Modelling and Simulation of Dynamic System
Prof. Dr. Pushparaj Mani Pathak
Indian Institute of Technology- Roorkee

Lecture – 31
Simulation using SIMULINK

I welcome you all in this lecture on simulation using simile which is a sub model for modeling and simulation of dynamic system course so we have seen that how we write the mathematical model for the different dynamic systems and once we have mathematical model of the next task is to do the simulation of that model, so we have earlier also seen in my earlier lectures transfer functions and then block diagram algebra, signal flow graphs, etc.

So simulation using SIMULINK is basically something very similar to manipulating of the blocks okay that is the block diagram so this SIMULINK is a toolbox to model system in a block diagram form as I said and it is a part of the MATLAB basically, so after opening the MATLAB window if we type the SIMULINK okay, a new pops up with the name of SIMULINK module comes and SIMULINK module and elementary blocks appear.

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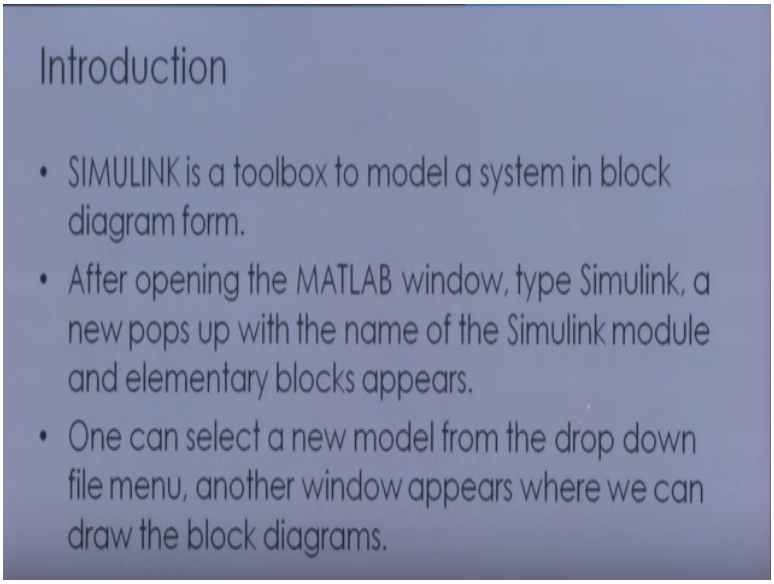

So basically when you are going to open the MATLAB, you will be getting a prompt like this and here in this prompt, you have to type the SIMULINK okay and once this SIMULINK module and elementary blocks appear then one can select a new model from the dropdown file

menu and after selecting the new model another window will appear and where we can draw the block diagrams.

So the SIMULINK has brought the graphical block diagram capability, we can drag and drop different components one can drag and drop and these components are called blocks and there is extensive library available for the blocks okay for example DS blocks that is distant signal processing that is there and then the real time workshop blocks are also available.

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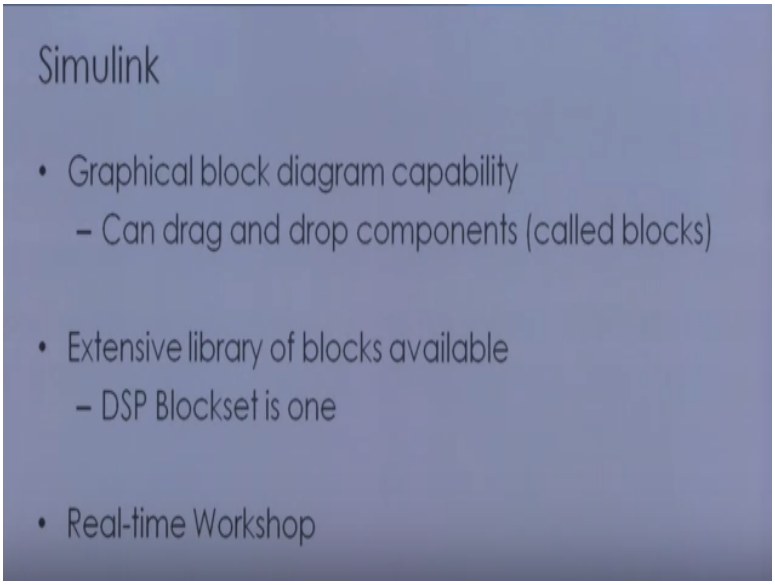

In this environment of SIMULINK, we can model the continuous, discrete as well as hybrid systems and we can also do the modeling for linear and non-linear components and it is very closely integrated with the MATLAB and the other tool boxes. So the SIMULINK model typically consist of 3 basic blocks, one block is the source, another is the system and then you have the sink.

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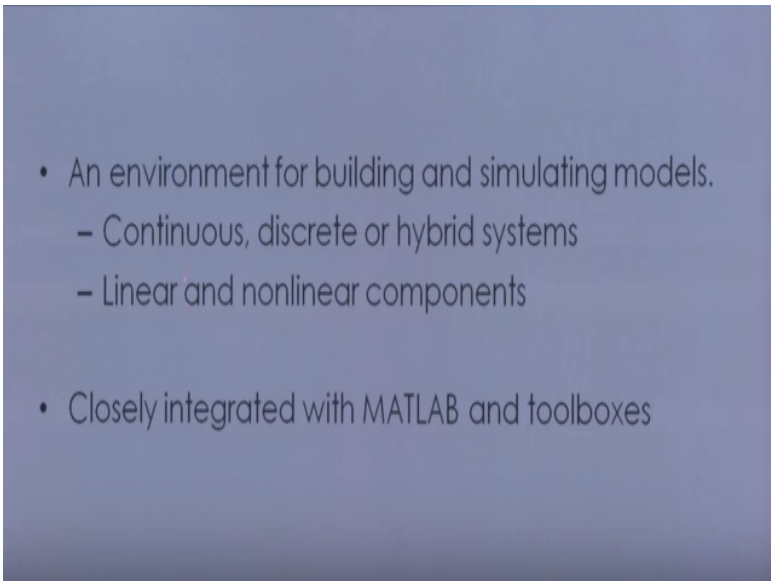

So the source is basically sources are basically the input blocks and sink are what you can say that the output where we see the output and then there are system blocks okay so in the system blocks, there are interconnection of linear and non-linear block, those linear and non-linear blocks forms part of the system.

