Basic Electrical Circuits

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Lecture – 41

Here I will discuss the assignment on units 5 and 6.

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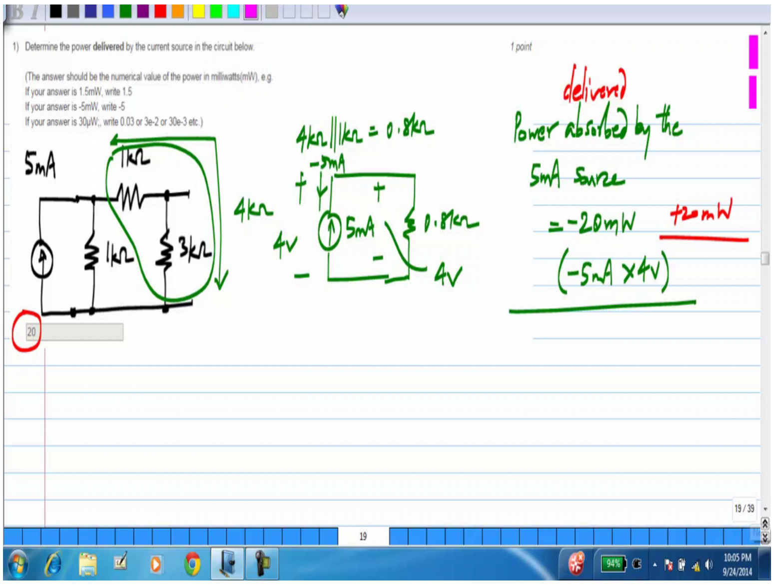

In the first question you are asked to calculate the power delivered by the current source, there is just one current source here and essentially, you have to find what is the voltage across it, so that you can find out the power delivered. By the way in general if you have a current source in a circuit, you could have the current source absorbing power or delivering power, but if the current source is the only source of energy in the circuit, then it has to be delivering power.

So, in this case for instance all the other elements are resistors, which can only dissipate power, so the current source will have to be delivering power and the power delivered will have to come out positive. So, now, we have 1 kilo ohm and 3 kilo ohm in series, so together these will give you 4 kilo ohm, these two together. And then, I have a 4 kilo ohm and 1 kilo ohm in parallel and that gives you 0.8 kilo ohms. So, now, we have 5 milli amp flowing through 0.8 kilo ohm, so the voltage with this polarity is 4 volts.

Now, if you take this polarity 4 volts and the current consistent with the passive sign convention, this current will be minus 5 milli ampere. So, the power delivered to the current source or the power absorbed by the current source, it equals minus 20 milli watts; that is, minus 5 milliamps times 4 volts. Of course, you are asked for the power delivered by the current source, which is the negative of whatever is absorbed by the current source.

So, the power if you calculate what is delivered, it will be plus 20 milli watts and like I said, if you have a single energy source in the circuit it will be delivering positive power or it will be absorbing negative power, so the answer is 20. Again, read these instructions you are asked to give the power in milli watts.

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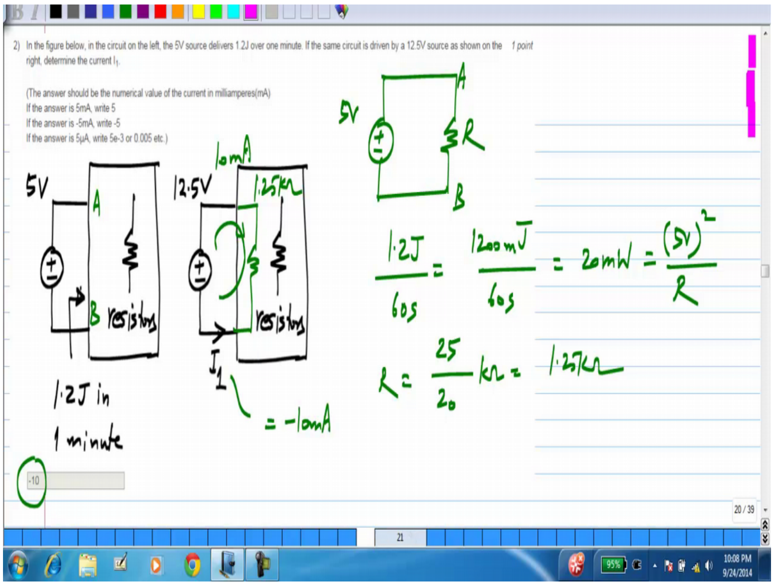

