Principles of Signals and Systems
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Lecture – 05
Classifications of Systems – Memoryless and Casual/ Non-Casual Systems

Hello welcome to another module in this massive open online course. We have looked at the classification of signals and we have looked at various classes of signals or various frequently occurring signals. Let us now start or let us now start discussing the other aspect or the other fundamental aspect of this course which is systems, their behavior and their properties.

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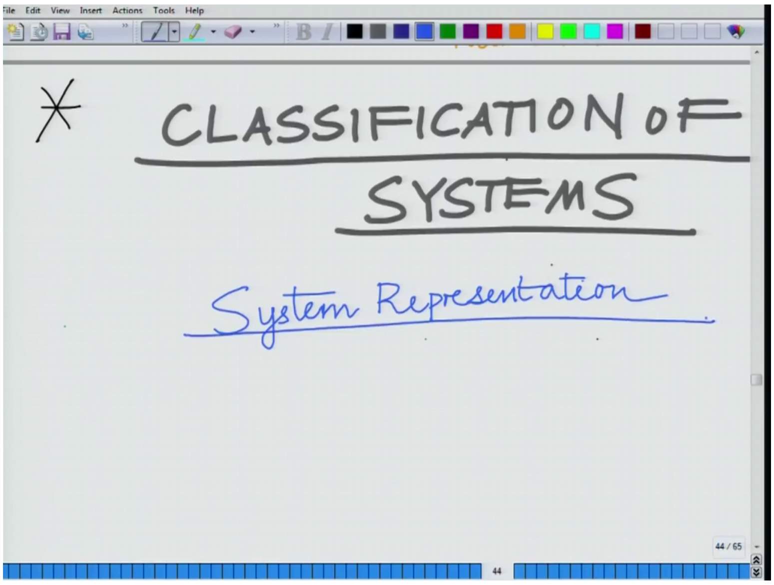

What we are going to start look what we want to start looking at is basically something equally if not more important which is the classification the classification of systems and when I say a system or its representation for us the system and its representation are going to be equivalent because frequently we are going to be dealing with a mathematical or an analytical representation of a system.

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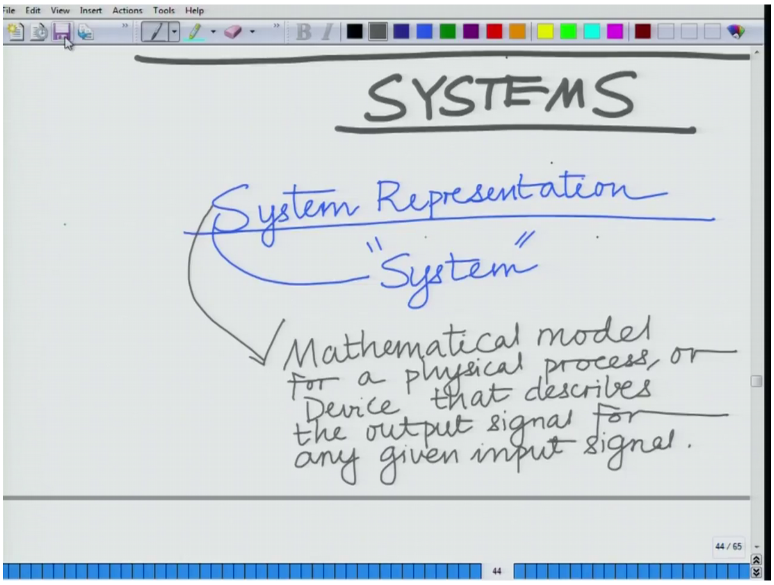

A system representation which will frequently refer to simply as a which will frequently refer to simply as a system or basically a representation or a system model correct is a mathematic is system or a system representation is a mathematical model correct for an actual physical process or a physical device or an object, it is an analytical model or a mathematical model that precisely captures the output the input output relationship of the system that is given an input signal what is the behavior of the system or what is the output that is given out by the system. It is a mathematical representation of a physical process which characterizes this input output system that for us is going to be a system or a representation of the system. A representation of a system that is basically it is precise mathematical model for physical process or device for a physical process or device that describes the output signal for any given input signal.

For any given input signal this system model or system representation must be able to characterize the output precisely characterizes the output.

