**Principles of Signals and Systems**
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**Lecture- 01**
**Introduction to Signals and Systems, Signal Classification – Continuous and**
**Discrete Time Signals**

Hello, welcome to this module in this massive open online course alright. So, this module alright, what we are going to look at is basically, in this course is signals and systems the properties of signals and systems, alright.

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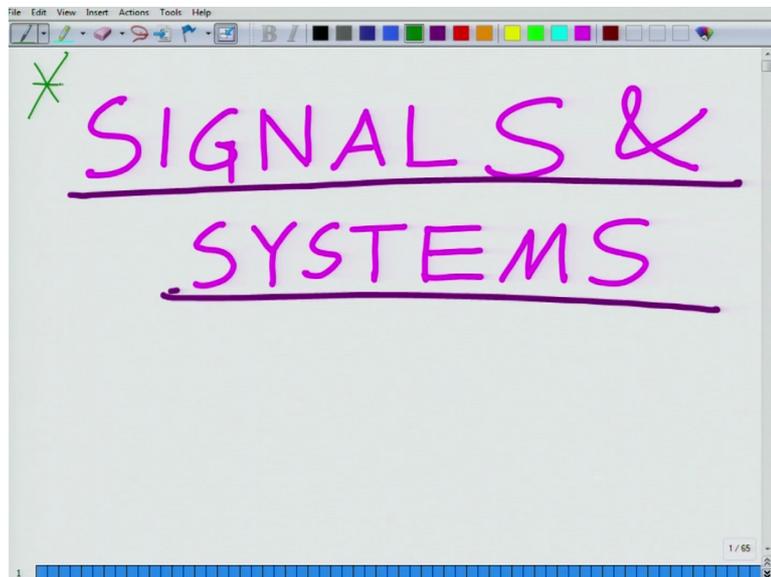


So, this course concerns itself with as the title implies, we would like to look at signals and systems two of the fundamental quantities which are relevant in all of electrical electronics and communication engineering and relevant at a very profound relevant data in a very profound sense. Since they are fundamental have fundamental relevance or understanding or their knowledge is, fundamental to understanding the various concepts or the various the aspects of you know different applications in electrical electronics and communication engineering correct.

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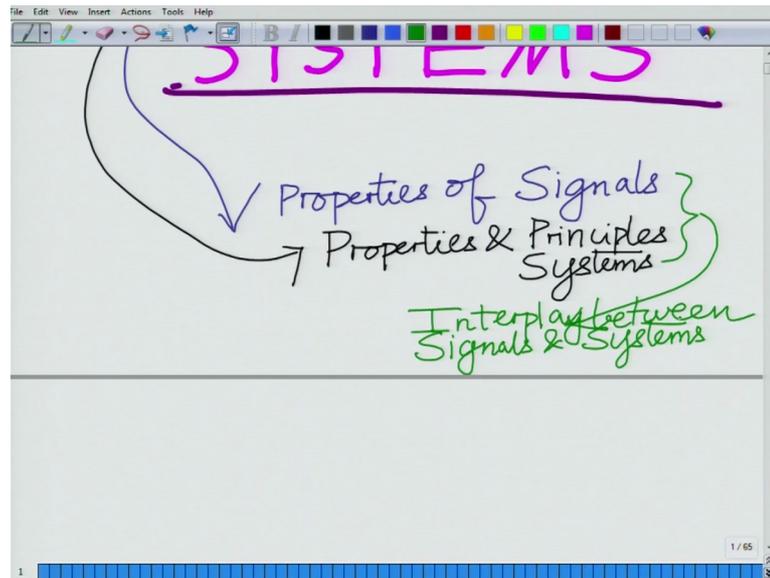


So, what we are interested in in this massive open online course is to understand as I already said the fundamental concepts in the properties of signals properties of signals, correct properties of systems various guiding principles properties and you know not just the properties, but various principles of systems alright and more importantly we are interested in this interplay between signals and systems that is the important not just a signal and system in isolation.

