Networks and Systems
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Lecture – 1
Introductory Concepts 1

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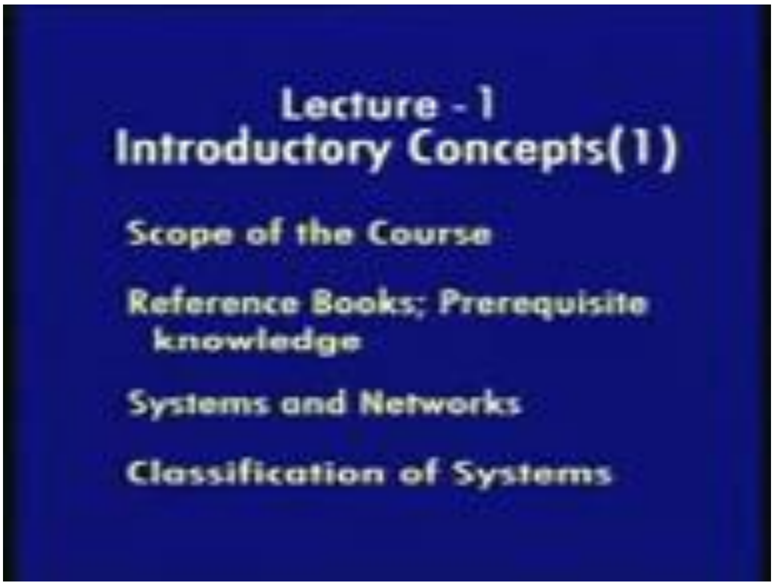

Hello, this is an introductory course on circuits and systems or networks and systems suitable for an undergraduate student majoring in electrical engineering, with either the power or communication option. In this course we will study the dynamic behavior of systems and networks. You will be exposed to a variety of tools and techniques which are used to study the behavior of the systems under which dynamic inputs so that, you can gain an appreciation of what; particular technique to choose under a given situation.

When talking about systems we should also talk about signals the input variables to a system the response variables that we are looking for. And the various intermediate variables which occur at different points in the system are all collectively called signals. And this is the term which we will use to describe these variables associated with any system. Later on we will say that a network is a special kind of system and the voltage and current variables associated with a circuit or a network therefore, are also called signals in the particular context of a electrical network.

These signals are usually functions of time. A study of the characteristics of the signals and their analysis therefore, is an integral component of our course. As a matter of fact it is the interplay between the signals and systems that will be the main theme and focus of our course. Among the topics which we will study are Fourier methods, Fourier transform, Laplace transform methods, network functions, network theorems, z transform methods and state variable techniques.

These will be the various topics that will be broadly covered under this course We shall for the most part confine ourselves largely to the discussion of linear time invariance systems. The meaning of these 2 adjectives linear and time invariant will become clear as we go along. Suppose, it to say they form a fairly large class of useful systems. So, at the end of this course you will have with you a toolkit of available techniques. So that, you can choose 1 of these techniques for the solution of the dynamic behavior of an network and system belonging to this very large class of linear time invariant systems.

Before i before we proceed further to discuss the meaning of a system, let me 1st talk about the various text books and reference books that you may like to refer to during the or your study of the material under this course. You may use these books to have some of your doubts clarified; to deepen your understanding to a particular topic may be to get additional information related to some of the topics that i discussed here.

But, most importantly, you should use these books for working out the various problems and answering the various questions that are given as exercises in these books particularly, for a subject with analytic orientation like networks and systems. It is very important that you should work out a larger number of these quantitative problems and answer these various questions.

It is only through such exercises that you can form your understanding of the subject make a grip of the various techniques stronger. And another important aspect with this is that like in any other discipline in networks and systems also, there will be always a number of approaches to solve a particular problem. Only through working out these various exercises you will be having the ability to choose the most direct method of attack for a given problem.

You will have the necessary expertise to gain the insight so that you can select the most appropriate method of attack for the solution of a problem and not only that to carry out the solution correctly and in quick time. So, i would once again emphasize the importance of working out a variety of problems and you can use some of the text books which i am going to mention right now as a source material for these problems.

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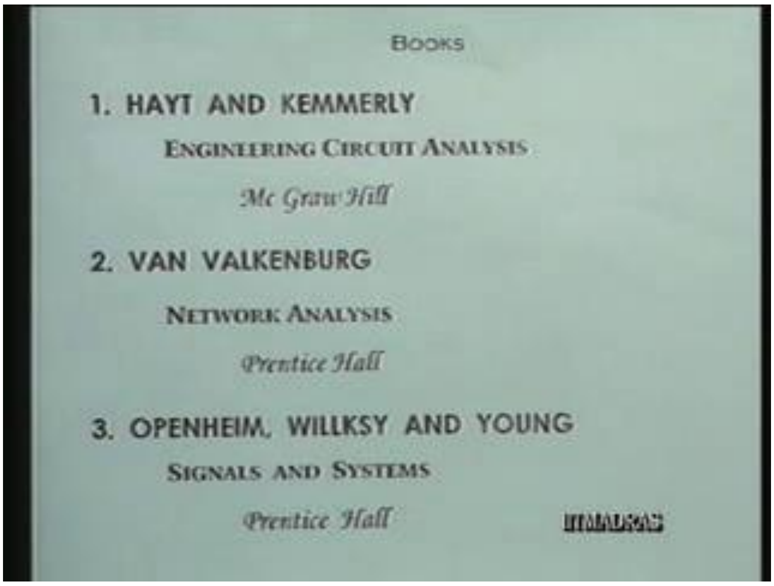

The particular text books that i would like to recommend ar: hayt and kemmerly Engineering circuit analysis, Van valkenburg network analysis These 2 are very popular books in this field. Openhiem willksy and young signals and systems is very comprehensive gives a very comprehensive coverage of the topicx we covered in this course plus some additional topics. And this also contains a wealth of problems as exercises.