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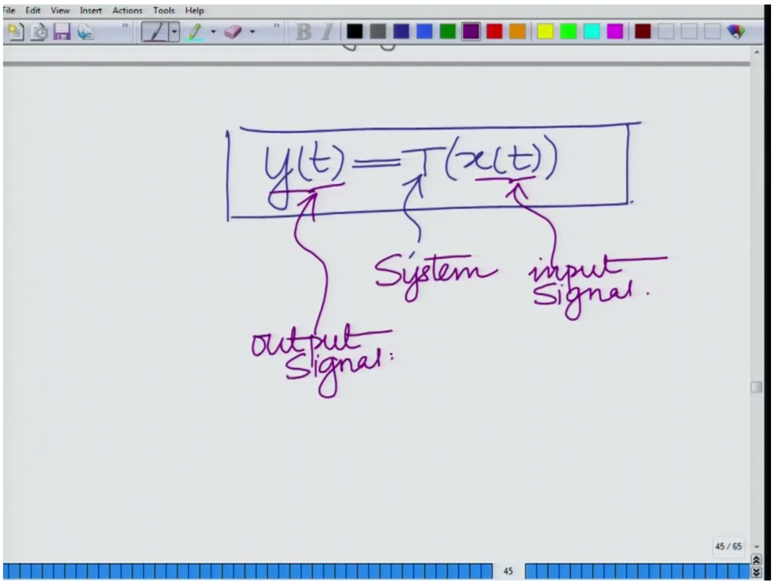

For the given input that for us is a system and the system is typically presented as mathematically as X t a general system or as one of the most frequent representations used is y t equals t of X t this is 1 of the most frequently used representation where t is basically captures this physical process of the system X is the input signal and Y this is the output signal.

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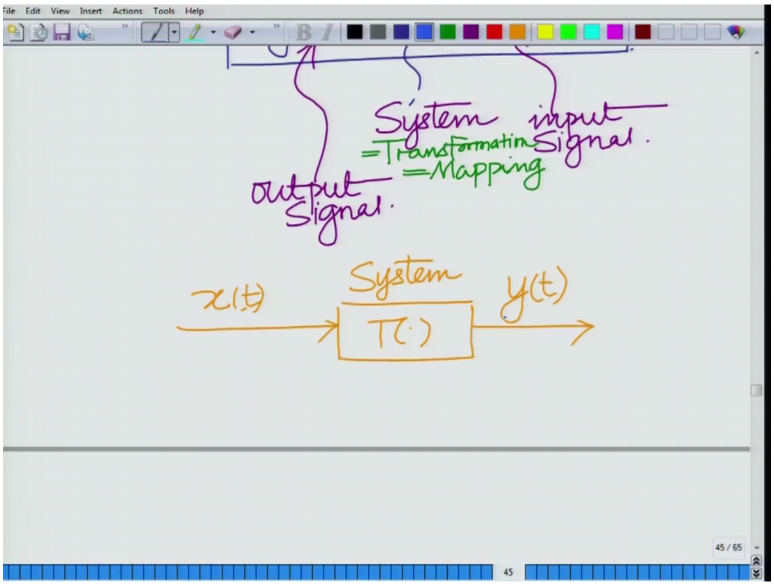

And also schematically represented and this is a system or basically it can also think it as or think of it as a transformation for us it is also going to be a transformation a transformation or it is also going to be an input output mapping. This is your system there is an input signal X of t there is an output signal Y of t and this is the this is our system this is our system or this is our definition first and more precisely this is a continuous time system.

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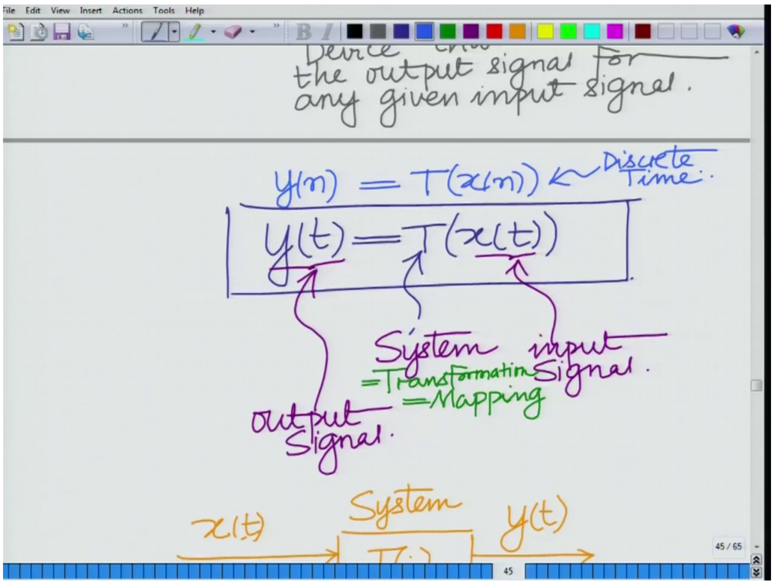