Now coming to the sources, there are various types of sources are available in the library say sine wave function generator, you can get those sources from the MATLAB work space as well and from the disk files, also the sources can be one can have and the sink has got displaced scope okay FFT scope is there then it can go to the MATLAB work space also and it can also go to the disk file.

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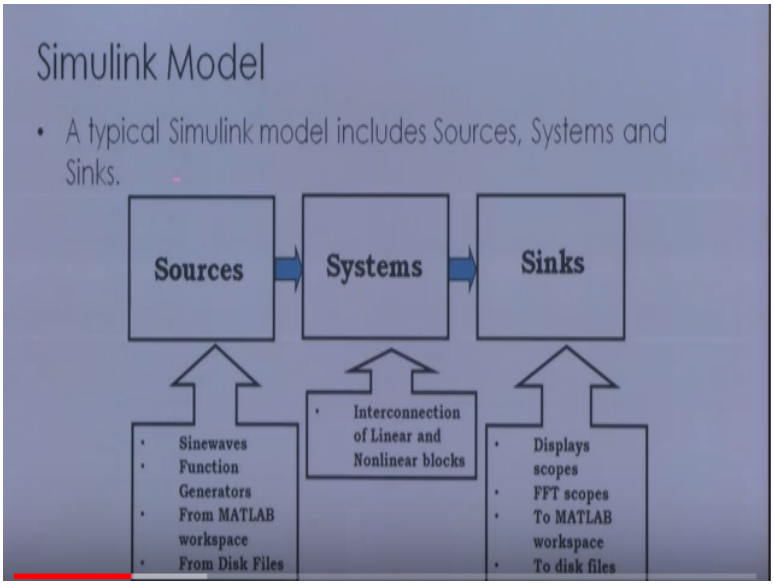

So these features are available in the SIMULINK. You can just broadly speaking what I can say is that we have the sources, where we can incorporate different types of sources in the model, we have the sink where you can visualize your output and in between and sources and sink, you can have system blocks where you can use the linear and non-linear blocks available in order to create your SIMULINK model.

So a simple SIMULINK model may look like this, something like this, here this portion basically, this portion the sine wave, this is basically your input okay, and the source, which you are seeing, so these are basically the sink, so you have the source and sink, and then various blocks has been used here in order to create the system model okay so like this you will be seeing in all the SIMULINK mode.

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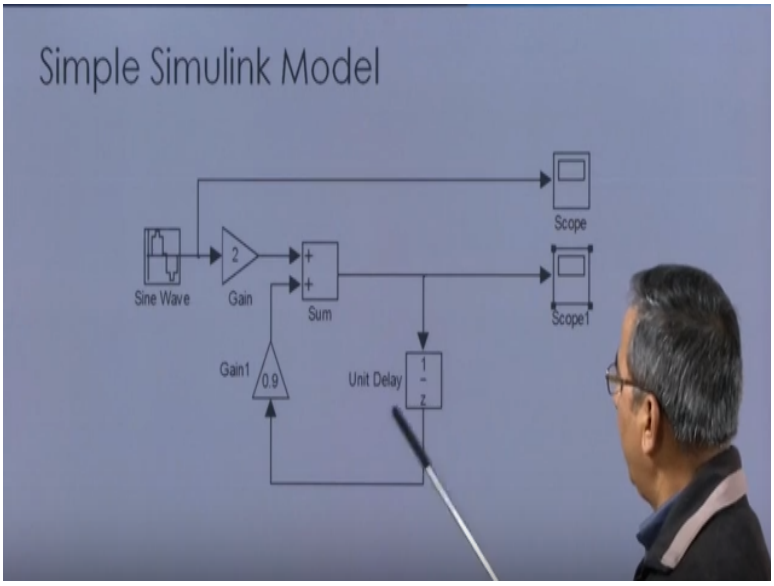

There will be scope, sink, and sources and then various linear and non-linear elements are there, say there is a unit delay is there, some gains are there, again some gains are there, some summation of these signals are there, all those things. Now SIMULINK block library basically contains components that can be used for the building of the blocks okay and these block library can itself has other libraries as block okay.