The second question, again it is related to energy. So, you have some network, some circuit here and when it is driven by 5 volt source, it delivers 1.2 joules of energy in 1 minute and it is also given that this circuit consists only of resistors. So, equivalently it looks like some resistor connected across the 5 volt source. So, I have 5 volts and there is some R between these two, this is A and B; there is some equivalent resistance between A and B, an energy of 1.2 joules is absorbed over a period of 60 seconds.

So, that is 1200 milli Joules over 60 seconds, which gives you basically 20 milli watts and that is equal to 5 volts square divided by R. So, R will be 25 volts square divided by 20 and I have this milli, so this will be in kilo ohms, so 1.25 kilo ohms. So, in the second circuit I have 12.5 volts across 1.25 kilo ohms, so that causes a current of 10 milli amp to flow in that direction. So, I 1 is the opposite of this direction, so I 1 is minus 10 milliamps.

So, you are given some information about the power or energy in this situation, from that you can calculate the resistance. The second part is straight forward, from that resistance and the given voltage you calculate the current.

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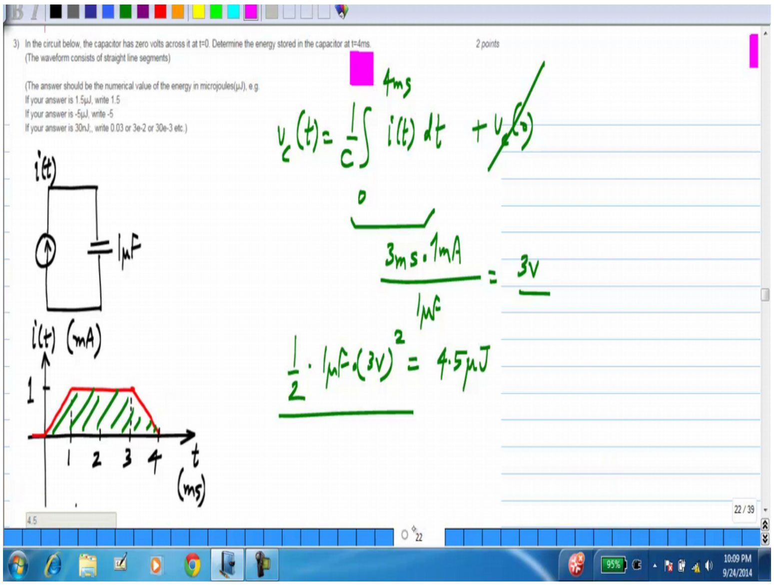

The third question, a current source is pushing current into a capacitor and the capacitor is initially discharged. So, you are asked to find the energy stored in the capacitor after sometime, the energy stored in the capacitor is half C times the square of the voltage on the capacitance. So, what you have to calculate is the voltage across the capacitor at t equals 4 milliseconds. So, this kind of problem you have solved many times before, you know that the capacitors voltage is integral over this time period; that is, 0 to 4 millisecond of the current divided by the capacitance plus the initial voltage which of course, is given to be 0.

This integral is this area, which is 3 milliseconds times 1 milliamp and divided by capacitance, which is 1 micro farad, so this gives you 3 volts. And the energy stored on the capacitor is half C V square, which is half times 1 micro farad times 3 volt square this gives you 4.5 micro joules. So, please use the correct scaling factors here and then, arrive at the answer. You are required to give the answer in micro joules, so the answer is 4.5.