In the same manner i can define also a discrete time system with the output is Y of n and the input is X of m. I can similarly have y of n equals T of x of n and the properties are similar, this is basically a discrete time version of this and similarly I can have.

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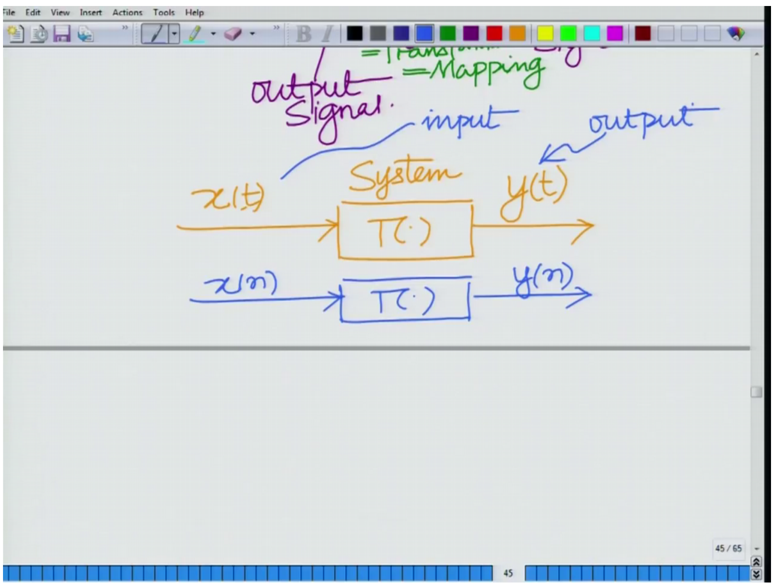

A representation that is that is x of n is the input and y of n is the output x of t also frequently simply referred as the input y of T simply referred to as the output this is the input output characteristic systems characterizes precisely characterizes the input output relation gives a mathematical model for the input output relation that is given an input signal what is the output signal.

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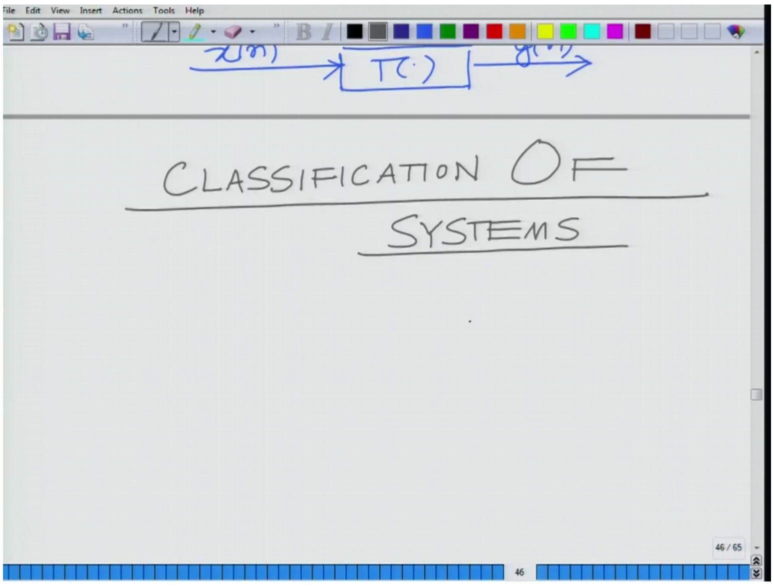

Now, there are several systems again let us now look start looking at a classification similar to classification of signals to better understand the properties classification of, let us start with a classification of system to better understand the properties of various system the first important class of systems that we are looking going to look at.