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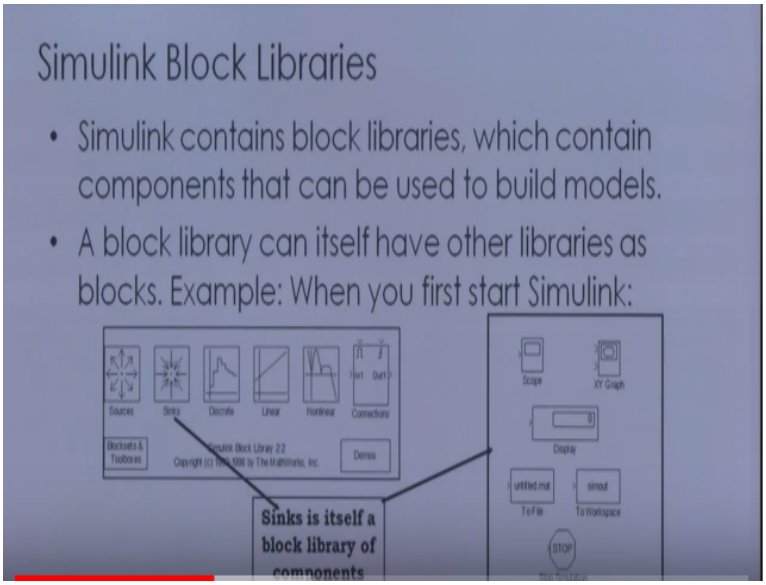

For example, here you can see that you have source, so in this source you can have the various types of sources available, then you have the sink and this sink if you have look at the sink then in the sink, you can have say the scope, your XY plot graph is there, display is there, If you want to take the output to some file.

So that is also there, some workspace if you want to take or if you want to terminate your simulation, then there is a stop simulation block is there, so these all form spot of the sink. Likewise your sources can have various sub blocks, discrete linear, non-linear, okay all those things are available.

Now if you have to build a SIMULINK model, then actually this is our model window where we have to pick the blocks and place it over here and do the connection between the different block, so this is our model window and say this is our source library available from where we can take the various sources say sine wave if I want to take so I can drag it over here.

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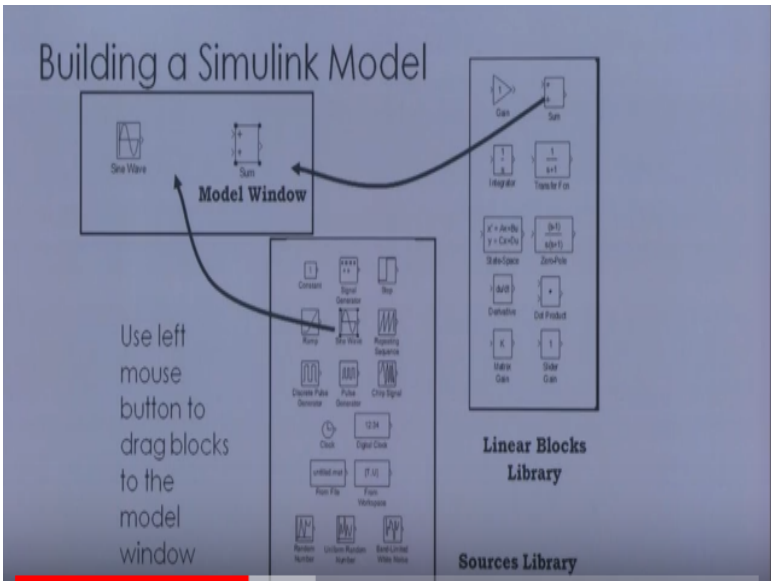

So sine wave similarly the model window, I can have the linear blocks library where I have summation, gain, integrate, transfer function, state space 0 pole, derivative, dot matrix gain, slider gain, all these things are available so I can take one here that is linear blocks for creating the system model and from here, I can take the source, fine and then once we have say the source and we have the various blocks here al right and say we have the scope that is the sink.

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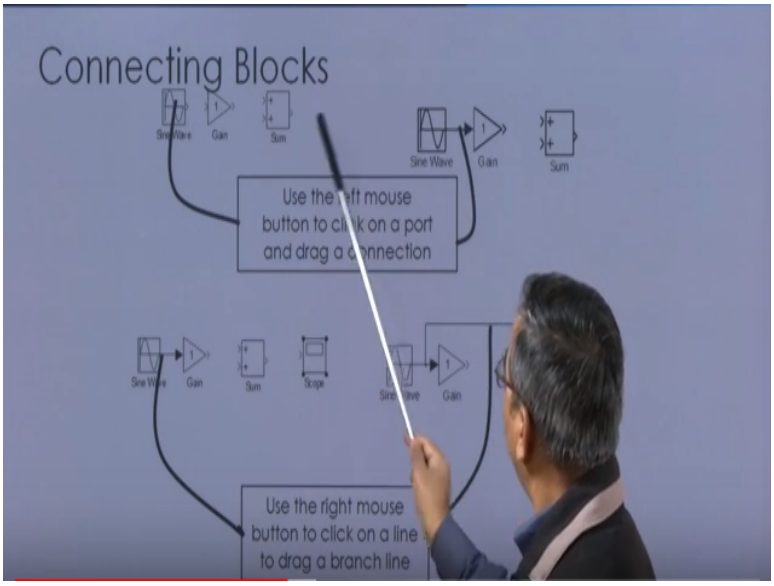

We can do the connections between these different blocks okay, so we can use the left mouse button to click on the port and drag for connection all right, so this is how we can do it and we can use the right mouse button to click on the line and drag for any branching if you are interested in or if you are model contain some branching.