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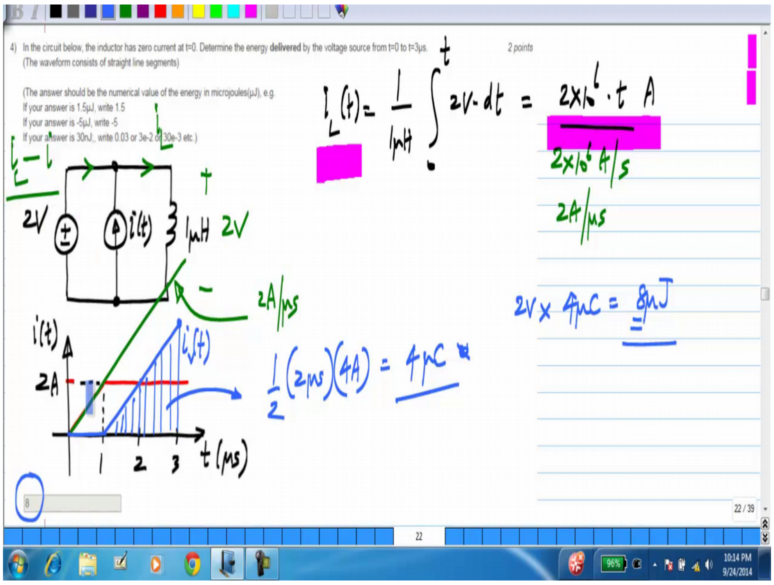

The next question we have an inductor, which at t equal to 0 as current of 0 and you have a voltage source across the inductor and also a current source. Now, first of all it is important to realize that, because you have the 2 volt voltage source across the inductor, you simply have 2 volts here and the inductor current will increase linearly, because of this constant voltage across the inductor. Now, what you are asked to calculate is the energy delivered by the voltage source from t equal to 0 to t equal to 3 microseconds.

So, you have to calculate the current that is flowing out of the voltage source and you are given some current i of t. First you have to calculate the current in the inductor, let me call that i L and the current from the voltage source will be i L minus i, so that is what you need to calculate. Now, the inductor initially has 0 current, so the current in the inductor, it will be 1 over L, 1 over 1 micro Henry and the integral of 2 volt with respect to time.

So, this what it gives you is 2 times 10 to the 6 times t amperes. So, the inductor current if you plotted it grows at the rate of 2 times 10 to the 6 amperes per second or 2 amperes per microsecond. Now, I will plot it on the same graph, the x axis is a microsecond and you have 1, 2 and 3 microseconds. This number here, the expression for the inductor current this means that at t equals 1 microsecond I have 2 amperes, t equals 2 microseconds I have 4 amperes and so on.

So, the inductor current itself does that and the slope of that is 2 ampere per microsecond and the current delivered by the voltage source is the inductor current minus this i. The purpose of this problem is to first of all make sure that you can calculate the inductor current correctly and also you can do simple Kirchhoff's current law calculations. So, what I have to do is to subtract this red curve from the green one, so what will I get the current will be 0 until time was 1 microsecond, after that the difference between these two is the straight line, so it goes like that, so that is the current from the voltage source i V.

So, I have to multiply this current by 2 volts and integrate the area under it. Now, because I am multiplying it by constant, so what I can do is I can take this area first and multiply it by the constant voltage. So, this area you will easily see it is a triangle, so it is half the base is two microseconds and the height will be 4 amperes. So, this is 4 ampere times microsecond, which is 4 micro coulomb and the energy delivered by the voltage source is 2 volts times 4 micro coulombs, which is 8 micro joules. You are asked for the energy in micro joules, so the answer is 8.

So, again first you have to recognize that there is 2 volts across the inductor. So, it is current is linearly increasing, then what you are asked for is the energy delivered by the voltage source. So, you have to see how much current is flowing out of the voltage source and that is a combination of the current in the inductor and this current source current and you calculate this current, integrate that, multiplied by the voltage to get the energy.

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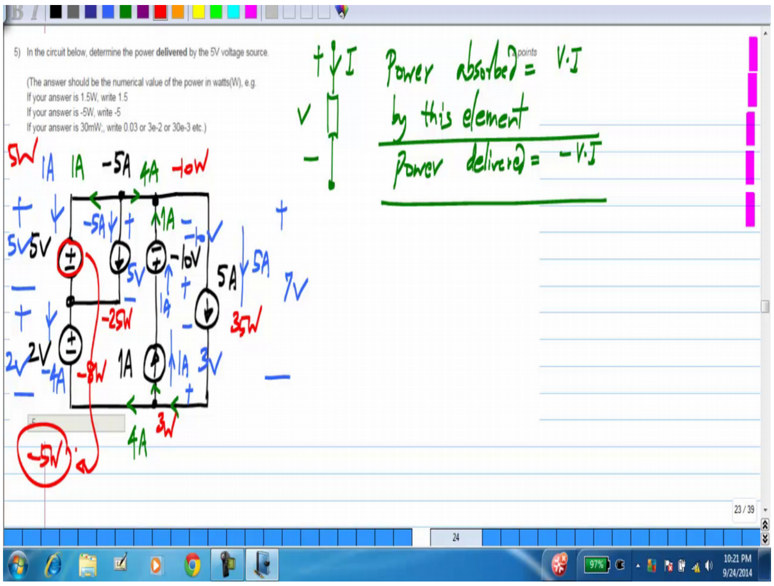