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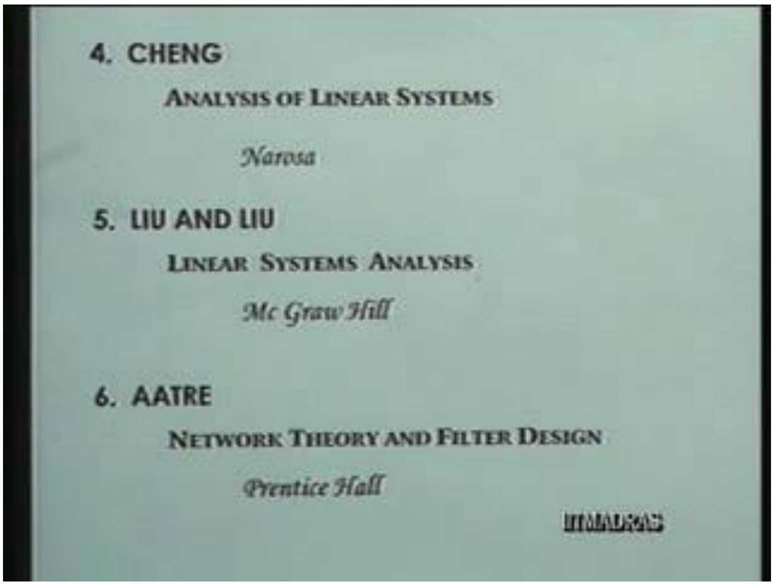

In addition to these 3 books you have a book by cheng titled analysis of linear systems Liu and liu linear system analysis and a 6th book by aatre network theory and system design. It contains discussion of some of the topics that we are going to cover in this course by state variable methods and so on which are not perhaps found in some of the other books. By way of background i expect of you to follow this course.

Let me mention that i expect the students to have a background on the following topics.

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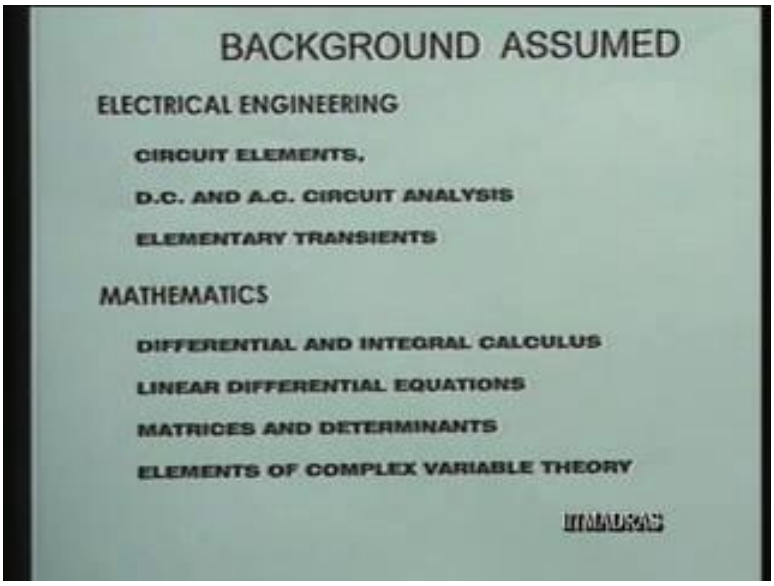

I would assume that, you had a basic course in electrical circuit analysis which includes the discussion of properties of various circuit elements d c and a c circuit analysis a c circuit analysis under steady state sinewy soil conditions. And an idea of elementary transients the time constants in r c circuit r l circuit and so on and setting up the differential equations pertaining to simple circuits.

This is the background in electrical engineering that 1 would assume. As far as mathematics is concerned we should be familiar with elements of differential and integral calculus. Solutions of simple linear differential equations are there differential equations with constant coefficients. You should also have an idea of matrices and determinants.

Solution of linear algebraic equations and then elements of complex variable theory is also expected of you to follow this course. So, this is the background 1 would expect you to have to follow this course. Now, let us discuss what a system means. All of us intuitively have an idea what a system is constituted of through its usage in every day terminology. We may formally say a system is a collection of components put together to serve a particular purpose.

These components or system components as they are called are unified through some kind of interdependence among them. They react with each other. So, the whole system functions as a whole to serve a particular purpose. You may think of a power system, the national educational system, hospital systems, railway systems, transportation systems and so on and so forth. Many of these systems also have as an integral component the interaction of people for example, in socio economic systems.

All these are constituents of systems. Now, therefore, a system is a collection of objects united through some form of interdependence among the various components or subsystems as you may call. Now, the variables that describe the status of these various components in a system may be quite diverse depending upon the nature of the component; the nature of the system and so on and so forth.

For example, if you are taking about an electro mechanical system you may have the electrical variables voltages and currents associated with electrical components. And mechanical variables like force and velocity which describe the status of a mechanical component at a particular of at a particular point in the system. Therefore, system is an omni bus type of concept which includes, the variety of situations that 1 comes across.

Now, what about a network? Literally speaking a network is structure which resembles a kind of net. But, in our particular concept we use a network the term network to describe a system in which all the components are of a related kind. That means, the variables which are of importance in the system are all of the same kind. So, in a particular electrical network for example, is a special kind of a system in which the variables are voltages and currents most often.

That is these are the 2 variables which are of interest to us in an electrical network. Similarly, we can have a network representing a mechanical system which we call the mechanical network in which the variables may be velocities and then forces and so on and so forth.

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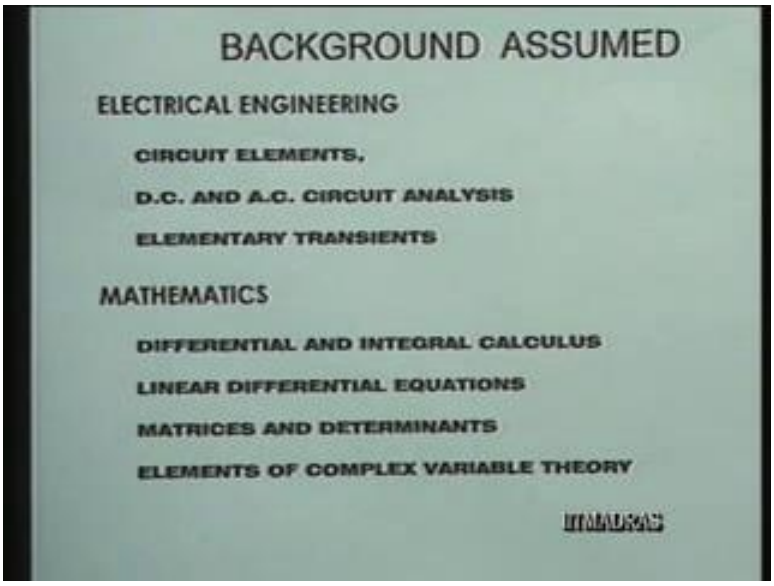

So, we can think of a network as a special kind of a system. An electrical network in particular is what constitutes the focus of our discussion here. Now, while analyzing these systems and networks the first step usually is to model the system the system in terms of idealized components put together in a particular fashion. This evolution of the model is done with 2 conflicting requirements in our mind. What are the 2 conflicting requirements?

First of all, we should like to have the model as realistic as possible. So, that it simulates the real system. In other words we should like to make the model as complex as possible. So, that we lose as little information about the system as possible. On the other hand we should also like to make the model as simple as possible to lend itself to convenient mathematical analysis. So, that the person who uses this model for analysis and synthesis will retain a sanity in a sense because, if it is going to be huge compel type of model you will never be able to solve it.