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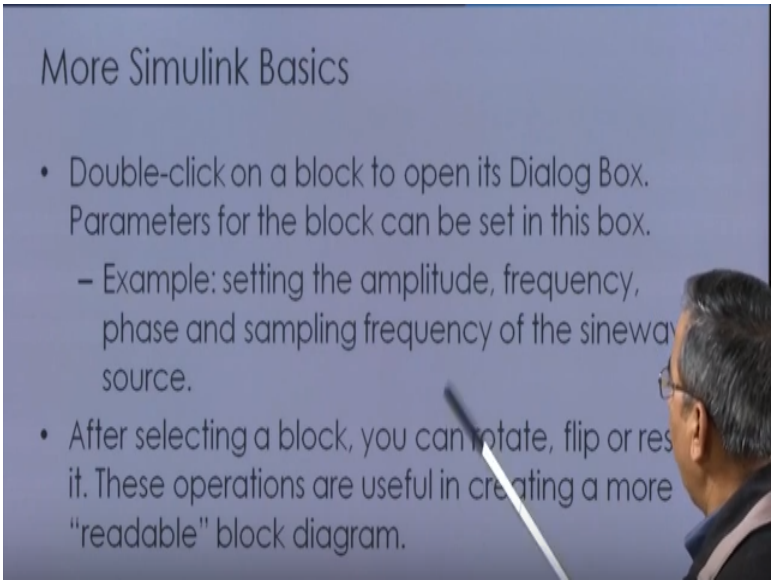

So that you can do and that way we can connect the different blocks and create the model consisting of the source, sink as well as the systems, so let us look at little more something about the SIMULINK basic. We can double click on the block to open its dialogue box and parameter for the block can be set in this dialogue box okay.

For example, if I am talking about some input sine wave source, then I can set the amplitude, I can set the frequency, I can set the phase and I can also set the sampling frequency of the sine wave source, so all these things I can do and after selecting the block, one can rotate, flip or resize it. These operations are useful in creating a more readable block diagram okay.

Then how can we set the simulation parameters okay so in order to set the simulation menu item of the model window can be used to set the simulation parameter. In this simulation parameter, you can specify the appropriate solver that is to be used for example, for discrete time system, we can use say fixed step discrete solver.

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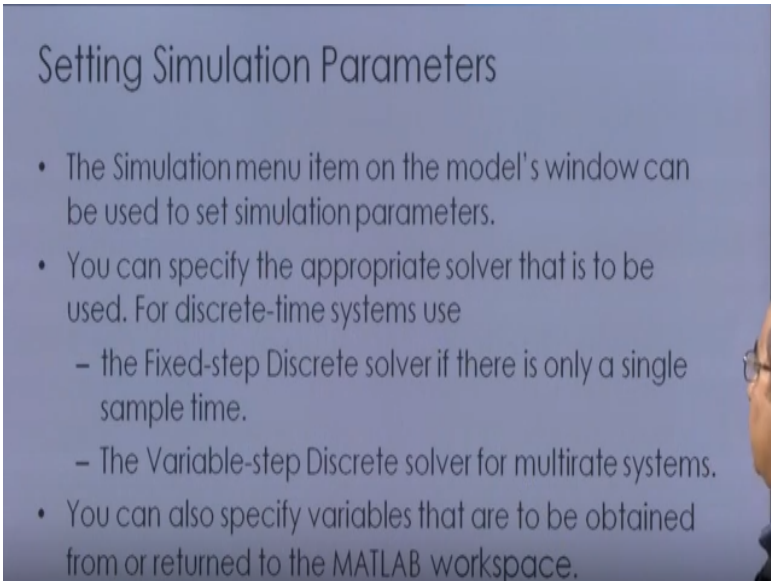

If there is only a single sample time or we can go for the variable step discrete solver if there are multi-rate system okay and you can also specify the variable that can be obtained from or return to the MATLAB work space, so all those things can be done, then we can create the various sub systems okay.

So one can select the portion of the model using the mouse and make them into a subsystem, actually creating subsystems many times helped us in debugging actually that is finding out some errors in your model, so you can create some of the blocks and you can make those blocks as the subsystem and also we can create or mask a subsystem that hides the complexity of the subsystem from the user, so this also can be done.

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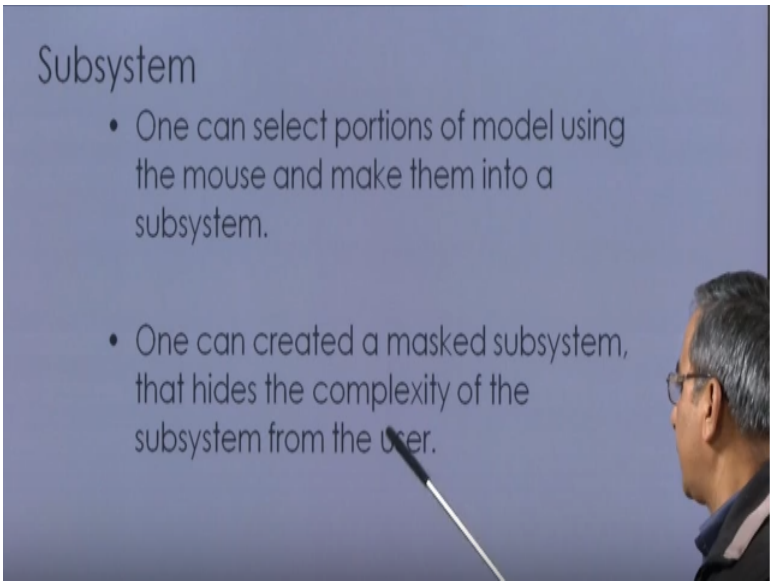

Let us take an example okay say I want this system to be simulated and this system contains a source here, which is a step source, there is a scope here okay that is the sink and there is a system here okay so this system is again some transfer function, so as I have been telling you this model consist of 3 blocks.