This one is just a network of voltage and current sources this is given, so that first of all you can apply Kirchhoff's voltage law and Kirchhoff's current law correctly. And then, also recognize that some of the independent sources could be dissipating power some others could be delivering power, what you are ask for is the power delivered by this. So, as usual if you have a 2 terminal element you take the voltage and current with the passives and convention the power absorbs will be V times i that is power absorb by this element and the power delivered will be exactly the negative of this.

So, now, this is not difficult at all first of all we have 5 amperes here due to this current source on the right side and out of that one ampere is going that way. So, here we will have 4 amperes, then pretty much you know everything. So, this is one amperes this is 4 amperes and again we have 4 amperes going that way and minus 5 amperes going that way or 5 amperes going upwards, so the current in this would be 1 ampere in that direction.

So, now, what I will do is I will calculate the power absorbed by every element just as illustration first thing is you denote the voltage and current of every element consistent with the passives and convention. Now, the first of them a let us say you chose the voltage any which I want, but then the next one that you it have the current should be consistent with passives and convention. So, let us say I take it for the 5 volt source I take the voltage this way and it is 5 volts by the definition of the voltage source.

I have to take the current flowing into wherever I have defined the positive to be this one and that is 1 ampere. And similarly, for this I take 2 volts like that and I will take the current in that direction and from here you see that that current is minus 4 ampere and for this current source I will take the current in this direction and that is minus 5 amperes and I have take the voltage in that direction and that one we know is 5 volts. And again this current here is 5 amperes and this volt is from Kirchhoff's voltage law we have this plus that one, so that is 7 volts. And for this current source, let me take the current in this direction it is 1 ampere, so I would take the voltage this way and; that is 3 volts.

Finally, for this voltage source, so let me take the current in this direction that is 1 ampere and the voltage in that direction is minus 10 volts. So, from this I can calculate the power absorbed by every element, so for this 1 it is 5 volt times 1 ampere, so that is 5 watts and for this 1 it is minus 5 amperes times 5 volts, so that is minus 25 watts and for this 1 2 volts times minus 4 amperes. So, that is minus 8 watts and for this 1 it is 1 ampere times 3 volts, so that is 3 watts and for this 1 it is 5 amperes times 7 volts, so that is 35 watts.

Finally, for this 1 we have 1 ampere times minus 10 volts, so that is minus 10 watts. And you sum the power absorb by all the elements; obviously, you will end of with 0 the question that you are ask is for the power delivered by this we know that the power absorb by this 5 volt sources 5 watts. So, the power delivered by that is minus 5 watts that is for this 1, but of course, you could calculate a power absorbed or delivered by any other element.

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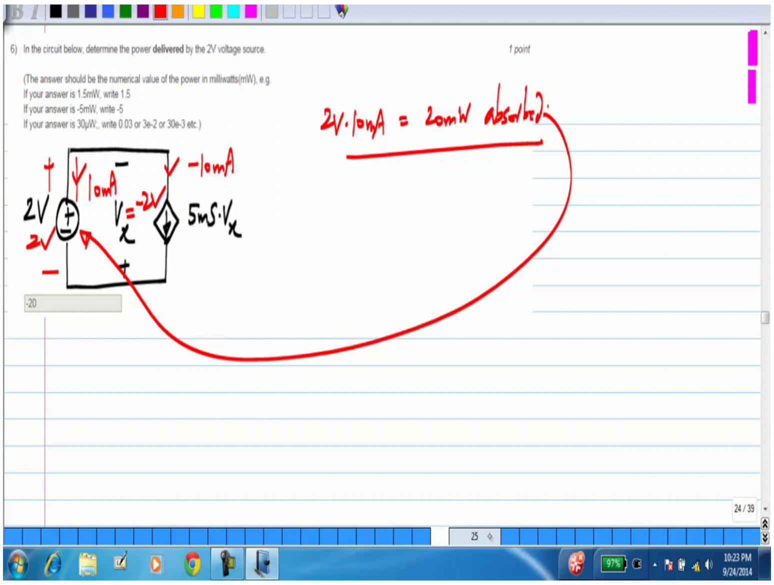