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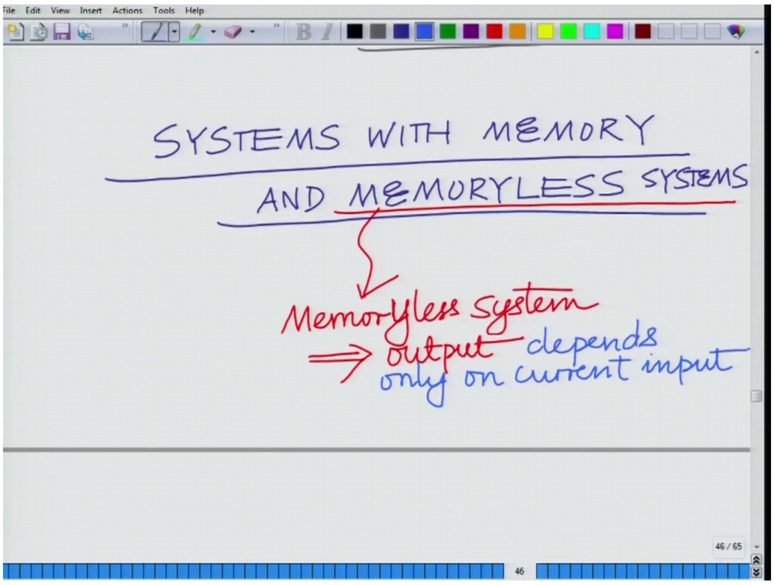

Systems with memory and memory less systems that is systems can either have memory or they can be or they can be that is these are two different kinds of systems memoryless; memoryless; memoryless systems.

Now, the system has system is memoryless that is it is known as a memoryless system implies if output depends only on that is both for discrete and continuous time output depends only on current input that is input at current time or in current only on current input or input at current time instant input at the current time that is the past inputs or the past history of the signal has no bearing on the output of the system and this is an important property all right.

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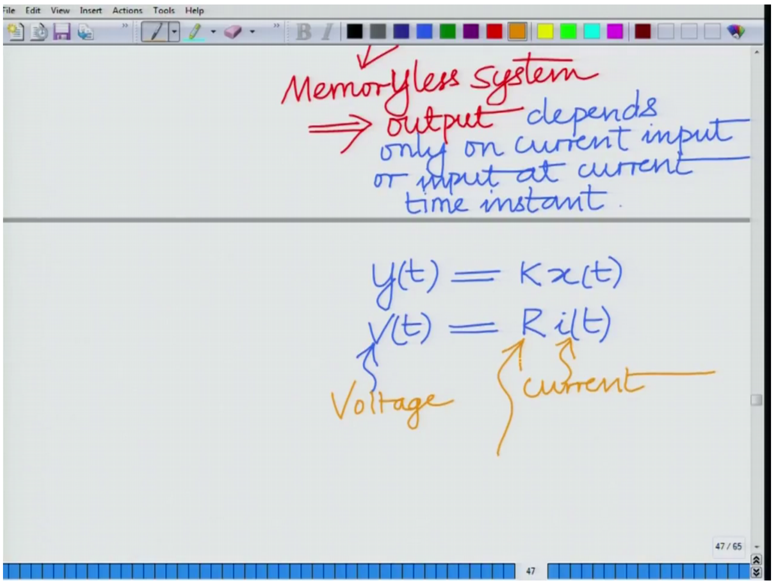

This characterizes a memoryless system for instance you have Y of t equals some constant K times x of t for instance in a circuit we have V of t equals R from the ohms law we have V of t equals R times i of t V is the voltage i is the current R is the resistance R is the resistance and the current voltage the voltage at time instant t depends only on the current at time instant t all right.