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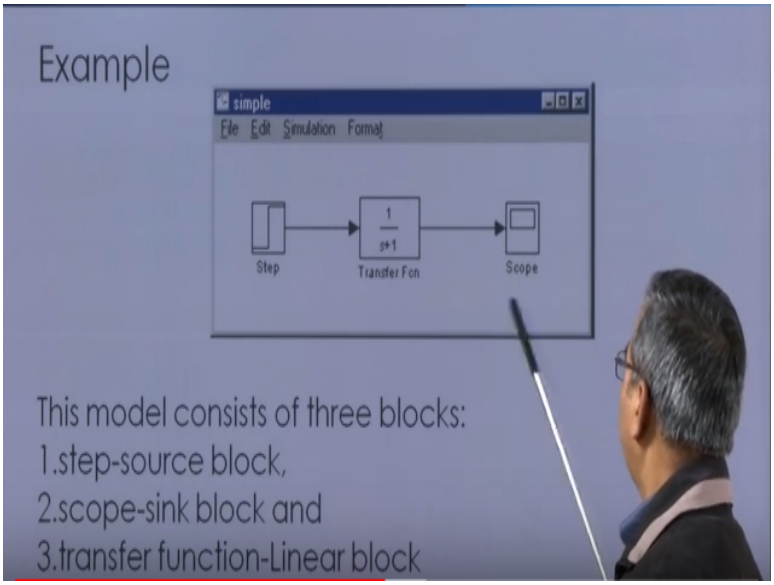

One is the step source block, this is the source then the scope sink block that is this is the scope sink block and there is a transfer function linear block okay. So these things are available, so now let us see through this example the various features of the SIMULINK.

Now a block can be modified basically double clicking on it hereby right click on the transfer function block yields okay so if you are going to right click on the transfer function block, you are going to see this window where basically you specify what is the numerator, and what is the denominator of the transfer function okay.

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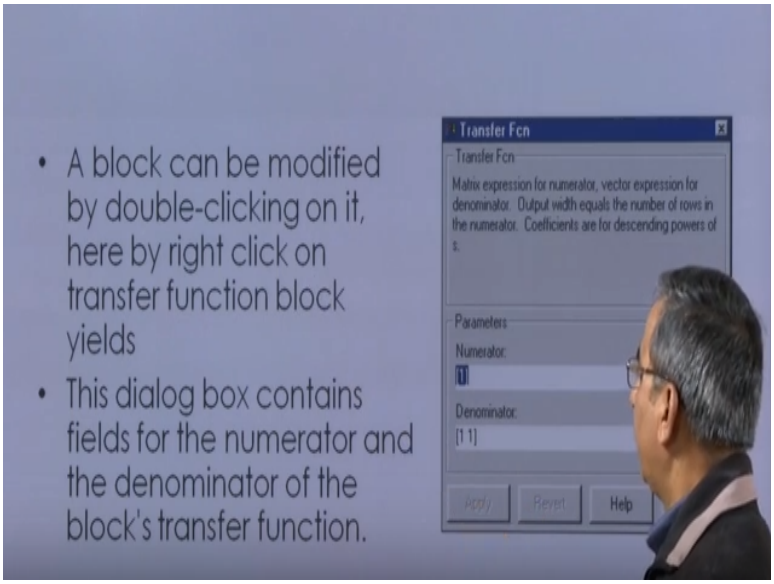

So here say numerator is 1 and here denominator is 1 1 and this 1 1 basically means that it is s+1, okay so this is what here we will be getting if we are putting it like this okay, so this is the numerator and the denominator 1 1 okay so this way, we can specify the transfer function, here see you get a help also where it is written that matrix expression for numerator, vector expression for denominator okay.

Output which equals the number of rows in the numerator, coefficients are for the descending power of s. So this is what is given. Now to change the denominator to say s square+2s+4, if I want to put it like this, s square+2s+4, here instead of 1-1 what we have to write is basically we have to write 1 2 4 here okay that is the coefficients in the decreasing order that you have specify 1 2 4 in the denominator field okay.

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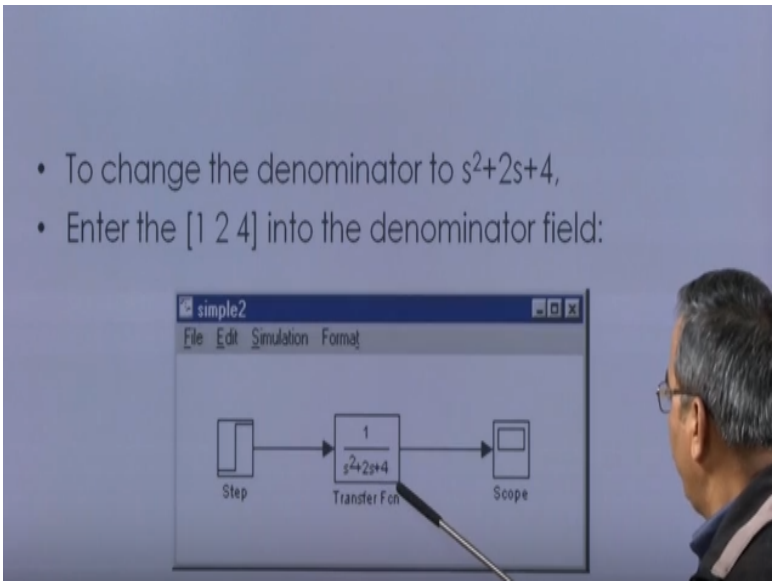

So that has to be specified that is here, in this denominator, you have to write 1 2 4, so if you do that you will be able to get this transfer function S square + 2S + 4 okay then so this was about the setting the transfer function okay in the system block. Now let us see the setting of the parameters in the input or source.

So the step block can also be double clicked, bringing up the following dialogue box, so if you double click on the step block, this will be the dialogue box, which we will be getting where it says that output step parameter here, step time is there, which is 1 second, initial value is 0 and the final value of step is 1.