In this again the question is for the power delivered and you have a controlled source here, but the principle is always the same simply calculate the power by computing the voltage across the element and the current through the element this V x is minus 2 volts. So, the current flowing in that direction is 5 Millisiemens times V x, which is minus ten milliamps. So, let me take the voltage to be in this polarity for the voltage source it is 2 volts the current in that polarity again I have said this many times consistent with passives and convention is 10 milliamps.

So, the power absorbed by the voltage source is to volt times 10 milliamps equals 20 millivolts absorbed in this element, so the power delivered by that is actually the negative of that which is minus 20. So, in this particular case the 2 volt source is actually absorbing power and this controlled current source is delivering power.

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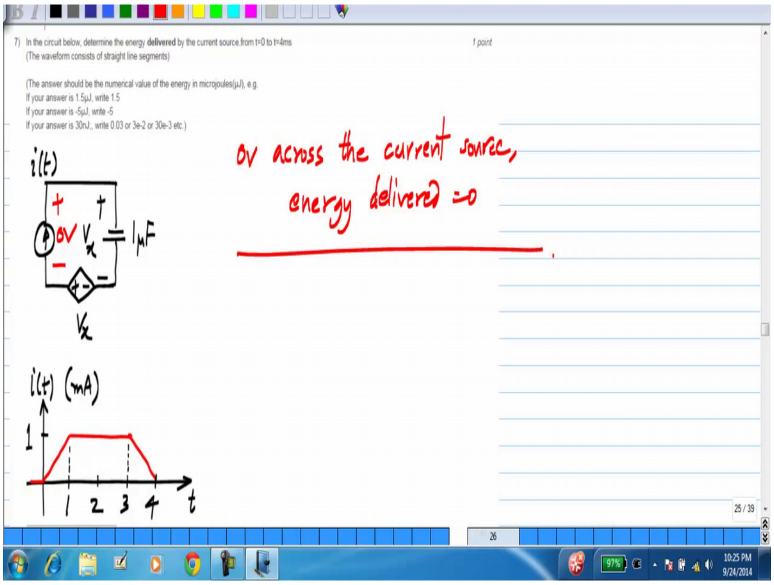

In this circuit you are ask to determine the energy delivered by the current source from t equal to 0, t equal to 4 Millisiemens. Of course, you can go and calculate the actual V x that results from this and so on, by integrating the current, but it turns out that in this particular problem you do not need any of that, if you did all of those thing it is perfectly all right, but if you look at it little carefully you see that V x this is the voltage controlled voltage source and this V x is defined to be across the capacitor.

So, if you calculate the voltage across the current source in terms of V x will have V x this way and minus V x, so across the current source we have 0 volts always. So, we do not need the details of anything the energy absorb by the current source is always 0 and then energy delivered; obviously, also 0. So, in this case it turns out that the controlled source is what is delivering energy. Because we have 0 volts across the current source energy delivered equals 0.

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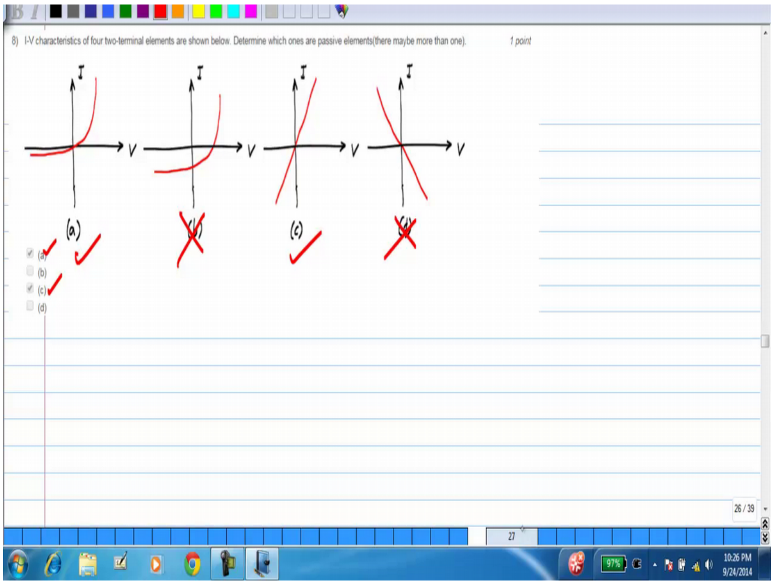