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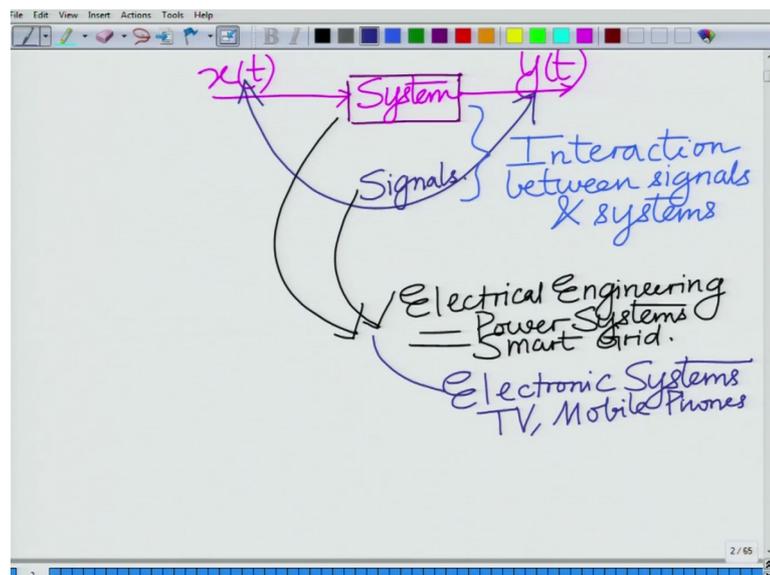
But interplay between signals and systems specifically correct and you would have seen several examples of this what happens when let us say I have a system correct I have a system which I am representing it which I am representing schematically over here and if I transmit a signal xt, I have an output yt. I transmitted through a system. Now these are the signals xt is the input signal y t is the output signal.

So, what we would like to characterize and better understand is what is this interaction what happens when I take a signal transmitted it through a system look at the output signal; what is this interaction what are different aspects of how does the system act upon this signal to generate because we are going to use system systems are of fundamental importance because we have signals in electrical engineering we would like to process these signals suitably and for that purpose we use system.

So, we would like to understand the interplay between signals and some of the impact systems have on signals and also to extract a certain behavior from a signal what kind of a system has to be designed all right that is something also that we would be interesting that is designing appropriate systems to extract certain behavior from the signals ok.

So, this interaction between signals and systems is of fundamental importance this interaction between signals and systems is of fundamental importance now and these are used in several branches the signals and systems these are applied in several branches of engineering for instance these are applied in these are vast applications, these are applied for instance have applications in electrical engineering for instance in the design of power systems smart grid you name it.

I mean there is hardly any application that you can think of the smart grid applications in the smart grid where you have power systems grid of power systems elements in the power system connected by a vast grid and there and they are monitored and efficiently they are monitored and efficiently controlled using the smart grid you can think of electronic systems such as TVs, radios, etcetera or your mobile phones such as your televisions mobile phones you can have.

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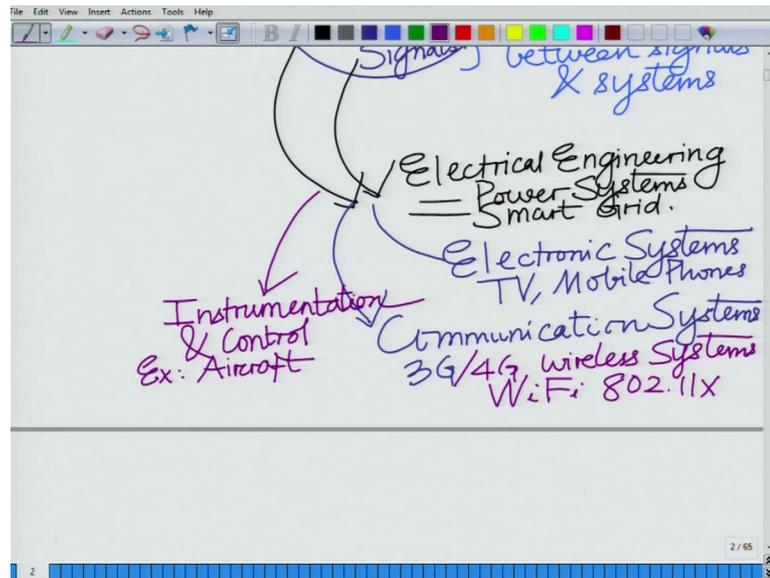


Applications in communication systems communication system such as 3 g wireless systems or your Wi-Fi such as a 802 dot 11 x systems, you can have control systems correct instrumentation and control such as for instance in aircraft that is a classic example of systems where has a huge applications of control instrumentation and control collect or opponent plant connector a factory or where you have large installations of such control and instrumentation system alright.