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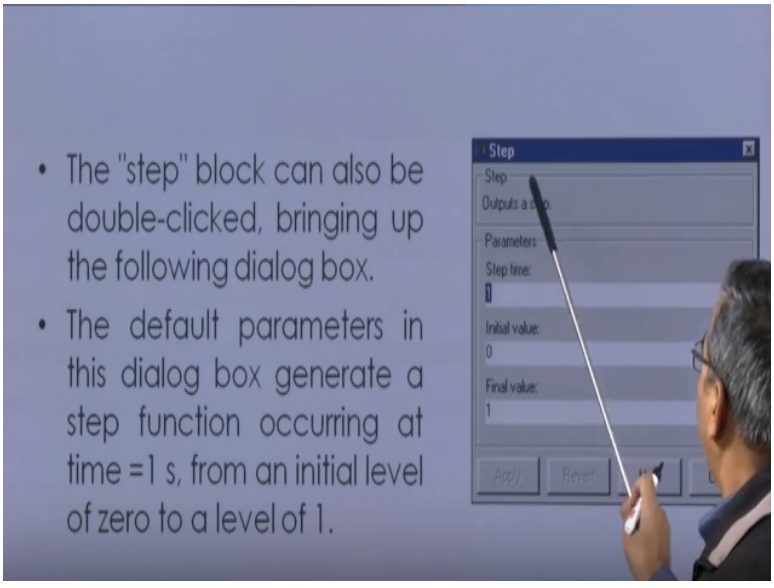

So here we can apply with it, we can modify it okay so the default parameter in this dialogue box generate a step function occurring at time 1 second as specified from an initial level of 0 to a level initial value of 0 to a final value of 1, so this way we can set the source okay so this way we can setup the source. Previous slides, we set up the transfer function block.

Then, if we double click on the scope block box also, it will bring up a blank oscilloscope screen, basically it is a output screen, which is there and which is also called the oscilloscope screen that will be coming here and when a simulation is performed, the signal, which feeds into the scope will be displayed in the window okay.

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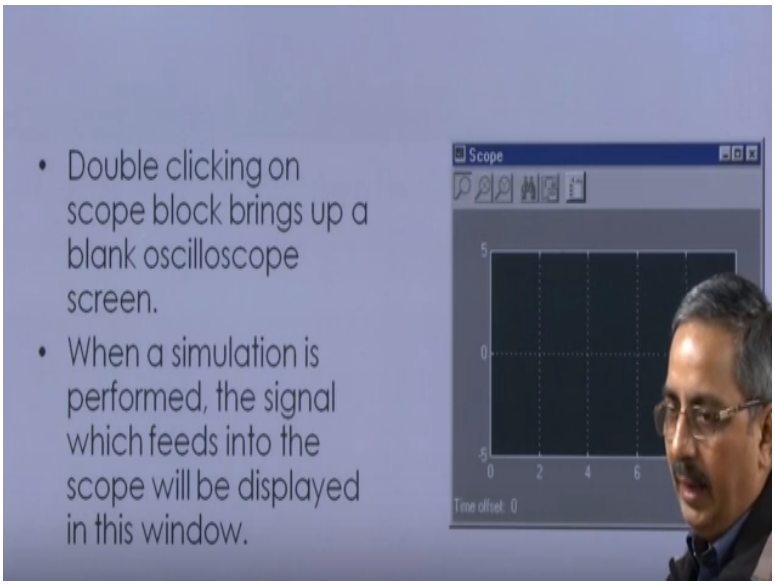

So when your simulation is running, whatever signal which will be coming here the output signal that is going to be seen in this window, so take the following model to run for the simulation. Let us take this model that is you have a step 1, step source, there is a scope and say transfer function is there that is why s square+2s+4.

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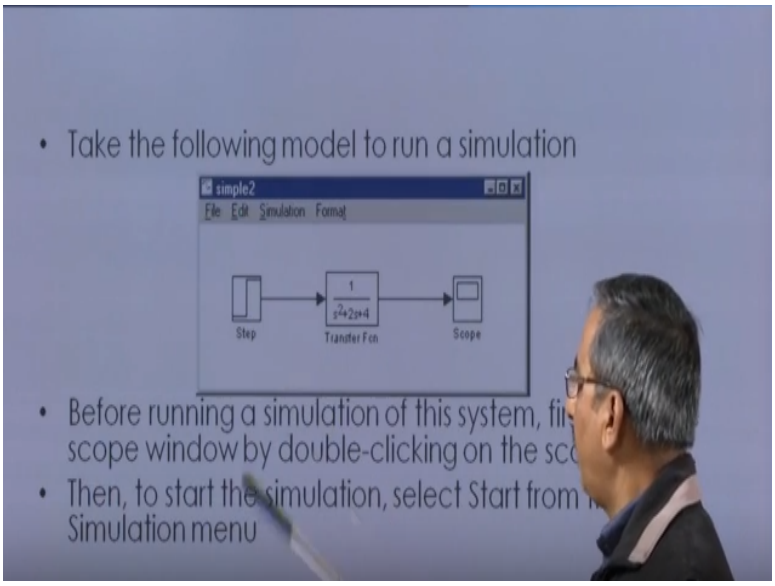

Now before running a simulation of the system, first open the scope window basically double clicking on the scope block so first you have to open the scope window basically double clicking on the scope block and then to start the simulation, select start from the simulation menu okay.

So we have this simulation menu here and on this simulation menu, you have to select the start then simulation will take place, so this is how it looks like, you have to click on this simulation and go to the start and click here okay and after you click here, the simulation should run very quickly and the scope window will be appearing okay.