Therefore, these are the 2 conflicting requirements in the evolution of a model of a given physical system. On the 1 hand it should be as complex as possible. So, that it will lose as little information about the system as possible. At the same time it has got to be simple enough to be lend itself to convenient mathematical analysis. Now, very often we refer to the model itself as the system. Even though, we must always keep at the back of our mind that, the model is a mathematical representation is an idealized representation.

The actual physical system is something different and in some ways the physical system may not the characteristics may not agree with the model. And if it is so, then we have to refine the model to make it more realistic wherever it is warranted. Now, in arriving at a model for a particular system, the derivation of the model is specific to the particular discipline.

You must study the physics of the situation. You must know the characteristics of these and arrive at a suitable model. But once we have evolved a model then a whole lot of the systems can be analyzed through a common framework a common set of mathematical tools which can be used to analyze a whole lot of these different system models. Because, the mathematical equations that govern the operations of these various systems are more or less the same.

Therefore, there is a unifying body of techniques of knowledge which come under the general title system theory or principles of system analysis; which will be the main scope of our study under this course. Then after having discussed what a system means and what a model means and how this analysis of these various models are facilitated by a common body of tools coming under name; system analysis and system theory.

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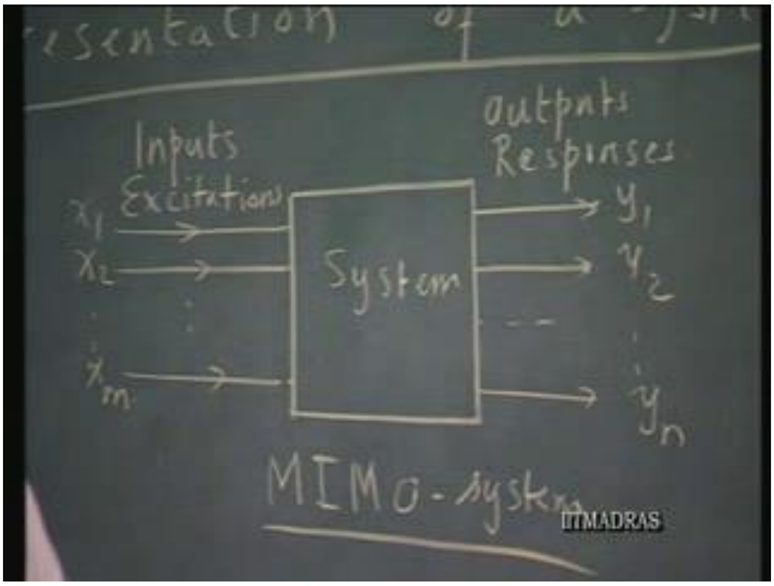

Let us now, look up see how we represent a system. Very often we are interested in finding out the response of a system under the influence of a particular input. We are not. so much bothered about the various variables the various signals internal to the system. In this event we represent a system as a black box and the various inputs that are given to the system are represented in this manner may be called this x 1 x 2 right up to x m. And under the influence of these various inputs there are certain responses in the system which we are interested in.

These are called the outputs or responses. Similarly, the inputs are called excitations also, other name is excitations. So, we may say the system responds under the influence of an excitation or the system gives an output under the influence of an input. And there may be n such responses we are interested in. So, in a in this particular system we will possibly have m inputs and n outputs. And then, a representation like this is referred to as the multiple inputs, multiple output, multiple input, multiple output system.

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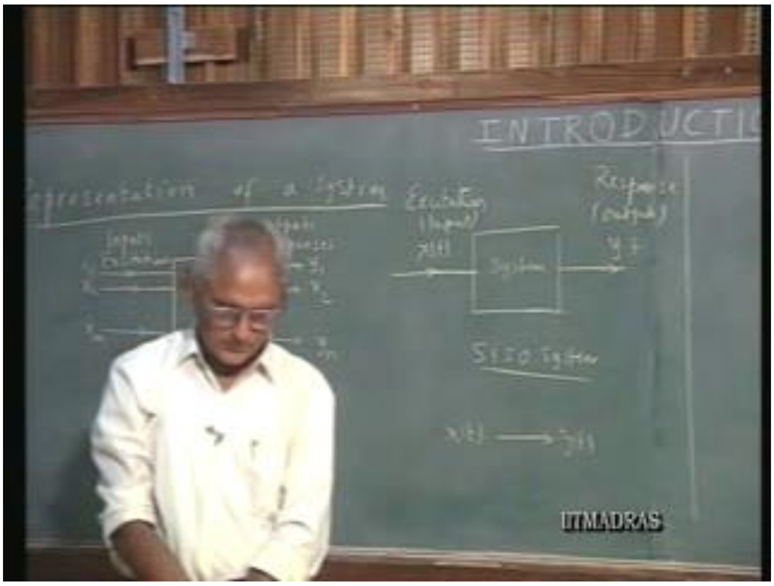

So, let us consider an electrical network, when you have several sources voltages and currents and who like these are the various inputs to the electrical network current sources and voltage sources. We are interested in finding out the voltage and current at different points. We are interested in finding out all those responses So, we can model this as a multiple input multiple output system.

On the other hand very often we might be interested in finding out the influence of 1 particular input and we would like to find out the response at a particular location. Then we have x of t may be the input signal y oft the output signal. So, we may call this again as input or excitation and this can be called the response output and this be called single input single output system.

But, the class of systems which we will talk about later linear time invariant systems. If we have a complete knowledge of how a system behaves with a single input and single output and a particular output. Then we can use that information to get a particular response, when a variety of inputs occur simultaneously occur by the principle of superposition. And this is something which we can always do for the particular class of systems that we are talking about.

So, our concentration may be for most of the time on a single input and single output system, but that does not in any case take away from the generality of the tools that we employ. To simply this notation this is a block diagram representation of a system. I mentioned this as a black box because we are not particularly interested in what is inside. Therefore, we can assume this to have 2 terminals where the input is fed and 2 terminals where the output is fed taking the electrical circuit as an example. And this whole concept of a particular input giving rise to an output can also be very succinctly and compactly indicated as x t an arrow y t.

That means in the particular system once we know what the system is we can say then the system input x t gives rise to an output y t. This is the excitation, this is the response. So, very often we use this type of notation when we have to deal with a particular system. And would like to have a variety of inputs and what are the outputs that you get we use this kind of compact representation to indicate input output relations of a system.