So, what this shows is basically there are a large number of systems correct call them electrical systems or electronic systems etcetera, which use signals which are based on signals right and systems to extract, right, systems to process; these signals systems to extract the desired behavior from these signals correct. So, signals and systems is of fundamental importance in all of electrical electronics communication engineering now. So, this course or this mooc as we have said this aims to look at properties of both.
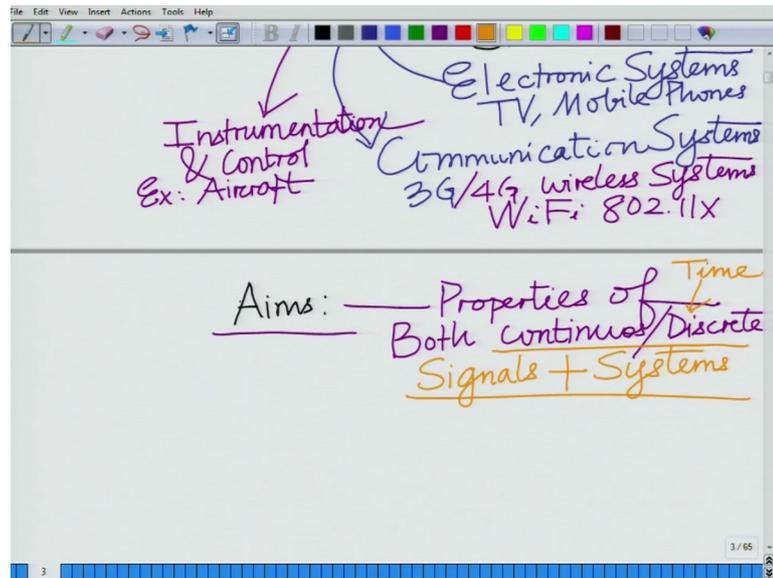
So, the aims as we have already said to summarize it, the aim should be to look at the properties of both continuous as well as discrete both continuous and discrete signals plus systems that is the fundamental that is the fundamental aim of this course you use look at both continuous as well as discrete signals and continuous and discrete in time right look at both continuous and discrete time properties correct principles right the properties and principles of both continuous and discrete time signals and systems ok.

Now, let us start with a definition of a signal alright that seems since this course is on signals and systems.
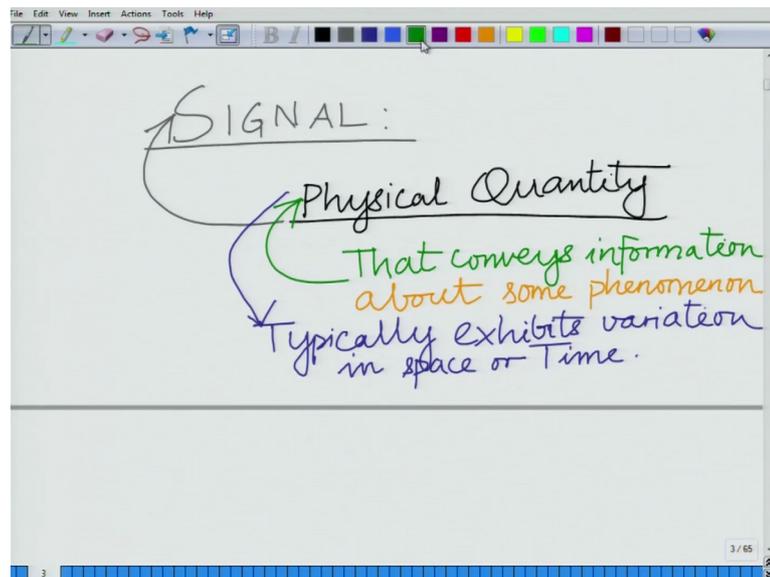
That seems to be a good place to start. So, let us start a definition of a signal a signal can be defined as basically it is a physical quantity and this is a fundamental importance all of you at some physical quantity all of you must be at some intuitive level familiar with the definition of a signal this is a physical quantity that conveys information about some physical phenomena that about some phenomenon that is the reason, we are interested in signals because a signal conveys information for instance such as a voltage signal electromagnetic wave which is a signal that is transmitted over the air from the base station to the mobile station right.

It is carrying information about the voice its carrying information about the communication between 2 individuals let us say or its carrying information. Let us say it is a data signal its carrying information about either a video or an image that has been transmitted or the internet that is being accessed. So, a signal basically fundamentally right a signal right fundamentally carries some it is a bearer of information all right correct. So, a signal conveys some information about a phenomenon that we are interested in that we are interested in monitoring that we are interested.

So, it conveys some information about a phenomena about some conveys information about some phenomenon conveys information about some phenomenon and typically it exhibits variation because something that is constant does not carry much information. So, typically exhibits variation in either space or time for instance let us look at time we

can talk about a signal in time such as an electromagnetic wave these are all examples electromagnetic wave or a speech signal voice signal correct.

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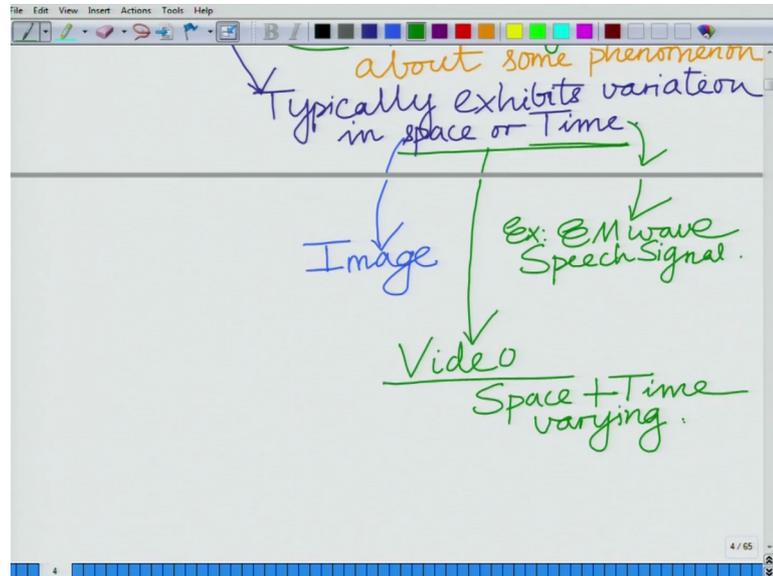


