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 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 an 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’s the interplay between the signals and systems that will be the main
theme and focus of our course

[03:07] 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 two adjectives linear and time invariant will become clear as we go
along
suffice it to say they form a fairly large class of useful systems

[04:00] so at the end of this course you will have with you a toolkit of available
techniques so that you can choose one 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 first 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’s very important that you should work out a larger number of these
quantitative problems and answer these various questions

[05:36] it’s 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

[06:06] 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
particular text books that i would like to recommend are hayt and kemmerly engineering circuit analysis
van valkenburg network analysis
these two are very popular books in this field
openhiem willksy and young signals and systems is very comprehensive gives a very comprehensive coverage of the topic we covered in this course plus some additional topics and this also contains a wealth of problems as exercises

[07:18] in addition to these three books you have a book by cheng titled analysis of linear systems
(Refer slide time [07:29])

liu and liu linear system analysis and a sixth 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 um i expect the students to have a background on the following topics
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 one would assume as far as mathematics is concerned we should be familiar with elements of differential and integral calculus solution 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 one 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 everyday 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

[11:10] therefore system is an omni bus type of concept which includes the variety of
situations that one 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

[12:00] that is these are the two 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
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 two conflicting requirements in our mind
what are the two conflicting requirements
first of all we should like to have the model as realistic as possible so that it simulates the
real system

[13:04] 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’s going to be huge
compel type of model you will never be able to solve it
therefore these are the two conflicting requirements in the evolution of a model of a given
physical system
on the one 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

[14:03] 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 it’s 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’s so then we have to refine the model to make it more realistic wherever it’s 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

[15:11] 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 these analysis of these various models are facilitated by a common body of tools coming under name system analysis and system theory let us now look up see how we represent a system

[16:18] 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 one x two 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

[17:32] 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 input multiple output multiple input multiple output system
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 one 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 of t 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.

[20:00] so our concentration may be for most of the time on a single input and single output system but that doesn’t 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 two terminals where the input is fed and two 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

[21:23] 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

[22:01] once can call classify system as either a classic system or a dynamic system a static systems is one in which the output depends upon the input at that time and nothing else it doesn’t 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

[23:01] 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 memoryless networks or memoryless systems
example a resistive network whereas a dynamic network it’s 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’s take a r l c network for example

[24:03] 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’s it doesn’t 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

[25:08] so if you are having a r l c network with given excitation functions it’s 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

[26:04] so you have on one 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
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

[27:07] 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

[28:07] 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 nought 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 times c d v c d t is the voltage v s
so v c is the output and v s is the input
[29:02] There is this differential equation governing the input quantity with the output quantity. So you can put this in a compact fashion as \( d + \frac{1}{r_c} \) times \( v_c \) equals \( \frac{v_s}{r_c} \) 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 dividing this entire all the terms by \( r_c \) this is what you get:

\[
d + \frac{1}{r_c} d_c \text{ equals } \frac{v_s}{r_c}
\]

So this is a first-order differential equation and this is the input-output relation for this. So this is what 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.

[30:02] As a discrete time system you would like you have this input-output relations described for discrete values along the time axis. 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 seconds microseconds months years as the case may be. For example, I may take this \( t \) in years in which case suppose I graduate this one two three four etcetera, say this is grade this as \( n \) \( n + 1 \) 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 don't care what happens in between two and three. So that is called discrete time system.

(Refer slide time [30:57])
[31:00] 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

[32:17] \( x_n \) 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 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

(Refer slide time [32:47])

\[ y_0 \] 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 one 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 one \( n \) minus one

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 one \( x_n \) minus one and \( w_n \) minus one

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 thousand
[34:00] therefore thousand 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 one th 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 eighty percent of this target amount is recruited so w n plus one is “point eight” times thousand 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 one minus x n minus one us “point eight” times w n plus one is this

[35:09] so w n minus one is “point eight” times thousand minus y n minus one n minus two because w n minus one this index now is n plus one has gone down by two steps therefore this must also go down by two steps

(Refer slide time [35:38])

that means the persons recruited in the n minus one th year will be based upon the number of people in position at the beginning of n minus second year 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 one plus “point eight” y n minus two equals minus of x n minus one plus eight hundred

[36:09] 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 years previous two years and also the number of people living in the organization in the n minus one th 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 \( y_n \)

[37:03] 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 two 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 zero one two three and so on and so forth we can’t read any meaning in that for non integral values of \( n \) this has meaning only for \( n \) equals one two three four and so on the distance between successive units in our case happens to be years but in general it could be seconds minutes or whatever you are having it’s also conventional that in most of the cases we take these intervals at regular points along the time axis

[38:09] so it could be seconds it could be months it could be days it could be years 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