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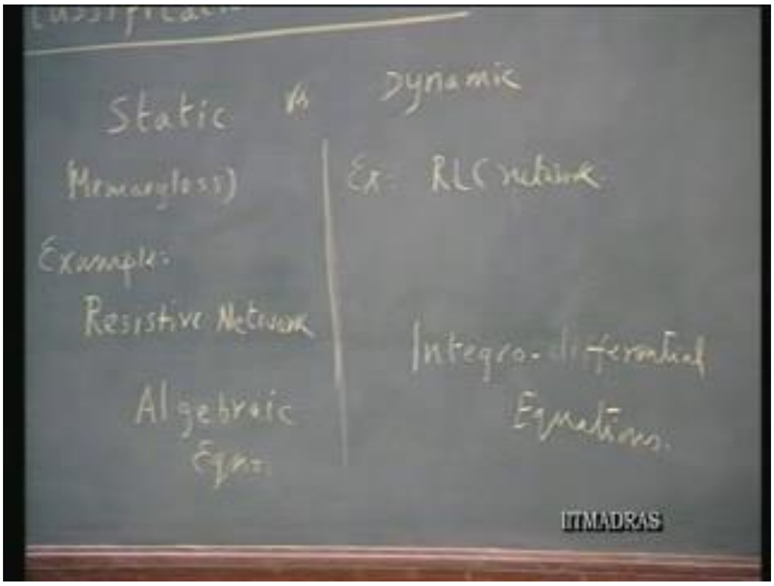

As i said systems are quite diverse in nature and naturally their properties will also be quite diverse in nature. But we would like to classify the systems depending upon the particular property or characteristic that we have in mind. So, let us now talk about classification of systems. One can call classify system as either a classic system or a dynamic system. A static system is 1 in which the output depends upon the input at that time and nothing else. It does not depend upon what happened in the past history or the system is immaterial.

So, if you give a particular input the output is dictated by that input and nothing else is required. Take for example, an electrical resistor. The current in that resistor depends only on the voltage at that particular point of time. Not that how that voltage has come about not about its rate of change etcetera. But, it depends just on the voltage at a particular time dictates the current in that resistor. So, if a resistive network is there a port resistive network then its input voltage is given.

The current is immediately deduced by the magnitude of the voltage at that particular point of time. So, static networks are also sometimes called memory less networks or memory less systems. Example a resistive network whereas, a dynamic network it is not enough if you know the values of the instantaneous values of the inputs at that time. We should know something more. We should know perhaps a kind of summary of what happened in the past .In the form of suppose; let us take a r l c network for example.

If you want to know the response of a r l c network an impressed excitation the driving force you should also know what is the initial charge in the capacitor? What is the initial current in the inductor? And this is what has come about because the past history of the network how whatever excitations it has been applied with and whatever remnants it has left in the system.

So, in a dynamic system the response depends not only on the instantaneous values of the input, but perhaps on the derivatives of the input and also the integrals of the input quantities and so on So, it is it does not merely depend upon the instantaneous values. The rate of change of the inputs the integral values of the inputs the past history of the input as summarized by the initial conditions are all important in the case of dynamic systems.

Example a r l c network. So, if you are having a r l c network with given excitation functions it is not enough to know the complete solution problem. You should also know the initial currents in the inductors and the initial charge in the capacitors.

So, it turns out that when you want to describe a static system the equation governing the performance turns out to be purely algebraic in character. Whereas, since in a dynamic situation you need to take stock of the derivatives the time variation of the various quantities. We have integro differential equations or an integral differential equation can always be reduced to a differential equation. But, in general we can say integro differential equation.

So, you have on 1 hand some differential equations and also you have differential derivatives as well as the integrations of the integrals of the various quantities. And so, in general it will be an integro differential equation that, govern the performance of a dynamic system.

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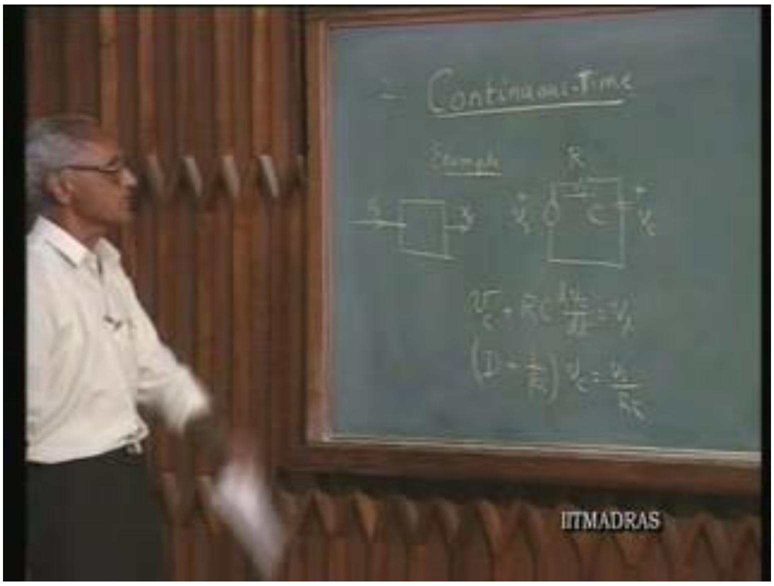

A second method of classification of systems is to categorize them as the continuous time system or a discrete time system; alternately, discrete time. In a continuous time system the input output relations are defined for every instant of time in a continuous basis.

In other words we are interested or we can calculate in principle the variables at every single point of time on the time axis on a continuous basis. Whereas, in a discrete time system you have this input output relations. In discrete time system you would have an input output relation defined at particular discrete points along the time axis not necessarily at every point of time.

We will see the meaning of this in a more clear fashion as we go along. So, let us talk about a continuous time system. An example of a continuous time system as an example let us take this r c network. So, we have a source v s a voltage source a resistance and a capacitance and this is the voltage across the capacitor v c. So, we would like to view this as a system in which, v s is the input quantity and the voltage across the capacitor v naught or v c as the output quantity.

So, the input output relation in this case is defined by the following relation. After all, v equals v c plus the voltage across the resistance and the voltage across the resistance is r times the current through the resistance i. And the current in the resistance is c d v c d t. So, r time's c d v c d t is the voltage v s. So, v c is the output and v s is the input there is this differential equation governing the input quantity with the output quantity.

So, you can put this in a compact fashion as d plus 1 over r c times v c equals v s over r c. where d is the derivative operator. You can instead of d c by d t you can write it as d v c as a more compact notation which i am sure you are familiar with this notation. D dividing this entire all the terms by r c this is what you get D plus 1 over r c d c equals v s over r c.

So, this is a first order differential equation and this is the input output relation for this. So, this is you can solve for this depending upon that v s that you are having and you can get the values of v c at every instant of time and the equation itself is defined for every instant of time. This is an example of a continuous time system as a discrete time system you would like you have this input output relations described for discrete values along the time axis.