If you are looking at space we can talk about signals in space right not just in time space such as an image which is a 2 d; 2 dimensional space signals x direction and y an image is a 2 dimensional signal correct. So, an image can also be thought of a signal in space and we have signals naturally in both space and time for instance such as a video signal that can say it has a; it varies both in space which is a 2 dimensional each frame of the video which can be thought of as an image. So, it has variation in space as well as time because it comprises of a sequence of frames in time. So, a video signal is very interesting in that it is a signal both in space correct space plus time exhibits a variation in both space and time that is a video signal ok.
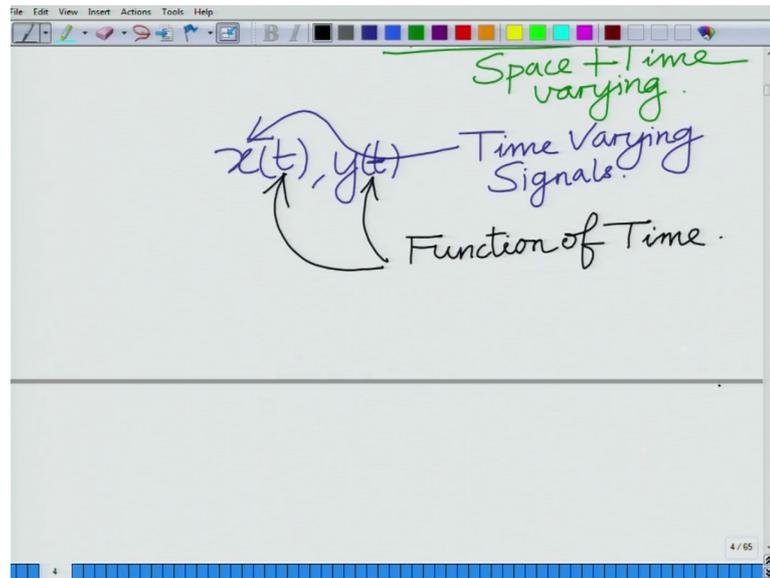
Now, typically when we consider time signals we represent them using x of t and these are the signals that we typically consider. So, these are time these are time varying signals and these are typically. So, instant for instance x of t y of t etcetera and many principles that we develop for the analysis of such signals which vary in time in a single dimension can also be extended can also be used as it is for 2 d extended to 2 d correct 2 dimensional 3 dimensional video signals or a separate set of techniques can be developed for them, but based on the fundamental principles that we learn for this time signal.

So, in this course is this is the fundamental massive of mooc course we are going to consider the analysis of such simple signals which are varying with time and these can be suitably extended to other scenarios other examples which are considering for instance images which are 2 d space signals or video which is a 3 dimensional both space and time varying signals alright. So, keep things simple we are going to consider signals which are a function of time ok.

So, these are signals which are a function of time the difference between a signal at a simple function as we have said is its physical relevance for us a signal represents something right represents some physical quantity correct arising from a its some physical quantity which conveys information about some phenomenon that we are interested and naturally to understand more about that phenomena for instance what the other person is speaking right that can be a voice signal. So, understand more about that

we need to process that signal suitably for instance we would probably like one of the simplest things that would like to do is probably since the voice is unclear because of noise we would like to suppress the noise to make the voice clear. So, that it is easier for us to understand what the voice signal is conveying and. So, on and there are a whole lot of whole lot of processing or processing right a lot of operations that can be that can be carried out on the signal.

So, a signal we are going to consider a time varying signals or signals which are a function of time these are known as time signals now a signal class now let us come to a basic signal classification let us look at a basic classes different types of signals.