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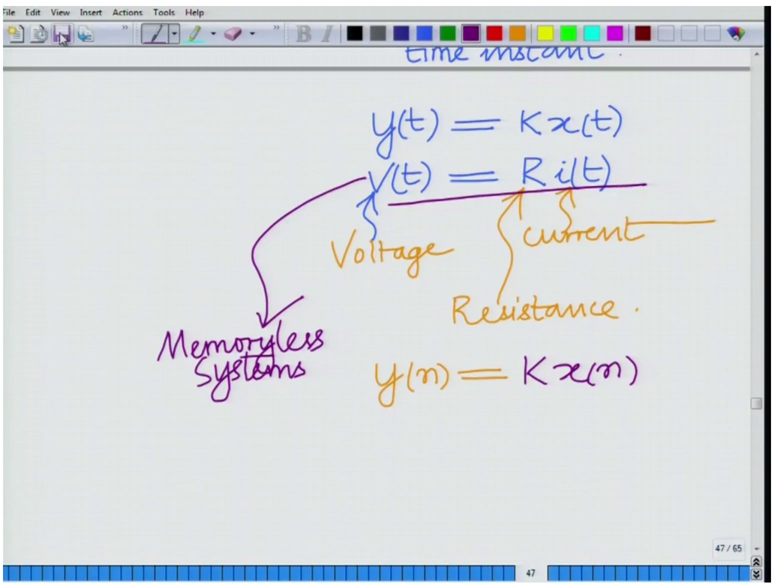

This is a classic example of a memoryless system alright.

Similarly, I can have for a discrete time signal I can have Y of n equals some constant K times x of n again there is an example of a memoryless all these are basically you are memoryless all these are basically examples of memoryless systems on the other hand.

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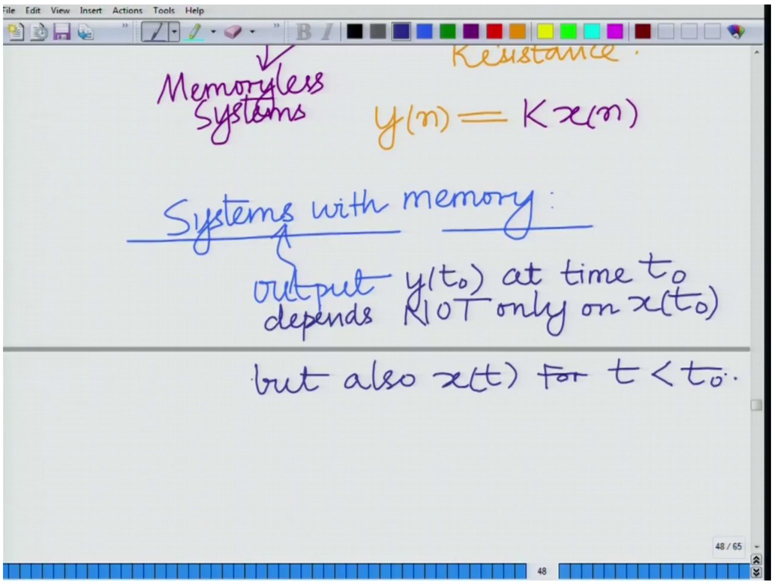

In systems with memory they are opposite of naturally systems which have memory or systems with memory these are the opposite of memory these are the opposite of memoryless systems and in which the output depends not only on the current input to the current time input at the current time instant, but also input at input at the past time instants or the inputs at the past time instants. The output depends not only on x t, but also depends on the past values of x t.

The output let us call this output Y t naught output Y t naught t naught depends not only on X t naught, but also X t for t less than t naught that is the key right X t for T less than it that is output depends.

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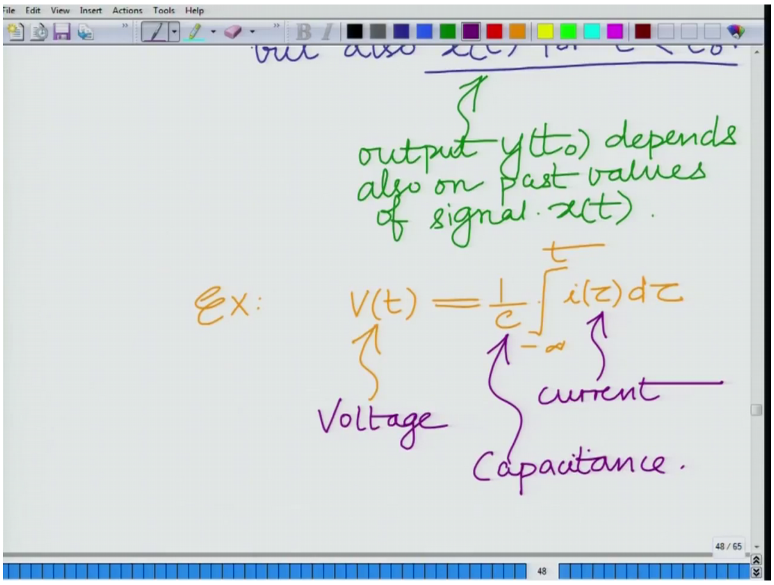