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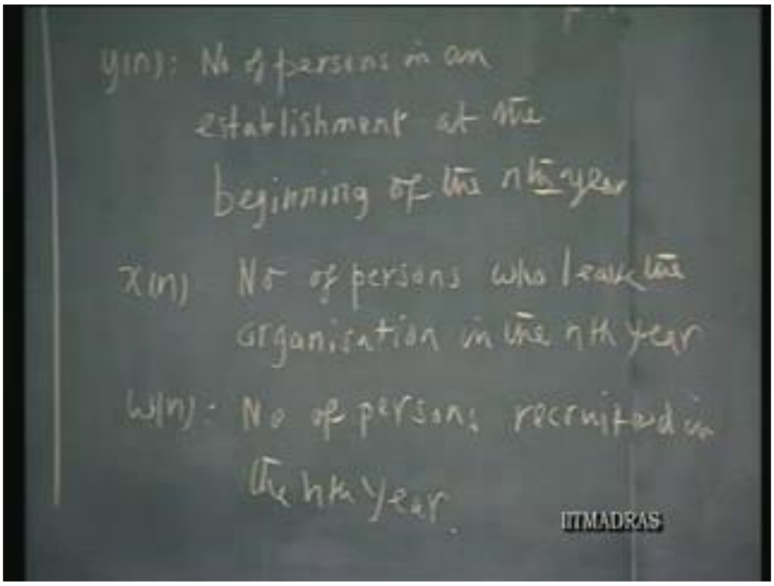

So, if this is a time axis you might be having equations which are valid only at certain points. So, the time axis may be defined in units of second's, microseconds, month's years as the case may be. For example, i may take this t in years in which case suppose i graduate this 1 2 3 4 etcetera say this is grade this as n n plus 1 etcetera.

I am interested i will have an equation which describes the operation of the system at particular points on the time axis. Not we do not care, what happens in between 2 and 3 so that, is called discrete time system. As an example let us consider an organization in which y n is the number of persons in the organization in an establishment number of persons in an establishment at the beginning of the n’th year at the beginning of the n’th year That is y n.

Let me take x n as the number of persons who leave the organization in the n’th year. Who left the organization; either they retired or left for other jobs or died. Whatever the reason might be x n is the number of persons who leave the organization in the n’th year.

Let w n be the number of persons recruited new recruit in the n’th year.

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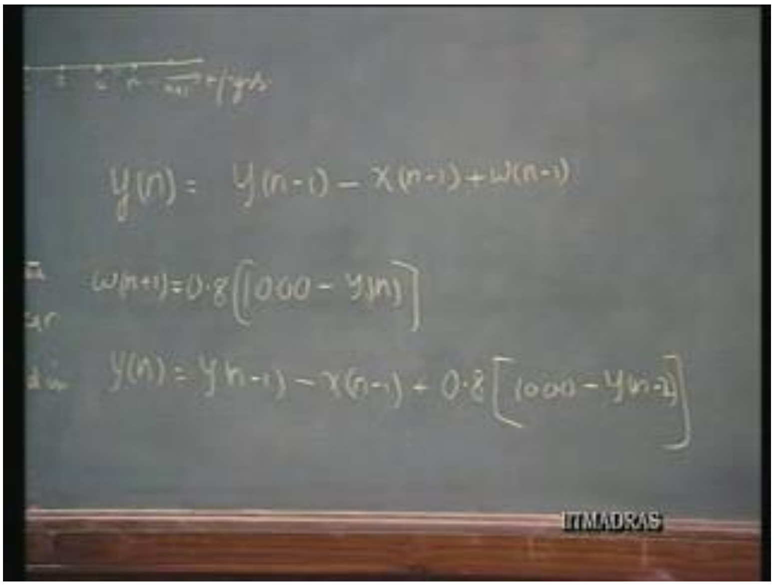

Then you can clearly see that, given these variables which describe the operation of the system the system now we are concerned the variables are these we are interested in the number of people employed in the organization. Y of n is the number of persons at the beginning of the n th year. This is the number of persons at the beginning of the previous year and out of these x people x n minus persons have left the organization during that year.

Therefore, so must be less by that amount, but so many people might have been recruited, therefore plus w n plus 1 n minus 1. This is the equation which gives us the number of persons in the organization at the beginning of the n th year in terms of y n minus 1 x n minus 1 and w n minus 1. Let me further assume that the recruitment policy of the organization is such that, that at the beginning of each year they would like to find the vacancies.

Their stand strength let us say is 1000 therefore, 1000 minus y n is the number of vacancies at the beginning of the n'th year. And then, they put an advertisement recruit people and then the recruitment policy is such that, it takes about a year to recruit people. And therefore, whatever recruitment steps have been taken in the n'th year will take effect only in the next year.

So, the number of people recruited in the n plus oneth year is let us say this is the target, but all the people who have been recruited may not join or they may be not suitable candidates. So, let us say 80 percent of this target amount is recruited. So, w n plus 1 is point 8 times 1000 minus y n. So, if you substitute now this expression into this expression into this you can now write, y n equals y n minus 1 minus x n minus 1 us point 8 times w n plus 1 is this.

So, w n minus 1 is point 8 times 1000 minus y n minus 1 n minus 2 because w n minus 1 this index now, is n plus 1 has gone down by 2 steps. Therefore, this must also go down by 2 steps. That means the persons recruited in the n minus oneth year will be based upon the number of people in position at the beginning of n minus 2nd year.

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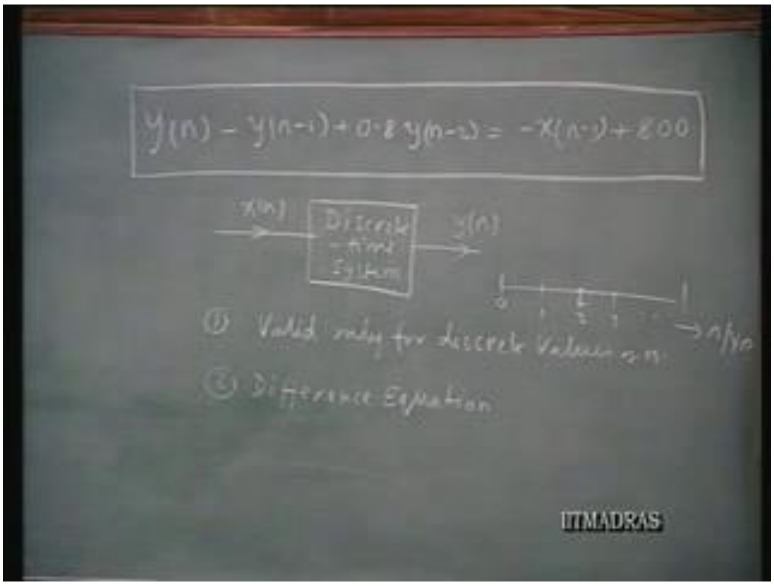

So, if you substitute all this you have now an equation which will be; the previous equation then leads to y n minus y n minus 1 plus point 8 y n minus 2 equals minus of x n minus 1 plus 800. So, this is an equation which will enable us to calculate the number of persons in the organization at any year n. In terms of, the values of y n in the previous year's previous 2 years and also the number of people living in the organization in the n minus oneth year.