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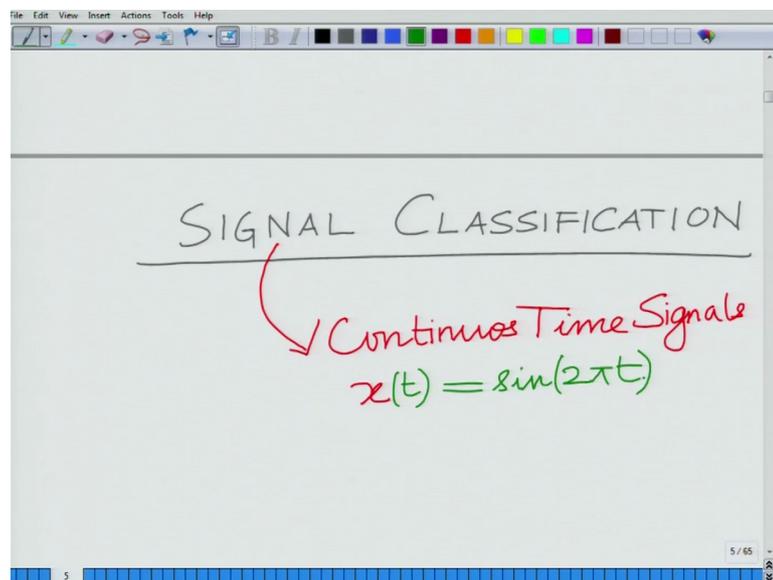


So, let us come to a classification of signals; signals can be well continuous time signals; signals can be continuous time signals such as for instance x t; xt equals sin 2 pi t that is a continuous time signal it is also known as a sinusoid looks something like this starts at 0 goes with time. So, this is x equal 2 sin 2 pi t; this is also known as a sinusoid or a sinusoidal signal either cos sin 2 pi t.

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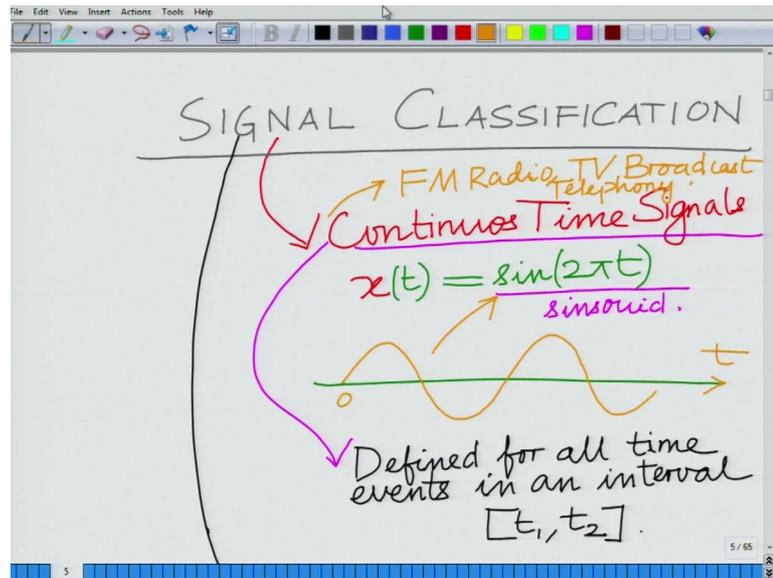


Or sin 2 pi t; both are known as sinusoids or sinusoidal signal or a signal this continuous time its remember it is varying its defined at continuously over time all right, it is not defined at specific time instants correct. So, it is defined continuously at all time instants from either from minus infinity to infinity all over a continuous time interval. So, the point here is that the continuous time signal defined over for all instance in an interval.

This defined for all time events in an interval t 1 to t 2 and generally speaking if t 1 equals minus infinity t 2 equals in infinite then it is defined for in finite time, but the point is its defined at each and every time instant not at a specific set of time instants. So, so this is a continuous time signal in addition you have what are known as discrete time signals ok.

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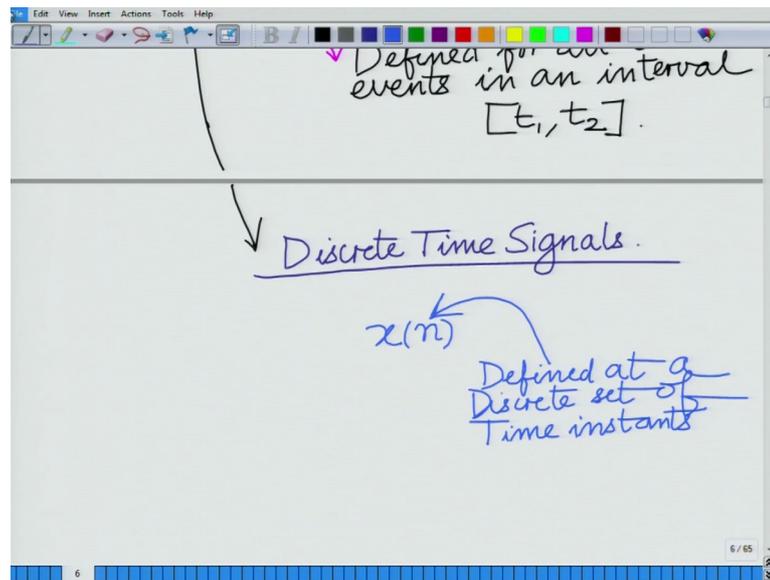


So, these are continuous time signals now we have discrete time signals for instance such as for instance which are defined at it for instance such as x of n correct these are different defined as these are defined at a discrete time set of time instants. These are defined at a discrete set of time instants for instance you have a discrete time signal.