This is the multiple choice question you are ask to identify a passive elements and this is pretty straight forward correct its assume that I n V r chosen consistent with passives and convention that is a we plot I V characteristics elements. So, if you have characteristics in either second quadrant or fourth quadrant it is not necessarily passive do you see that this has no part of it characteristics in the fourth quadrant this one has it and this one has in both second and fourth quadrant. So, b and d are not passive a and c are passive that is what is given here.

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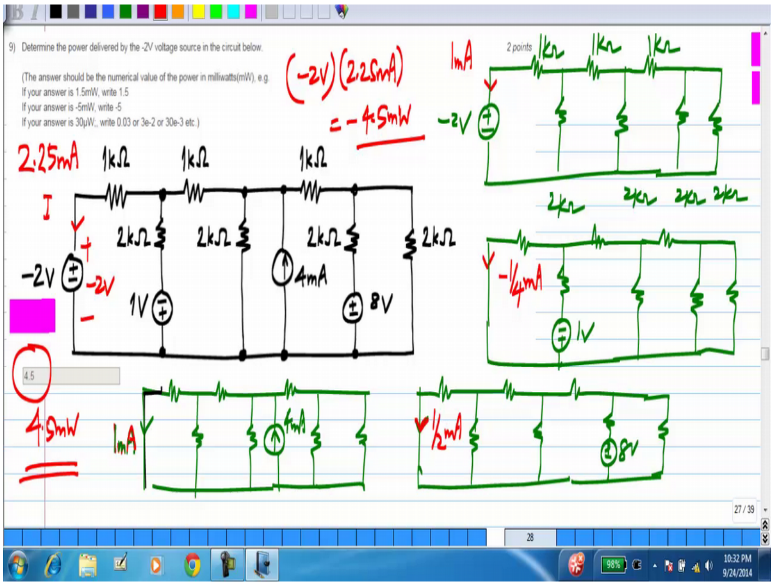

Now, this one the circuit looks complicated basically it is an exercise and both solving for circuits using super position and then of course, calculating the power delivered by some sources. Now, you are asked for the power delivered by the minus 2 volt source, which is here, which means that you have to calculate the current. So, the voltage in this polarity is minus 2 volts and you calculate this I once you do that you know the power absorbed by the voltage source, which is minus 2 volts times I and you can calculate everything else.

So, now, we have multiple independent sources and you solve for this by superposition. So, I will not show the detail of a every step, but I will show you the 4 scenarios, which have to be super post there are 4 independent sources right for superposition you have only one of the sources to be non 0 at a time set all the other sources to 0 and some of the solutions that is when I say some of the solution you some of the voltages or current resulting from that not the power voltages and current can be super post, so let us do that.

First let me take the minus 2 volt source and if I set this volt is to 0 it is a short circuit in the current source this is an open circuit and this is a short circuit. So, the resulting circuit is just this these are all 2 kilo ohms and these are all 1 kilo ohms and you can solve for this we will find that the current flowing this way would be 1 milli ampere in this case. Next you take the other voltage source this is 1 volt in this direction and the current from this turns out to be in this direction minus 1 by 4 milli ampere.

Let me take the third case that is having only this current source factor this is 4 milli ampere in this case current flowing here turns out to be 1 milli ampere again you can solve for this and find out. And finally, the last of the voltage sources I have 8 volts over here if you calculate the current here it turns out to be half milli ampere now this current I here the simply the sum of all these 1 minus 1 4th plus 1 plus half. So, this I will be 2.25 milli ampere.

So, the power absorb by the minus 2 volt source is minus 2 volts times 2.25 milli ampere, which is minus 4.5 milli watts. So, the power delivered by this is simply the negative, which is plus 4.5 milli watts, so that is all that is there do it.