So, this can be thought of as a discrete time system in which you have the input x n the number of people leaving the organization. That is something which is unpredictable. That is the kind of input we have for the system. So, under the influence of the input we would like to calculate the output or the resultant in the number of people in the organization in the n'th year y year.

So, it can be represented by means of a discrete time system which has got x n as the input and y n as the output. Now, we have to keep in mind that these 2 quantities the input and the output x n and y n. Now, meanings only for integral values of n so n is the number of years in our case 0 1 2 3 and so on and so forth. We cannot read any meaning in that for non integral values of n.

This has meaning only for n equals 1 2 3 4 and so on. The distance between successive units in our case happens to be years, but in general it could be second's, minutes or whatever you are having. It is also conventional that in most of the cases we take these intervals at regular points along the time axis. So, it could be seconds, it could be months, it could be days, it could be year's etcetera. In our case it happens to be years.

So, the point to observe is, this is valid only for discrete values of n and usually their integral values of n in the appropriate set of units. Now, certainly this kind of equation is called a difference equation in contrast to the differential equation that we will come across in continuous time systems. In discrete time systems the equation will be the independent variable takes all discrete values and the equation of this type is called the difference equation in contrast to, differential equation that we come across for continuous time systems.

So, that is the major difference between a continuous time system and a discrete time system. In a continuous time system you have the differential equation coming into operation. In the discrete time system you have a difference equation that is important. Secondly what we would like to know is the order of this difference equation. It is the difference between the highest index and the lowest index. So, n and n minus 2 these are the dependent variables.

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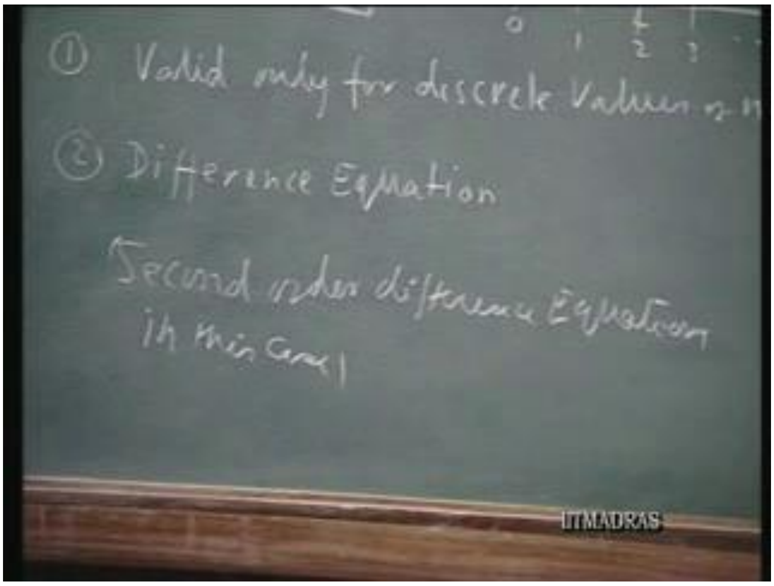

The difference between these 2 is 2. So, in our case this is the 2nd order difference equation in this case, it could be higher orders in the general case. So, in the discrete time system the points to note are that the equation is valid for specific integral values of the independent variable m. And the independent variable usually is time that is why this is called discrete time system. But, the same methodology is applicable even to situations where the time may not be the independent variable.

For example, if you have got along a line you would like to point out you would like to graduate these and you would like to have an equation; which specifies the values of kind of some kind of independent variable along discrete points along the line. The space coordinate can also be an independent variable. Even though systems are referred to as discrete time systems because, this is a more common type of system you can say discrete system, but we will call it discrete time system given that case.

So, the 2 important differences between a continuous time system and discrete time system are continuous time systems the differential equation comes into play here the difference equation comes into play. And the continuous time system the variables are described at every point and time along the continuous basis. In the discrete time system they are defined only for discrete values of the independent variable, which is usually timed and that is why it is called a discrete time system.

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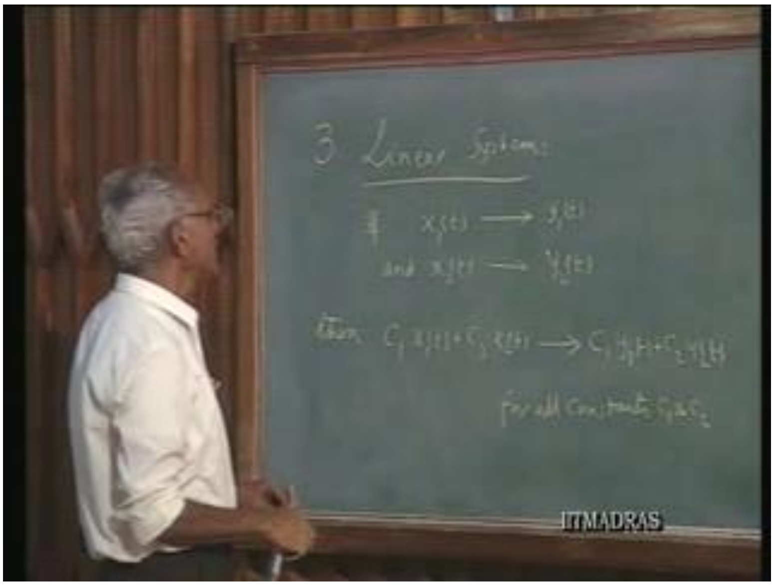

A third important classification is the concept of linear system and non-linear system. In a linear system if an input x 1 of t i am talking about a continuous time system now. This is our discussion will be mostly in terms of continuous time system. In later point of time in this course we will talk about discrete time system specially.

But, wherever examples are given we talk in terms of continuous time systems now for the most part. If x 1 of t gives rise to an output y 1 of t and x 2 of t gives rise to an output y 2 of t. Then for a linear system no matter what x 1 and x 2 are a constant times x 1 of t plus another constant times x 2 of t will give rise to an output which is c 1 y 1 of t plus c 2 y 2 of t for all constants c 1 and c 2.

This is what is referred to as the principle of super position. Sometimes people refer to this break this up into 2 parts homogeneity and editivity. What they are saying is if x 1 of t gives rise to y 1 of t then c 1 x 1 of t gives rise to c 1 y 1 of t [43:04] that is called the principle of homogeneity. Then the 2nd part is if x 1 of t gives rise to y 1 of t and x 2 of t gives rise to y 2 of t then, x 1 plus x 2 will give rise to y 1 plus y 2.

