Basic Electrical Circuits
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Lecture – 05

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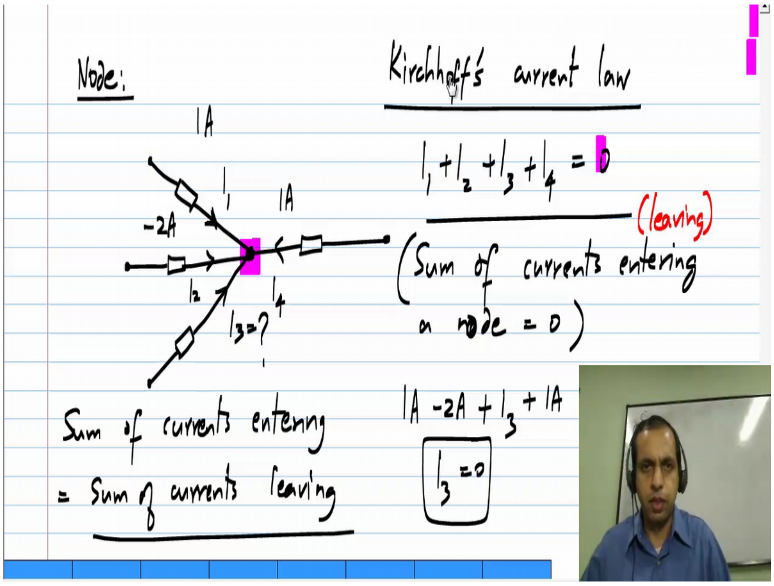

Now let us look at some general properties of currents and voltages, which hold true regardless what element you connect, so they are not properties specific to any circuit, but general properties of currents and voltages in a circuit. So firstly, let us consider a node with a number of elements connected together. And let me define the current in each element to be flowing towards the node I 1, I 2, I 3 and I 4. So, now, there is a law Kirchhoff's current law, Kirchhoff was the scientist who first stated this which says that sum of all currents entering a node is 0. Now why does this make sense, let us imagine that the sum was not 0, what would that mean, what is current after all, current is rate of flow of charge so that means, that there is some net rate of flow of charge into this node. If the sum was not 0, then there is some net flow of charge into the node over time, so that means, that the charge is either accumulating at the node or somehow charges spontaneously destroyed or created; so neither of that is true, charges conserved it is not destroyed or created that much is true and also we will make the assumption that there is no local charge accumulation.

Now, this is true and circuits are small and so on compared to something. So unless you have some very large circuits operating at high frequencies, this much is true that there is no local charges accumulation and sum of currents flowing into a node will be equal to 0. Now sometimes this is stated differently you could also equally well say that you can consider currents in the opposite directions that is leaving the node and say that the sum of all currents leaving the node is 0. And if you call this current as I 1 dash, it is simply equal to minus I 1 because I told you earlier that plus 1 ampere going from A to B is the same as minus 1 ampere going from B to A, so this is simple.

Sometimes it also stated as sum of currents entering equals sum of currents leaving. Now whether you choose to represent a current as entering the node or leaving the node is up to you. Any current can be thought of as entering this node or leaving this node. What will happen is the value of the current will get reversed in sign. You can say plus 1 ampere is flowing through this element into the node or minus 1 ampere is leaving this node, there exactly the same. So you can use any of these definitions and any of those currents could be positive or negative, but just do it consistently so that you get the correct answer; do not get confused by polarities of currents and whether the currents are consider to be entering the node or leaving the node.

Now, what does this mean you can calculate an unknown based on the other currents. So let us say I one happens to be one ampere I 2 is minus two amperes let me get rid of this red stuff, it could be confusing and I 3 is unknown and I 4 is 1 ampere. We know that I 1 plus I 2 plus I 3 plus I 4 is zero so that means, that 1 ampere minus 2 ampere plus the unknown value of I 3 plus 1 ampere equals 0, so this means that I 3 has to be equal to 0. And for different numerical values of I 1, and I 2, and I 4, you will get different values of I 3.

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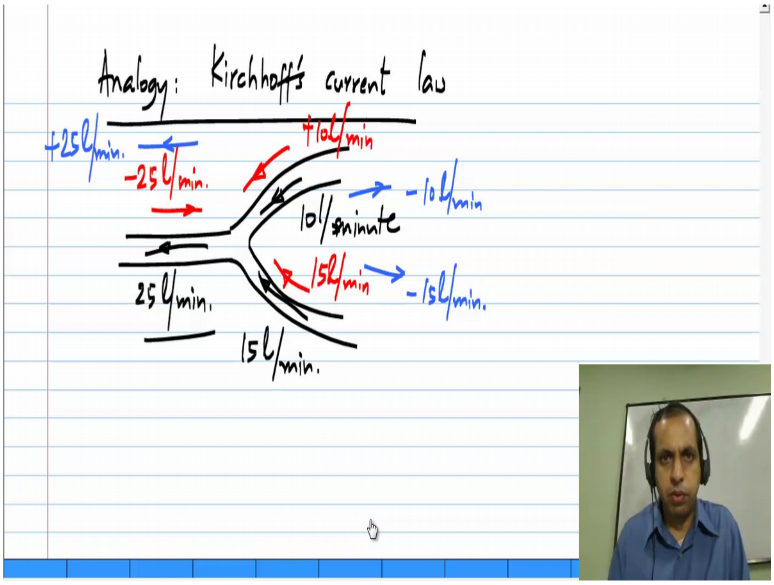

Here is the analogy for Kirchhoff's current law. Let us say you have some pipes connected together to form a junction; I will just take 3 pipes. Now let say water is flowing here at 10 liters per minute and water is flowing here at 15 liters per minute you obviously, know that water will flow out here at twenty five liters per minute this is all that is right Kirchhoff's current law as the same thing, but it relates to flow of charges instead of flow of water that is all. And it this makes the same assumption that we did for Kirchhoff's current law that is water of course, is not magically being destroyed or created from this node. If that is the case then what is coming out will be more or less than a total of what is going in. It also obviously, means that this pipe is not leaking here etcetera; if it were leaking, what coming out here would be less than these things.

The way we stated Kirchhoff's current law is to take flows only towards the node. So if we do that for this we can say that water is flowing here plus 10 liters per minute and here at 15 liters per minute. And if we have to take this flow in this direction, we know that water is going out, but in this direction minus 25 liters per minute, and the sum of these three minus 25 plus 10 and plus 15 is obviously 0, and you could equally well take all of them going outwards, you can consider this to be going out at minus 10 liters per minute and this going out at minus 15 liters per minute, and this one going out at plus 25 liters per minute, so obviously the sum of these things marked in blue is also 0.