Basic Electrical Circuits
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Lecture – 116

After that they would like to have an expression for something like this and that, we can get by solving this.

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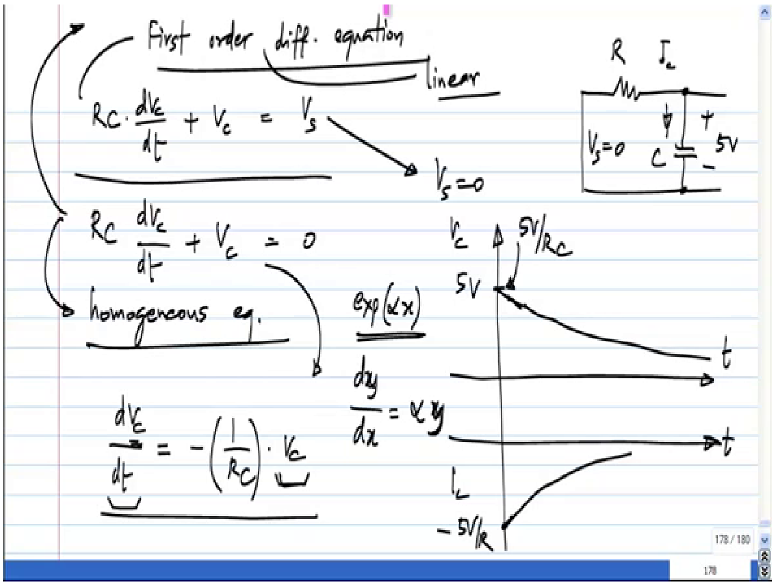

We will do this and many different ways I know that this is very simple and many of your probably all ready now the solution, but we will leave this, so often that it should become automatic, if you look a circuit you should be able to tell what is going on and why it is that going show on. So, that is why you will spend a lot more a time on this and we would them mathematics class on a first order differential equation by the way this kind of thing is known as a, this is a first order differential equation.

Why is it called first order? Because, differential equation is nothing but, on the left hand side you have the variable itself V c in this case and derivatives of the variable and you can have higher and higher order derivatives. So, the order is define by the highest order derivatives that is there on the left hand side, on the right hand side you group all the constants which are short of a inputs to the system and this one which has 0 on the right hand side, what is this it is called a homogeneous differential equation.

So, in general if you have only variables and 0 on the right hand side that is called a homogeneous equation. So, if I rearrange this now I get... So, now, we have this expression which says that the derivative of some variable V c is some constant minus 1 by R C times this same variable, this is the kind of differential equation he could not may be 5 minutes after learning about differentiation, because a given the table of different derivatives and you see a which is the same on the left and right side on the table that is the solution. What is that, this is usually the form energetic put. So, what is the solution to this y equals.

Student: ((Refer Time: 02:19))

Exponential alpha y here what is it exponential of alpha x. So, the derivative of an exponential is an exponential ((Refer Time: 02:41)) very significant think. So, the solution to this is all of you easily guest as.

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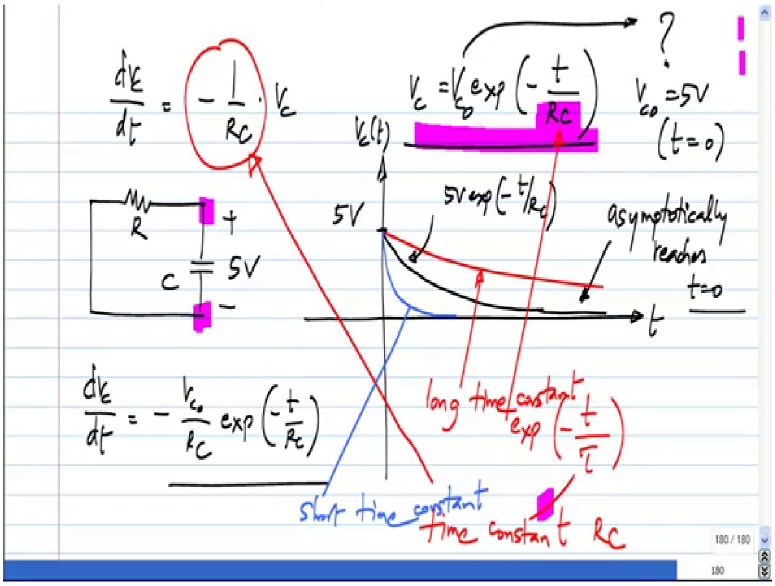

Now, there has to be some constant here, this is of the form of exponential minus t by R C, but there will be some constant because if you multiply if you scale V c by any number that is also a solution this is by the way this kind of it provide to mention that particular term. So, this is not just a first order differential equation, this is the first order linear differential equation. Because, we have V c and the derivatives of V c, but squares of V c R squares of the derivatives etcetera, etcetera.