That is called editivity. But, now we will combine these 2 together and we will say c 1 x 1 of t plus c 2 x 2 of will give rise to c 1 y 1 of t plus c 2 y 2 of t for all constant c 1 and c 2. And this is the class of systems which are called linear systems 1 which obeys the principle of super position. And most of the electrical networks that, we have solved earlier belong to this class. But you must keep in mind that this particular super positional principle will be valid for example, in the case of electrical circuit with 0 initial stored energy, if a capacitor, has got some stored energy in that this principle of super position will not be valid.

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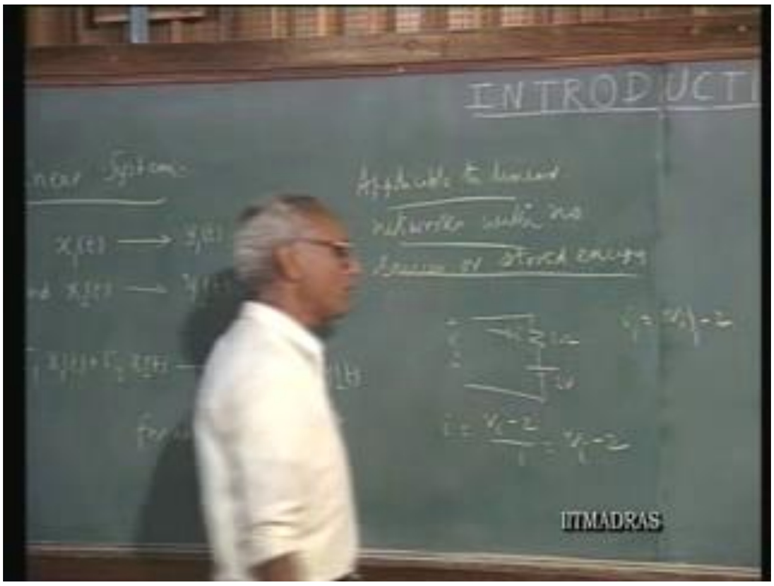

Let us take an example; for example, i will say this is applicable to linear networks at a special case of course, with no independent sources or stored energy important. For example, this is a linear network resistance. Suppose, i have a source here 2 volts 1 ohm then if i have an output input here v i and would take the current to be my response quantity. I equals v i minus 2 divided by 1 or v i minus 2 and if i have 2 different voltages v 1 and v 2 and find the currents i 1 and i 2. And if i say if i have v 1 plus v 2 then i will not get i 1 plus i 2 as you can see.

For example, i 1 here is v i 1 minus 2 for 1 particular excitation. For a certain excitation i 2 equals it is v i 2 minus 2.

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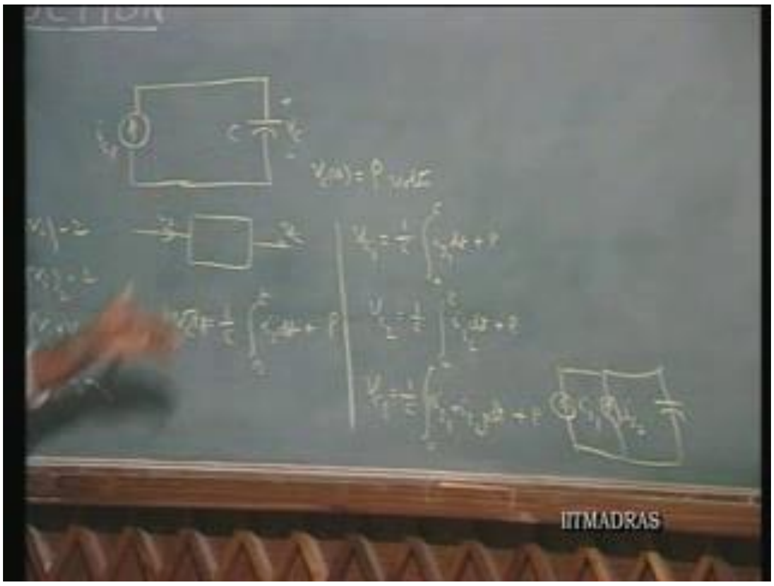

But suppose, i have a single excitation which is equal to v i 1 plus v 2 then the current would be v i 1 plus v i 2 minus 2. That will be the current when i have a single excitation v i 1 plus v i 2, but i 3 is not equal to i 1 plus i 2. Why because of the source here I 3 is not equal to i 1 plus i 2. So, when you apply this linearity principle or super position principle you must make sure that, you are applying it to a network which does not have sources or stored energy for that matter.

Let us take a second example to illustrate this second point which i have in mind. Suppose, i have a capacitor which has got an initial stored v c this is c and i have a current source as excitation. So, i think of this as a system with i s as the input quantity and v c as the output quantity. And let me assume that v c 0 equals some row volts. That is the initial capacitor voltage is row volts. Then you have the relation i s equals v c equals 1 over c 0 to t i s d t. That is the initial charge that is conveyed to the capacitor in the interval from 0 to t.

This is v c of t plus the initial voltage that is across the capacitor row. That's this initial voltage that is across the capacitor row. That means this initial voltage plus the increment in the voltage due to the additional charge that has been conducted to the capacitor in the interval 0 to t. This is the equation between the input quantity i s and the output v c t.

Now, let us take a situation where i have i s is there's 1 i s 1 then it will you will get v c 1 equals 1 over c integral i s 1 d t plus row 0 to t of course. And let us take a second excitation which is 0 to t i s 2 d t plus row that is v c 2. So, i s 1 and i s 2 respectively will give rise to these voltages v c 1 and v c 2 suppose, i had a single source which is i s 1 plus i s 2. Both of them are acting in parallel simultaneously, i s 1 and i s 2 together charge in the capacitor.

Then the third time the voltage v c 3 will be 1 over c integral i s 1 plus i s 2 d t plus row again, because initially the capacitor charged row volts. Now, you can see v c 1 plus c 2 which are responses due to i s 1 and i s 2 will not add up because, v c 3 is not equal to v c 1 plus v c 2.

What spoils is this the initial charge of the capacitor because when you add this up you get 2 row, but it is only 1 row which means that, the argument is that the principle of super position is valid only for systems, which are purely linear in the sense. That they should not have any sources inside independent sources or initial charges at the capacitors or initial currents in the inductors which are always considered to be equivalent to sources.

So, this is a very important principle and to keep in kind when you talk about linearity of systems. A system which is not linear is of course, called non-linear.