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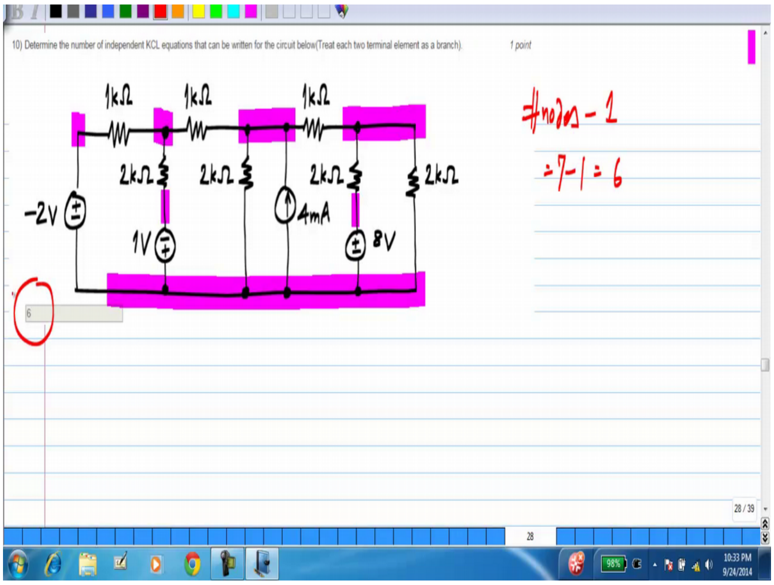

This question is very simple you should determine the number of independent KCL equations, what you need to do is to count the number of nodes node is the point of connection of two or more component. So, this is a node, that is a node, this is a node; that is a node that is a node, this one is a node and that one is a node. So, identified points of connection in the circuit, where two or more components get connected. So, we have 1 2 3 4 5 6 7 and we know that the number of independent KCL equations that can be written is the number of nodes minus 1, which is 7 minus 1 equals 6.

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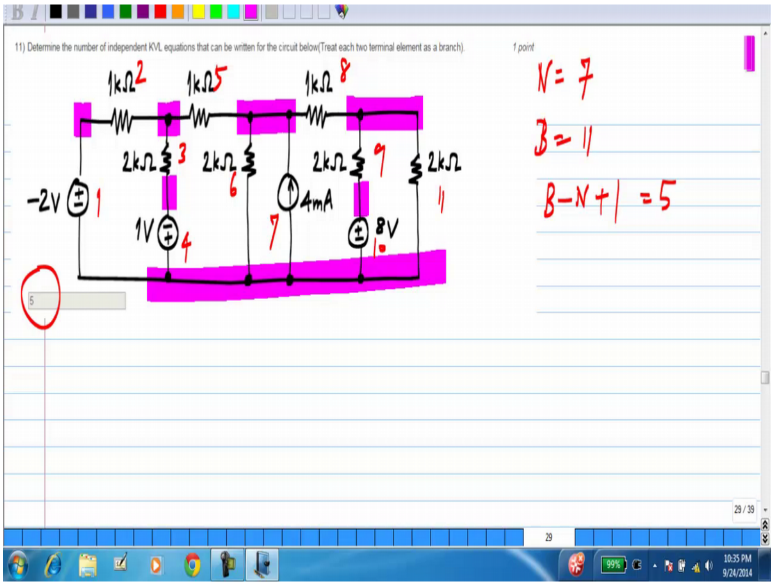

The same circuit here, this time you are asked to determine the number of Kirchhoff's voltage law equations. So, what we do is again let me identify the nodes, then draw a graph of the circuit I have identified let me identify nodes same as what I had before. So, the number of nodes N is 7 and I have to identify the branches, branches are basically every element in this I will have to count that, so I have1 2 3 4 5 6 7 8 9 10 11.

So, the number of branches is 11 we know that the number of independent loops that can be form is B minus N plus 1, which turns out to be 5. So, hope fully you are able to do all of these correctly as usual if you made a mistake, then do not just look at my explanation go back and solve the problem independently and make sure that you get the same answer. And another thing to do is of course, if you make a mistake go back and see where you made a mistake and understand that properly. So, that you do not repeat the mistake as for as possible.