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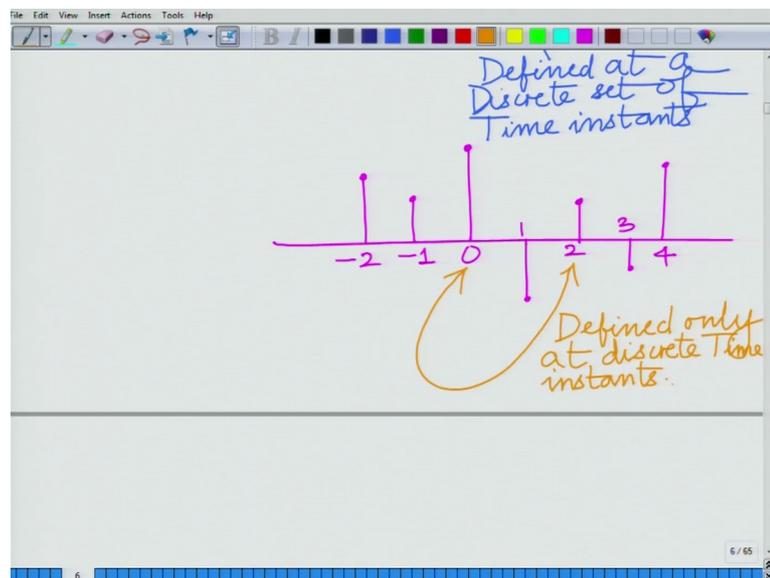


Which can be defined as this is known as what is known as a stem plot discrete set of time instants time instants can either be positive or they can also be negative for instance you have time 0; x 1, 2, 3, 4 minus 1, minus 2. So, these are its only defined as the point

is its only defined as defined at defined at defined only at a set of discrete time instants define only at discrete time instants. So, it can be identified as a series or sequence of numbers for instance we have here x of 0, x of 1 at time instant 1 x of 2 at time instant 2 or you have x of minus 1 x.

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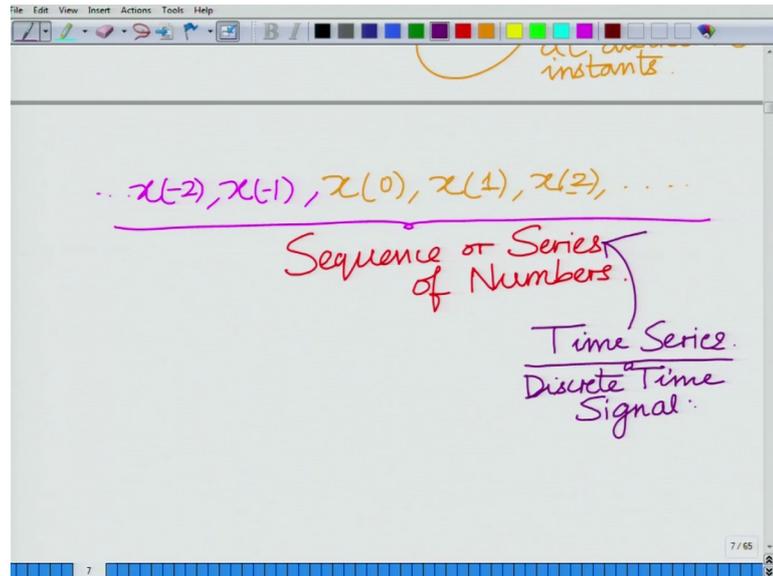


So, minus 2. So, these can be defined as a sequence or series of numbers; these are defined as a sequence or series of numbers. So, also known as a time series for instance if the signal is in time it is a discrete time signal a discrete time signal, alright.

So, naturally similar to discrete time signals you can also have discrete space signals continuous time continuous space discrete time discrete space that is for instance if you take an image signal and if you sample it at appropriate instance in space points in space this is a discrete it is a discrete space signal. In fact, if you look at modern images which are represented as a collection of pixels its nothing, but a discrete space signal you have a 2 d set of grid over which you have representation of the picture elements the intensities of the picture elements and of course, the color information alright. So, it is a 2 dimensional discrete space signal that is what most modern images are alright.

So, it is a time series this is a discrete time signal a discrete time signal is nothing, but a time series and this is a time series its x minus one and discrete time signals can also be obtained by sampling continuous time signal. So, I can go from a continuous time signals to a discrete time signal and also although it might not be extremely clear at this point I

can obtain a continuous time signal from a discrete time signal by through a suitable filtering operation alright, but to start with a discrete time signal can be obtained.