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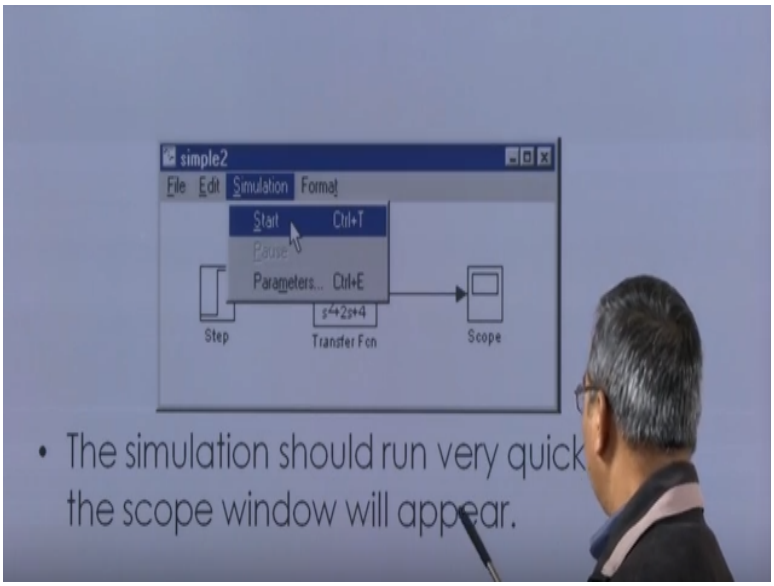

So you will be getting the scope window and the simulation will be running. So this is how, it turns out to be okay this is your scope where you will be seeing one yellow line something like this, so the simulation output shown in yellow here is at a very low level related the axis of the scope okay and to fix this, to see the proper values here okay.

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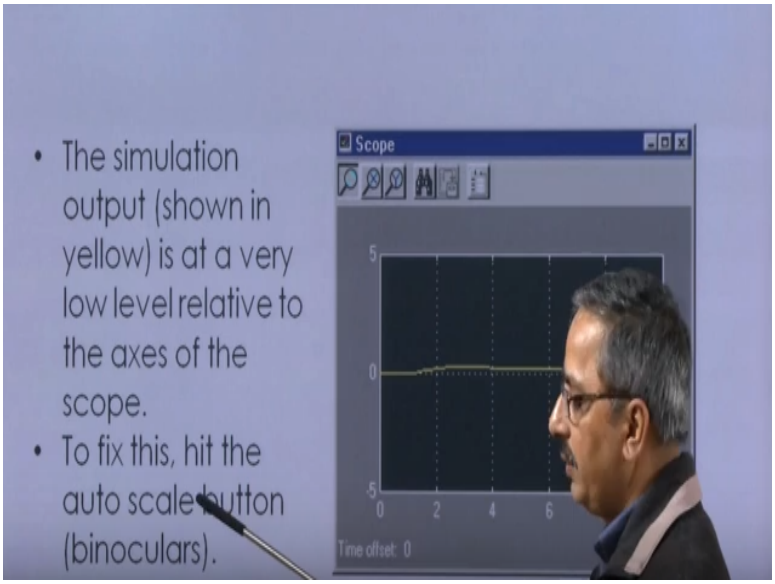

What we can do is that we can hit the auto scale button or which is also called the binocular, so you can hit at the auto scale button or the binocular and you will be able to see the true variation okay so this is how your things will be seen basically going to the auto scale button or the binocular, you have to hit it and this way you will be able to see the variation okay.

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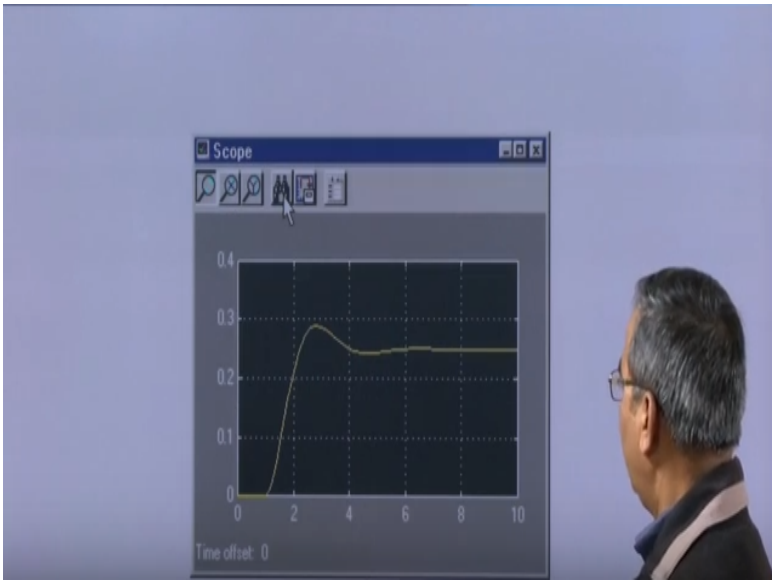

So this is how, one can do the simulation using the SIMULINK okay so this is basically as I said it is a block diagram type of approach for doing the first you create the model of the system and then after once you have created the model, then you can simulate that model after specifying the input and the system parameter.

So what are your inputs and what are your system parameters if you specify these things then you can see the output something like this okay so this is a simple example I have taken and during our this course I have been discussing with you the many types of SIMULINK models so this is the basic procedure which will be applicable for any types of SIMULINK model okay.