Also output Y t naught depends also on past values of output Y t naught depends also on the past values of the signal X t n this is known as a system with memory for instance again 1 can look at some quick examples for instance if you again go back to the example of circuits you can have the voltage VTVT equals 1 over C integral minus infinity to infinity I of TAU data will V of t is a voltage this is a voltage signal.

This is a current signal and this is the value of the capacitance correct this is the value of the capacitance and what this says is the voltage current relation this the capacitor is a system with the memory and I am sure this you also know from your analysis knowledge of some basic circuits that the capacitor has memory because the current voltage depends not only on the value of the current at this time instant T, but also on the values of the current signal I t at the past time instants. This is the classic example of a system with memory unlike a resistance which is gone by ohms law and does not have memory a capacitor is a system with memory.

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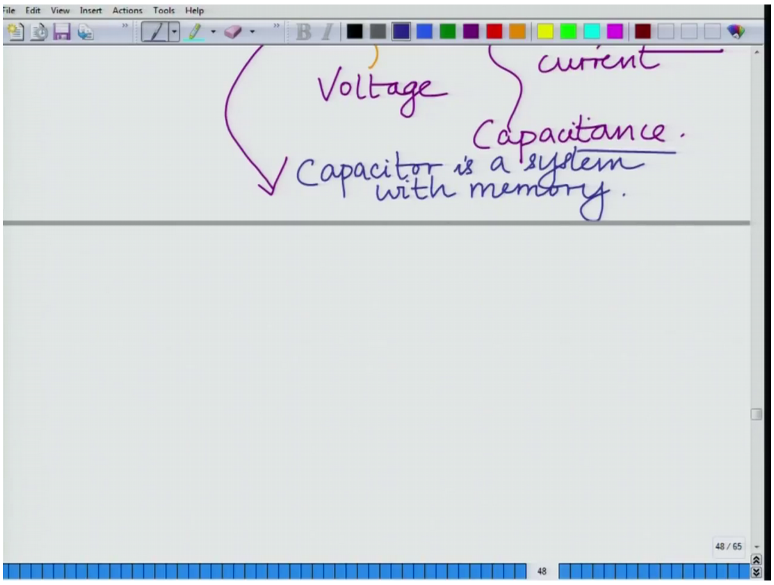

This is a system with memory, capacitor is a system with memory capacitor is a system with memory, which means current values of voltage depend on past values of the current signal if you treat this as an input output system where the input is current output equal to voltage current value the present values of the voltage depend also on the past values of the current signal. The capacitor is a system classic example of a system with memory.

Let us now come to yet another important property of a system that is causality that is causal versus non causal systems causal and non causal and non causal systems.

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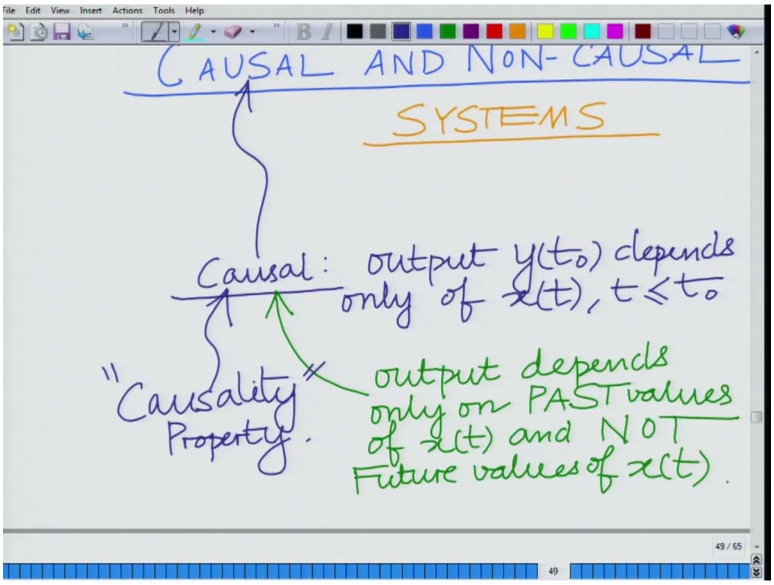