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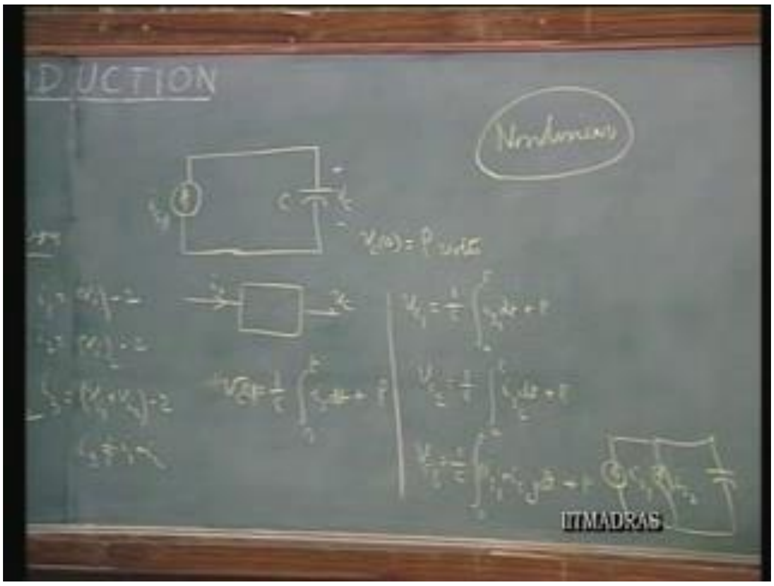

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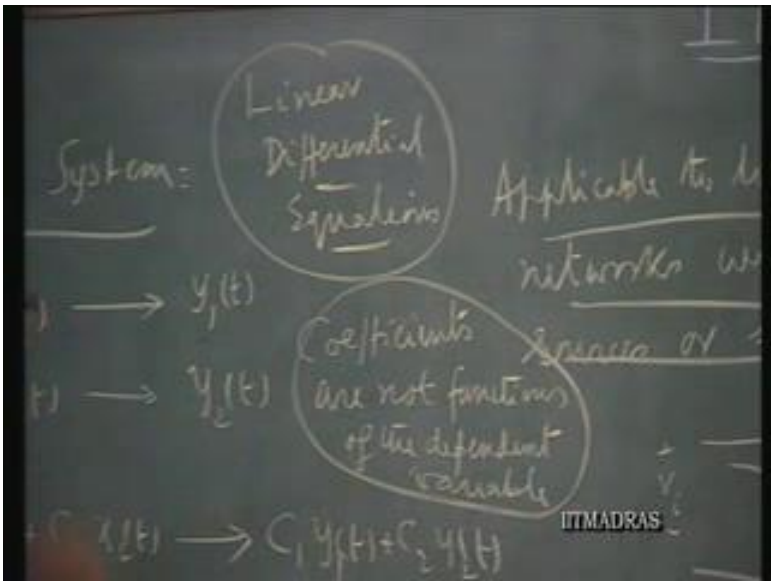

The difference between the linear system and the non-linear system is: a linear system is governed by linear differential equations and a non-linear system by non-linear differential equations. What is the meaning of a linear differential equation? Linear differential equation is 1 in which the coefficients are the various derivative terms; coefficients are not functions of the dependent variable. I will take some examples later on.

So, if i have a term like d Square by d t square its coefficient should be either constant it could be a function of time, but it cannot be a function of another derivative of y or y itself. So, linear differential equations are the 1 which govern the operation of a linear system and the equation fails to be linear then it becomes non-linear and that this super position principle will no longer be valid.

We will take some examples of these equations which govern the performance of the different kinds of systems in the next lecture. But let me stop at this time and briefly summarize what has been discussed so far; starting with the scope of the course which is mainly the dynamic performance of linear time invariant systems and networks.

We had a look at the number at the reference and text books that you may use for following this course. Then i mentioned the background material i assume that you have had before taking up this course. Then we looked at the meaning of a system. Broadly speaking we said system is a collection of objects or system components united to some form of interdependence among the various constituent components.

We said a network is a special kind of system in which all the variables will be of a particular kind 1 kind in electrical network and mechanical network given as examples. And then, we also talked about the modeling of a system. Modeling of a system is done in the form of ideal components put together that constitute the system; interconnected in some fashion. And we do this idealization keeping in mind on the 1 hand keeping in mind on the 1 hand that the complexity of the system should be not too large to ficiate convenient handling of the model.

At the same time, it should be substinctly realistic so that, the results obtained from the model generally realistic in practice. Otherwise the model has to be refined once again.

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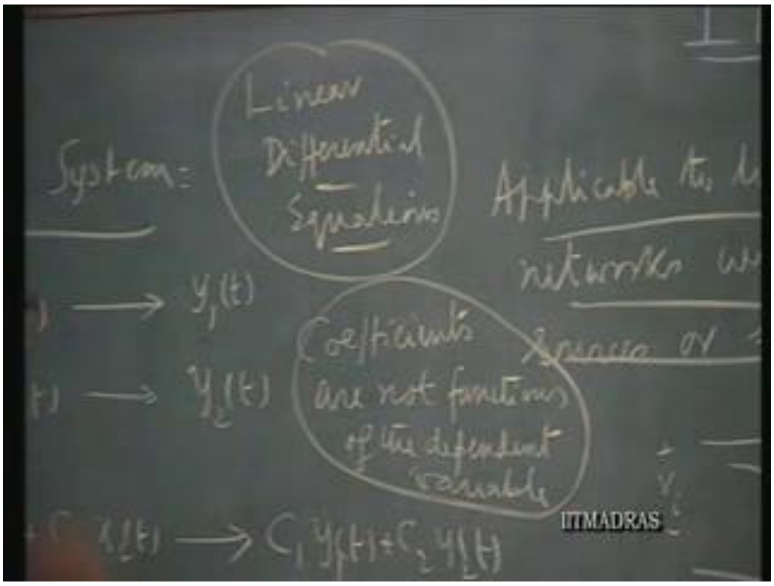

Also, mentioned that the model and the system we use the 2 terms interchangeably almost as if the model itself is a real system which is of course, not true. Then we looked at the representation of a system and we talked about the multiple inputs multiple output system and a single input single output system. And then, we went on to discuss the various kinds of classifications of systems because as i mentioned we are talking about linear time invariant systems.

Therefore, we must know what they mean. So, for that with that in mind we looked up at the we are trying to find the classification of various the important classifications of systems. We talked about the difference between static systems and dynamic systems. We talked about the difference between continuous time systems and discrete time systems and lastly we had talked about the difference between linear systems and non-linear systems.

The discussion on the linear and non-linear system is not complete because, i would like to give some examples of the governing differential equations for both the type of systems. And we will pick up at this point in the next lecture and continue our discussion from that point onwards.