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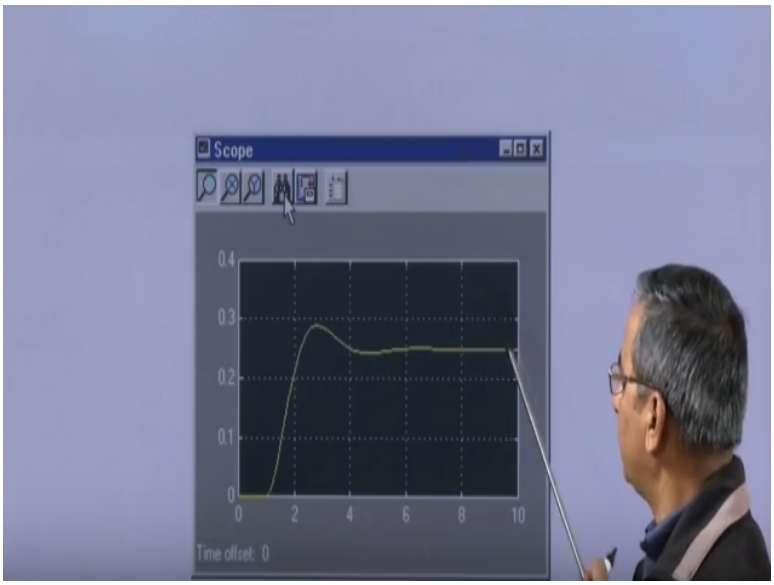

So if you want to try, you can make a try and you can create a SIMULINK model in order to simulate say our well known systems mx double dot+bx dot+kx=say ft, okay so you can simulate for free as well as for the force vibration case for this system and you can see the behavior okay and again here what I will suggest is that you go for say mx double dot+bx dot +kx=0.

So get the transfer function for this case okay and then do the simulation and find out or observe all the 3 cases depending on the values of MB and K that is the over damped critical damped, and under damped okay so simulate for all these 3 cases, create the SIMULINK diagram and simulate for all these 3 cases basically choosing the appropriate values of m,b and k.

We can change the parameter of the simulation also as I was talking to you and in the model window, select parameters from the simulation menu okay and you will see the following dialogue box and in this dialogue box, you see we have the start time, stop time, and solver option you have the variable step and here what that is od45 solver you are using.

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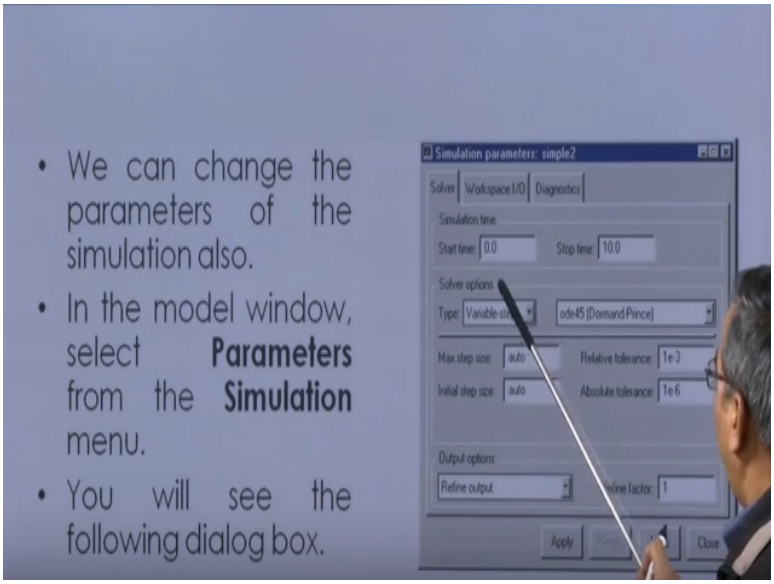

So here various solvers are available and you can choose the appropriate solver from here okay and of course, maximum step size this initial step size has been given auto related to some tolerance has been specified and output option has been given okay so this way we can change the parameters of the simulation also okay and say in the previous one, if I change this time say stop time from 10 to 2 seconds.

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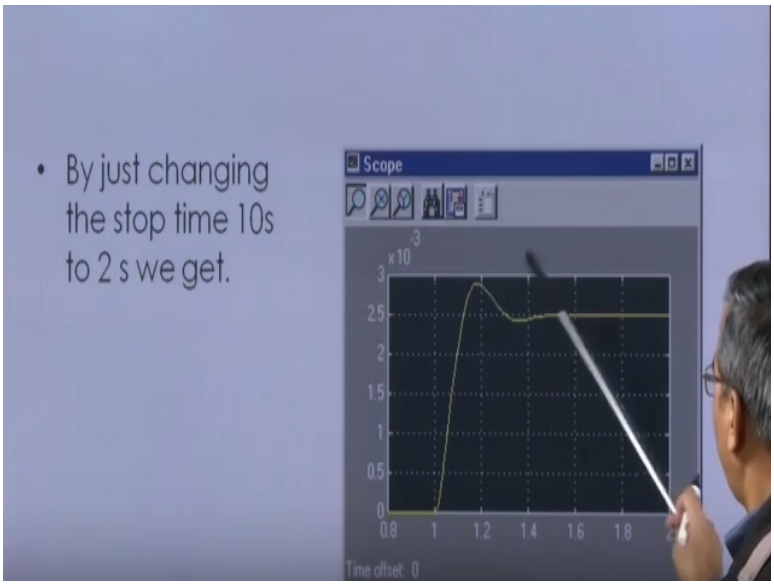

Then of course we can basically changing the stop time from 10 seconds to 2 seconds this is what we get and here of course this is our amplitude and this is our 2 seconds okay so this is how you get the output, so this way we can do the simulation and if you want to practice further, you can go through the following reference that is the mat work help book on the Simulink Dynamic System Simulation.

Go through this help book and you will be seeing many more examples and many more cases available here and practice it yourself, thank you.