Now causal system causal implies or a system is causal if output depends only on X t alright output depends only on X t for t less than or equal to t naught, causal system is causal if depends X t that is output Y t naught only on X t for t less that is output depends only on past values of X t does not depend on future values of X t that is to explain it plainly the output depends only on and not future values of that is output depends causal system is one in which the current output; output at the current time instant depends only on the past values of the input it does not depend on the future values of the input signal such a system is known as a causal this property is known as causality that is the input causes the output this property is termed as causality this is termed as the causality the property and arises from the English word cause which means the input causes or the input explains the output for instance again and if a system is not causal it means non causal obviously, implies system is not non causal implies system is not causal.

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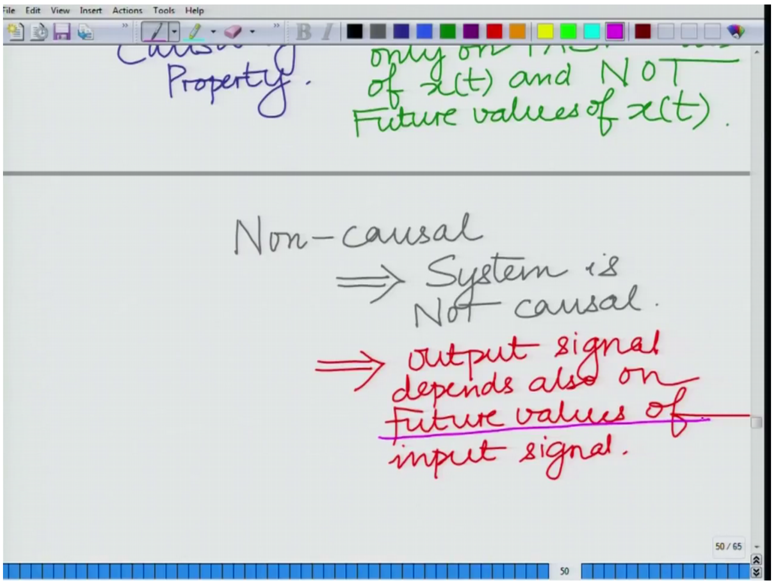

Which means that output depends also on future values of the output signal depends also on future values of output signal depends also on future values of the input signal for instance again let us go back.

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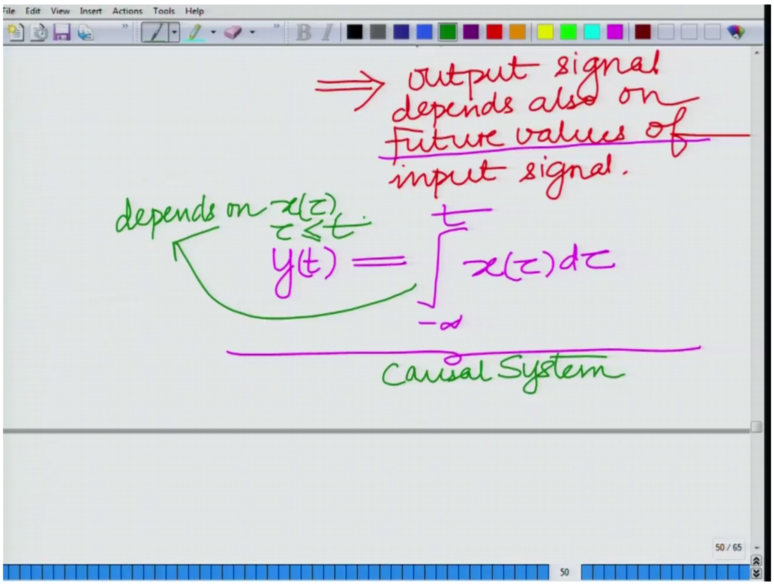

To a simple system Y t equals minus infinity to T x of TAU D TAU you can see this is a causal system this is a continuous time causal system because it depends on Y t depends on all X t all TAU X TAU less than equal to T because this depends on X TAU TAU less than or equal to that is the important property, however on the other hand if you have a system.