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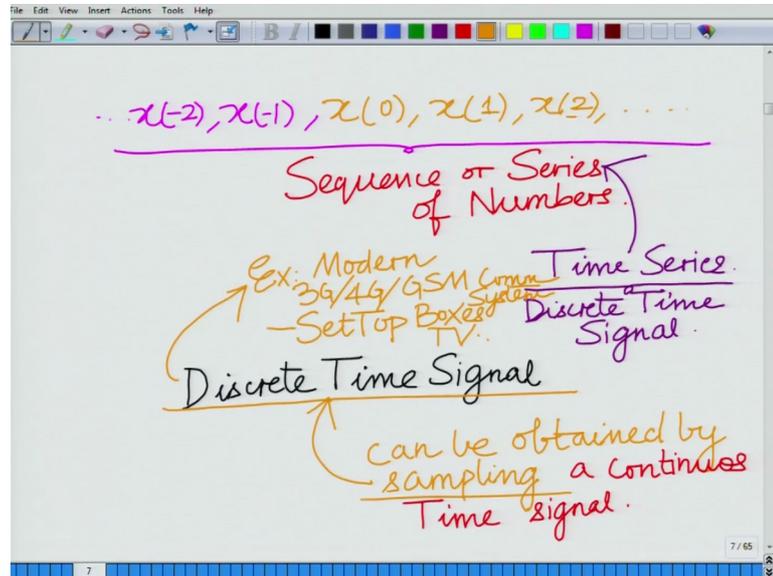


So, I have a discrete time signals or discrete time signal this can be obtained can be obtained by suitably sampling and this is an important idea sample can be obtained by sampling can be obtained by sampling a; this can be obtained by sampling of a continuous time signal ok.

And there are certain properties I mean how do we do the sampling how do how can we carry out the sampling.
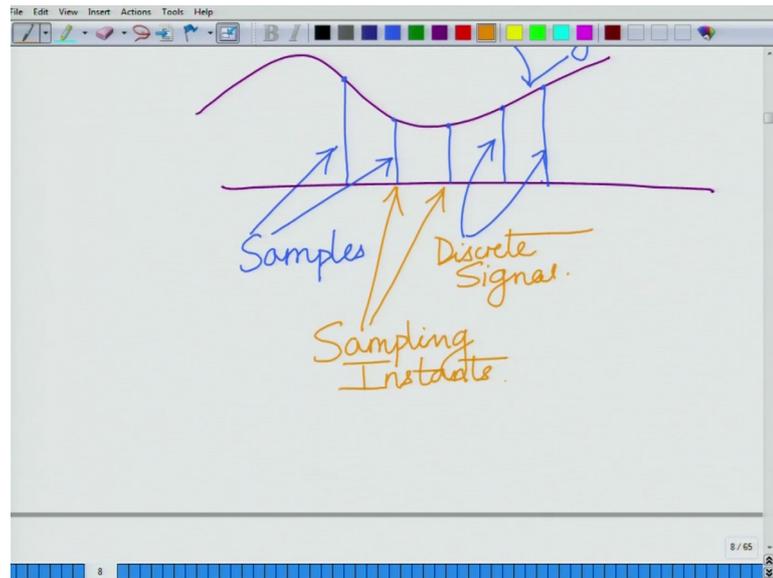
So, that information there are set of principles alright and properties of the sampling process but if you take a continuous time, but broadly speaking generally speaking if you take a continuous time signal if you sample it at suitable points over a time grid you get a at suitable points typically points that are equal spaced in time correct samples these are the samples this is your original continuous signal.

These are samples these are your discrete signal this is the discrete signal this comprises the and these are the sampling time instants or the sampling instance alright the instance where you are sampling the signal these are the sampling instant. So, by sampling by suitably sampling correct by suitably sampling a continuous time signal I am able to obtain a discrete signal alright when I want to obtain a discrete signal and we will see what are the uses of a discrete set what are the properties of a discrete time signal what is a behavior how do you process a discrete time signal ok.

For instance these frequently discrete time signals are more convenient to process as digital signal correct represent them as digital signal and process them as digital signal for instance in a digital communication systems such as most of our mobile phones are based for instance most of our mobile phones which are based on digital communication systems such as for instance 3 g, 4 g, wireless communication systems, it is convenient in them to handle digital signals which can be obtained again from discrete time signals. So, discrete time signals give rise to digital signals correct and these such signals are

basically much more readily much more readily can be processed much more readily in comparison to the conventional systems which were analog in nature for instance your conventional communication system such as your amplitude modulation radio or frequency FM radio and so on. So, for instance examples of such systems continuous time systems would be your conventional systems such as FM, radio, TV broadcast, etcetera or even conventional telephony your conventional telephony such as your PSTN correct and examples of discrete time signals would be the more modern communication systems modern systems such as based on.