[39:12] 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 (noise) what we would like to know is the order of this difference equation it’s the difference between the highest index and the lowest index so \( n \) and \( n \) minus two these are the dependent variables
(Refer slide time [39:41])

the difference between these two is two
so in our case this is the second order difference equation in this case

[40:01] 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’s 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 two important differences between a continuous time system and discrete time system are continuous time systems the differential equation comes into play

[41:04] 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 a discrete values of the independent variable which is usually timed and that’s why it’s called a discrete time system
a third important classification is the concept of linear system and non linear system
in a linear system if an input $x$ one of $t$ i am talking about a continuous time system now this is the-, our discussion will be mostly in terms of continuous time systems
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

[42:05] if \( x \) one of \( t \) gives rise to an output \( y \) one of \( t \) and \( x \) two of \( t \) gives rise to an output \( y \) two of \( t \) then for a linear system no matter what \( x \) one and \( x \) two are a constant times \( x \) one of \( t \) plus another constant times \( x \) two of \( t \) will give rise to an output which is \( c \) one \( y \) one of \( t \) plus \( c \) two \( y \) two of \( t \) for all constants \( c \) one and \( c \) two

(Refer slide time [42:48])

this is what is Referred to as the principle of super position
sometimes people Refer to this break this up into two parts homogeneity and editivity
what they are saying is if \( x \) one of \( t \) gives rise to \( y \) one of \( t \) then \( c \) one \( x \) one of \( t \) gives rise to \( c \) one \( y \) one of \( t \)

[43:04] that is called the principle of homogeneity
then the second part is if \( x \) one of \( t \) gives rise to \( y \) one of \( t \) and \( x \) two of \( t \) gives rise to \( y \) two of \( t \) then \( x \) one plus \( x \) two will give rise to \( y \) one plus \( y \) two
that is called editivity
but now we will combine these two together and we will say \( c \) one \( x \) one of \( t \) plus \( c \) two \( x \) two of \( t \) will give rise to \( c \) one \( y \) one of \( t \) plus \( c \) two \( y \) two of \( t \) for all constant \( c \) one and \( c \) two and this is the class of systems which are called linear systems one 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 zero initial stored energy
if a capacitor has got some stored energy in that this principle of super position will not be valid
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 two volts one 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 two divided by one or v i minus two and if i have two different voltages v one and v two and find the currents i one and i two and if i say if i have v one plus v two then i will not get i one plus i two as you can see

for example i one here is v i one minus two for one particular excitation
for a certain excitation i two equals v i two minus two
but suppose i have a single excitation which is equal to v i one plus v two then the current would be v i one plus v i two minus two
that will be the current when i have a single excitation v i one plus v i two but i three is not equal to i one plus i two
why because of the source here
i three is not equal to i one plus i two
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

(Refer slide time [46:07])

[46:07] 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
okay and let me assume that $v_c$ zero equals some row volts
that is the initial capacitor voltage is row volts
then you have the relation $i_s$ equals $v_c$ equals one over $c$ zero to $t_i s\ d\ t$

[47:06] that is the initial charge that is conveyed to the capacitor in the interval from zero to $t$
this is $v_c$ of $t$ plus the initial voltage that’s across the capacitor row
that’s this initial voltage that’s 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 zero 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 one $i_s$ one then it will you will get $v_c$ one equals one over $c$ integral $i_s$ one $d\ t$ plus row zero to $t$ of course and let us take a
second excitation which is zero to $t_i s\ two\ d\ t$ plus row that’s $v_c$ two
so $i_s$ one and $i_s$ two respectively will give rise to these voltages $v_c$ one and $v_c$ two

[48:02] suppose i had a single source which is $i_s$ one plus $i_s$ two
both of them are acting in parallel simultaneously
$i_s$ one and $i_s$ two together charge in the capacitor

(Refer slide time [48:20])

then the third time the voltage $v_c$ three will be one over $c$ integral $i_s$ one plus $i_s$ two $d\ t$
plus row again because initially the capacitor charged row volts
now you can see $v_c$ one plus $c$ two which are responses due to $i_s$ one and $i_s$ two will not
add up because $v_c$ three is not equal to $v_c$ one plus $v_c$ two
what spoils is this the initial charge of the capacitor because when you add this up you
get two row but it’s only one 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 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

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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

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

[50:01] linear differential equation is one 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 can’t be a function of another derivative of y or y itself
so linear differential equations are the one 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

[51:17] 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

[52:04] we said a network is a special kind of system in which all the variables will be of
a particular kind one 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 one hand keeping in mind on the one hand that the complexity of the system should be not too large facilitate convenient handling of the model at the same time it should be distinctly realistic so that the results obtained from the model generally realistic in practice

[53:00] otherwise the model has to be refined once again also mentioned that the model and the system we use the two 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 input 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 classification 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