So, this also means that because it is a linear different equation if you have particular solution V c of t than some k times V c of t also a solution, because all of these terms will get multiplied by the same k. So, V c will be of the form V c naught exponential minus t by R C and so if take my example of R C with initial voltage of 5 volts and in general this always true, because your solving for linear differential equations when yours solve for homogeneous linear differential equation the results you can get it, but it will be ambiguous by some factor, because you multiply the solution by any factor that is also a solution.

So, how do you tell what this factor is, so that is done based on the initial condition. So, you should be given initial conditions when you solve for differential equation and based on the initial condition you can fine this consistent. And in case of the first order differential equation you will have one such constant, if you have a second order differential equation two such constants and so on.

So, the number of initial conditions has to be equal to the order of the differential equation. In this case it is very obvious what is the value of V c 0, so in generally you will find by sub suiting some suitable value of t for which you all ready know the solution and this case you know that far t equal to 0 the solution is 5 volts. So; that means, that V c 0 is 5 volts, this you get from the value t equal to 0. So, it start with 5 volts and does that discovered 5 volts exponential minus t by R C and this is V c of t.

Now, before I did just all for this and plotted, because some times when you can lose the feel for why it is the way it is we earlier solved it sort of graphically, we have 5 volts and minus 5 volts perhaps through of the capacitor and that will reduce the voltage as the voltage reduces the current reduces. So, the rate of change keep some ((Refer Time: 06:17)).

So, this business of the rate of change being proportional to the function itself that is what gives you an explanation. In this case the rate of change is proportional, but weather negatives sign, so that is why what happens is, it is following and then the rate of following become shall over and shall over until finally, it reaches 0, but only t could infinity that is known as asymptotically reaching some value that is it won't reach that 0 value for any finite value of t, but only for t equal to infinity.

So, you should know both this like how do solve for this is after very simple equation at the same time why it comes out the way it is that you know from the circuit that the current in the capacitor keeps on following. Now, what is the initial slop of this. What is d v c by d t?

Student: ((Refer Time: 07:16))

Minus V c naught by R C exponential minus t by R C. So, again if you look at the value of t equal 0 it is V c naught by R C that we good tell also by just looking at the circuit, because we have 5 volts across the capacitor which is also across the resistor. So, the current is 5 volts by R and the rate of change voltages I by c which is 5 volt by R C that is the rate of all and then that keeps on reducing this is fine and this quantity R C here, like we will see later that we will do more calculations of this circuit and that thing appears all over the place.

So, this exponential will have minus t by some quantity that has dimensions of time. So, this is known as the time constant and that comes about because many of write the homogeneous differential equation like this, the coefficient is over there you have minus 1 by R C that is what makes is R C going to the exponential. So, that say characteristics of the solution to this differential equation that is a time constant and it is very common to here the terms like R C time constant of the circuit, so this is what it is.

So, it influences the rate at switch this falls what happens of the time constant of very large, what happens to this curve red for quickly or slowly, slowly. So, because if let us R is very large I mean the time constant could be very large by the R being very large or c being very large, if R is very large what it menses is that the current is very small, initially for the same 5 volts the current is much smaller. So, that we instead it is discharge the capacitor let us say after all what is happening, initially we have some charge across the capacitor that is leaking through this R and then close all the way to 0.

Now, if the resistances very large than it means that very little charges take an out for unit time should this charges very slowly, alternatively the time concept can be very large by the capacitor being very large. So, that means it has so much charge that if you take a certain amount of current out of it the reduction in voltages much smaller. So, these are all just intuitive explanations for what comes out algebraically very easily and there all it is also quit important to realize these things intuitively. So, this is a circuit for the long time constant and could have very short R C and then it will do something like that and this is the circuit whether very short time constant and depending on the application we may short time constant.