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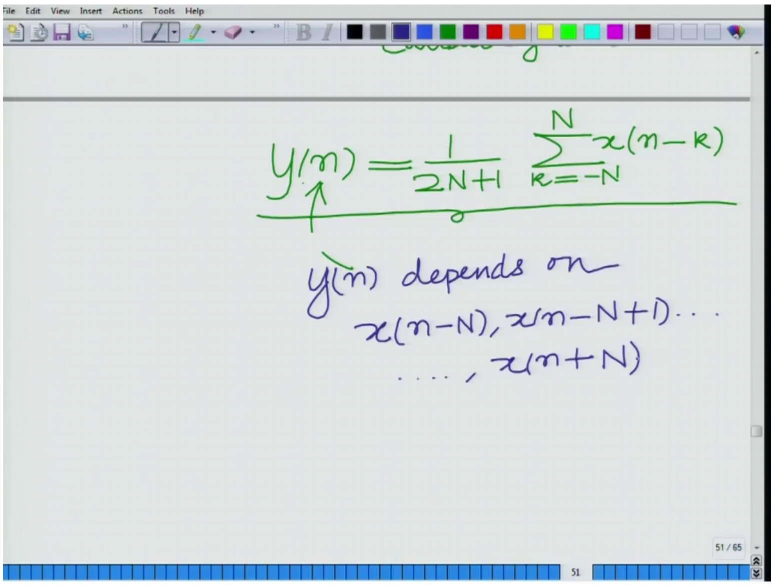

Let us take a discrete time system such that Y n equals 1 over 2 N plus 1 summation n equal to minus n to plus n x of n minus n correct x of n minus N you can clearly see Y equal to x of n x of summation x of n; n equal to minus n; n equal to minus n two plus n or let us put it this way why n equals 1 over 2 plus summation k equal to minus N 2 plus and x of K plus or x of n plus K or x of n minus k you can see this goes from n minus and. This depends on, if you look at y n this depends on it depends on x of well n minus n x of n minus n plus 1, on until x of n plus and, it also depends on the future values of x that is the whole point it also depends on depends also on the future values of X n depends also on depends also on future values of X n hence this is non causal.

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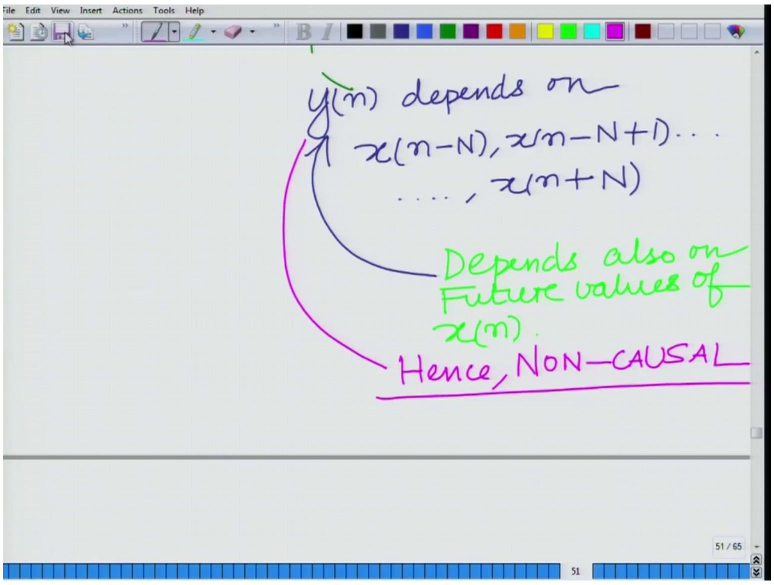

Since the output depends not only on the past values, but also on the future values of X n this is non causal it is an example of a its an example it is an example of a non causal system all right. We have causal systems, we are looking at systems different types of systems you are looking at a classification of systems we have causal and non causal systems in a causal system the current output depends only on the current input and past values of the input; however, in a non causal system the current output depends both on the past values of the input as well as the future values of them. That is a non causal system alright. We will stop here and continue this discussion in the subsequent lectures.

Thank you very much.