Of course, these are just in communication because these are easier to understand such as your pick any modern 3 g, 4 g or your GSM which is a 2 g communication system or for instance all your modern communication systems such as Wi-Fi, etcetera even your modern landline probably uses digital communication systems your set top boxes in TV that is a very good example for your which are alternative to your analog cable. So, this set top boxes for TV that is your digital cable basically these are your digital communication systems which represent information digitally correct which represent information digitally and they are processed as discrete type it is convenient to process the signals as discrete time signals.

And these discrete time signals again as I have told you have to be obtained by suitably sampling the continuous time signals alright and most of their modern systems also I have given you examples from communication, but if you look at any system for instance such as based on your control and or instrumentation etcetera most of the modern systems are basically digital in nature in which it is continuous to represent and process signals as discrete time signal alright. So, basically that concludes the basic classification of signals as both continue and again there are other simple time simple examples of.
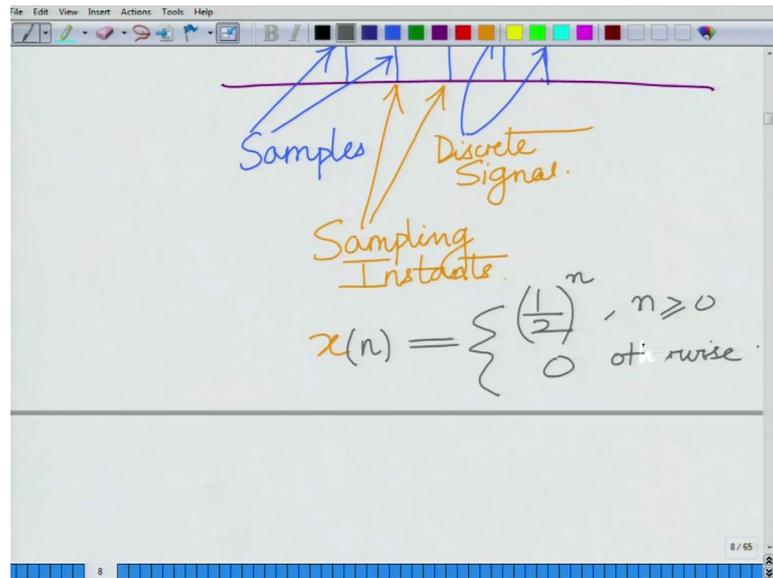
Discrete time signals for instance such as an exponential kind of signal for instance half to the power of n for n greater than or equal to 0 and 0 otherwise.
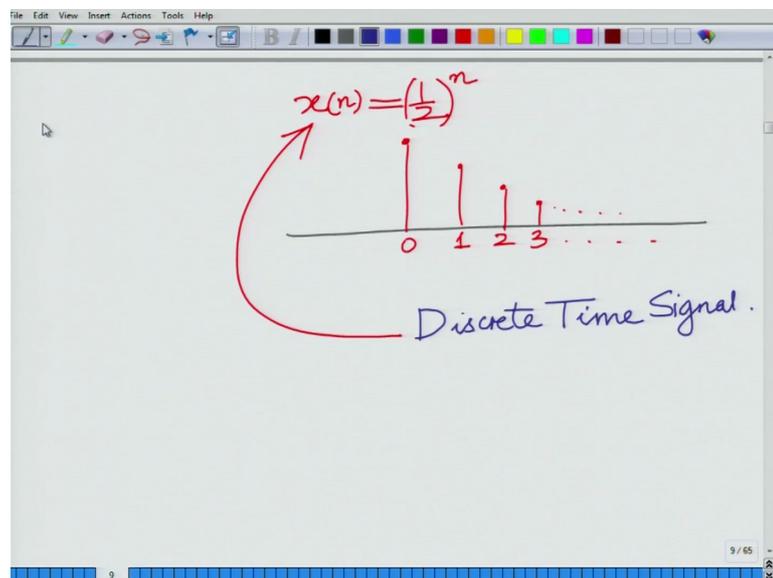
It was entered compactly as an exponential and if you can look at this signal since half is basically less than one, it is going to be a decreasing signal something that is one at 0 correct. So, this is 0, 1, 2.

So, decreasing exponential half to the power of n again this is another discrete time signal goes without saying that this is another it is defined only at discrete time instants

therefore, it is a; this is a discrete time signal alright. So, basically let us conclude this module with that. So, we have signals. So, this course is of our signal the properties correct and principles of signal analysis and signal behavior system analysis system behavior the interplay the rich set the rich theory which considers itself with the behavior and principles of the analysis of signals and systems and their interaction and signals as we have seen are basically physical quantities that convey some information about a certain phenomena which arise from a certain physical phenomena alright.

And we are interested in studying the signals behavior of these signals modifying the properties of these signals correct and we begin with the characterization or classification of this signals first as 2 basic classes its continuous time and discrete time signals. So, we will stop here and continue with other aspects in subsequent modules.

Thank you very much.