actually it is your v 1, right? Similarly, this voltage is your v 2; that means this node voltage actually it is in v 2, right. With respect to your what you call that reference node. So, and this is your this potential is 0.

So, v 0 is 0 so, that means, here the this is voltage actually it is v 0 is equal to 0 which I have written here, right? So, that means, these voltage this node this node voltage is v 1, this node voltage is v 2 instead of writing v 1 and v 2. So, let me clear it, right. So, if we that means, reference voltage here marked as 0 and node 1 and 2 are assigned voltages v 1 and v 2 respectively.

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Therefore, if you look into that a node voltage is defined as the voltage rise from the reference node to a non-reference node, right? So, it is a node voltage defines the voltage rise from the reference node to a non-reference node. Now the second step in the nodal analysis is to apply KCL to each non reference node, just hold on let me clean it, right.

Second step is that you apply each node that KCL.

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So, that means, at node 1 you have to apply KCL and node 2 you have to apply KCL. So, you have to mark some current and what current is flowing, just before moving to that, this 10 ampere current actually this 10 ampere current it is a current source entering into your this node 1. Similarly, that 6 ampere 6 ampere current it is entering at your node 2, right. This node 2, that means, this 6 ampere current is leaving your this node 1 to this side.

And suppose if I have that this is another direction of the current i or what you call say something like i 1, I have might have taken something is later suppose this is my i 2, right. And this current say through R 3 this current is say it is i 3, right. So, 3 currents we are marking so, if you apply your what you call KCL at node 1, then you will get your just apply node 1, then you will get that look only outgoing current is just I am writing, outgoing current is your incoming current is 10 ampere.

So, here I am writing 10, right is equal to that this current is this current is also leaving this timeline is equal to 6 plus this current is i 2, right plus this current is your i 1. This is at KCL if you apply at node 1 so, 10 is equal to your 6 plus because all are out going plus i 2 plus i 1, this is one equation.

Similarly, if you apply KCL here, then this current is incoming it is 6, right. Just I am writing this i 2 current also coming to this node 2. So, it will be plus i 2, and this current leaving the terminal it is your i 3, right? Because i 3 is the current leaving this terminal so, right this is nothing but your that KCL equations were apply. Now, if you try to find out that what will be your i 1 i 2 and this thing. So, first let me clean it, then I will go to this first let me clean it, right. So, if you see this circuit, here now these voltage here it is marked.

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So, it is i 1 i 2 i 3 all are marked, all the equations I sorry, all the equations I wrote for you for i 1, i 2, i 3 now question is that what is i 1? This voltage is v 0 is equal to 0, this is your datum node, this is your this is datum node; that means, your i 1 will be look, i 1 will be is equal to v 1, it is going this direction v 1 minus 0 by R 1. That is actually v 1 upon R 1, right?

Similarly, your if you look into i 3, i 3 is equal to i 2, I will come later this is i 2 will come the i 3 also will be v 2 minus 0 because datum node voltage is 0 I am not writing v 0 again and again directly writing v 2 minus 0 divided by R 3. That is actually is equal to v 2 by R 3, right.

And i 2 is equal to writing here, i 2 is equal to it is this voltage is v 1, this voltage is v 2, and current actually flowing from your node 1 to node 2 i 2 actually node 1 to node 2; that means, if you write like this i 2 i 1 2 is equal to i 2. That means, i 1 2 means current flowing from node 1 to node 2. So, it will be your v 1 minus v 2 this is v 1, this is v 2 v 1 minus v 2 resistance is R 2 v 1 minus v 2 by R 2, right this is actually v 2, right v 1 minus v 2 upon R 2.

These are all, that means, all the KCL equation we have written after the replace i s by all the v s. So, you will get the equation for the voltage simultaneous equation will get. So, let me clean it, hope this things are understandable to your not a not, a difficult one a very simple one.

And you can easily solve it. And after that you will solve several varieties of problem, I mean all possible types of problem such that you will have actually no problem, no problem for solving this thing, because this course that mostly it will come, I mean the lot of your what you call mathematical so, I mean all that is mathematics will come, a simple mathematics for solving this circuit, circuit analysis both and whatever we are learning now in this (Refer Time: 29:56) same philosophy will be applied to ac right.

So, at that time you will find things are very, very, very simple. So, anyway so, if you write down the equation this one, I mean KCL what I wrote initially?

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That 10 is equal to 6 plus i 1 6 plus i 1 plus i 2 at the beginning, I showed you all these and I wrote also for you and at node 2, it is 6 plus i 2 is equal to i 3, right. And all the i all the expression for i 1, i 2, i 3, I wrote for you, right. So, again from the circuit only I have to explain everything, now again all these things written here.

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That if you look into that whatever I said it is looking for i 1 is equal to v 1 upon R 1 equation numbers marked, right. Similarly, i 2 also I wrote for you, right. It is v 1 minus v 2 our, i 2 means that it is in the it is in that branch 2, current flowing from node 1 to node 2 it will go back to the circuit are already I have told you v 1 minus v 2 upon R 2, and i 3 also I told you v 2 minus 0 upon R 3 so, v 2 upon R 3.

So, all these all these i 1, i 2, i 3 this all this expression, let me clean it. All this expression you just you just put in this 2 equation that is equation chapter 3. So, 3.1 and 3.2 you will that all i s replaced by this equation. So, it will be equations of v 1 and v 2, right linear equation.

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So, basically if you put it so, it will be and simplify it you will find that you are substituting equation 3.3 and 3.4 into equation 3.1, it will result this equation, 1 upon R 1, plus 1 upon R 2 into v 1 minus 1 upon R 2 into v 2 is equal to 4, this one equation, similarly substituting equation 3 4 3.4 and 3.5, right? In equation 3.2 you will get 6 plus v 1 minus v 2 upon R 2 is equal to v 2 upon R 3.

Now, you simplify you will get minus 1 upon R 2 v 1 plus 1 upon R 2 plus 1 upon R 3 into v 2 is equal to 6. So, basically this is this equation is to answer of v 1 and v 2 and this also function of v 1 and v 2 and this also function of v 1 and v 2. So, you can easily solve equation 3.6, right and your what to call if equation 3.7, upon v 1 and v 2, but here parameters are present not given. Later we will take the numerical so, we will take different parameter different examples, right.

So, in this case, if you solve it, and put it in a you know all these things are written here.

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These are all simples no need to clarify again whatever I said, right? So, this circuit actually you have a you have a 3 I mean if you look in the circuit, you have a basically you have a this one node this is node 2, and this is your datum node, right.

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So, this is basically v 0 is equal to 0 so, basically you have so, n is equal to 3. So, for you have n minus 1 number of equations simultaneously equation for solving, because this voltage reference voltage is 0 so, that means, you have n minus 1 is equal to 3 minus 1 is equal to 2; that means, you will have a 2 equations and 2 unknown. So, v 1 and v 2 2 equations and we have got 2 unknowns, right.

So, thank you very much, we will be back again.