Modeling & Simulation of Discrete Event Systems
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Lecture - 02
Concept of System, Model and Simulation

Welcome to the lecture on Concept of System Model and Simulation. This is lecture two of the course modeling and simulation of discrete event system. In the last lecture, we discussed about the simulation process, its advantages, I mean when to use this simulation, when not to use the simulation and what system is what simulation is. Now we will discuss more elaborately about the system model and simulation in this lecture. We will also discuss about the advantage and disadvantages of the simulation practices, and will also discuss about different kinds of models which are basically studied in simulation practices.

Now coming to the definition of system, what a system is? Whatever we study basically that is a system. In the last lecture we discussed that when we are going to study a bank:

a bank is a system because in the bank we are going to study the behavior of many processes, like behavior of moment of the customers, behavior of the persons who are standing in the queue or how they are getting the service all that.

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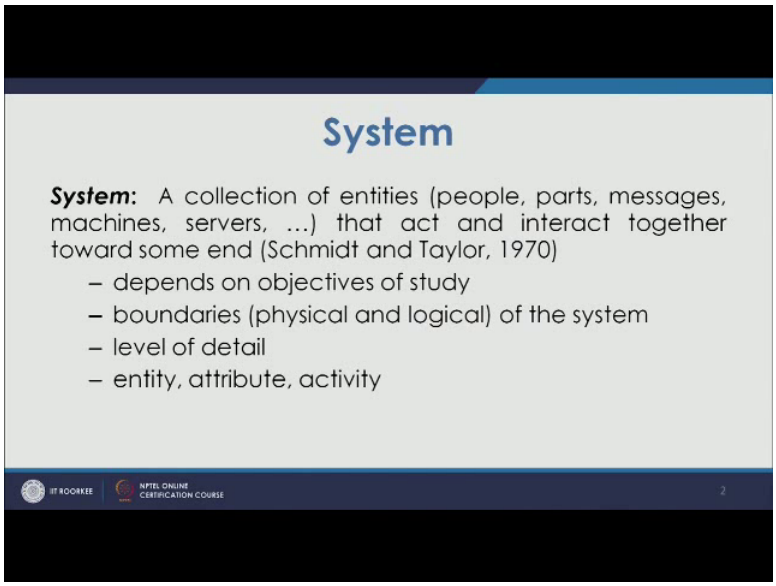

So, that is why a system is defined as collection of entities that is, it may be people, it maybe parts, may be message, it will be machines, it may be servers; so the collection of entities which are acting and interacting together towards some end. So, as we discussed you have the entities like people, when the people are interacting like that on a platform a railway platform or a counter of ticket booking or in a bank or so. Parts that is when there is movement of parts in the soft floor from one machine to other. So, they are basically the one which are going from one place to other. So, they are the entities.

Similarly messages, in the case of you know telecommunication where the messages are coming and they are being forwarded or so there also one has to come they have to wait, there may be waiting line queue or so. So that time the entity is a message which is delivered from one person to other or so. Similarly machines servers, these are all the different kind of entities and they are basically interacting among themselves. Now they are acting and interacting together towards some end. So, basically that is that whole thing is a system. So, that definition is given by Smith and Taylor in 1970.

So, what we see is that it depends on the objectives of study where you are confining your objective: what you want to study, what should be your the domain. So, what you want to achieve, what you want to study that defines or that sets the limit of that system. So, a system may be smaller one system a may be larger one, so that way you will have the boundaries of the system. So, certainly you will have to call find yourself in a certain domain, to you may have a logical boundary or a physical boundaries of the system. And you have to define that you are going to a study the changes in between the different components in that particular domain. So, there must be a domain under which you have to study.

What level of detail you want? What level of detail of the knowledge of or the behavior of the system you need to know? How much you want to predict? What quality of the information you need? So that also takes tells you that how the system is going to be studied, how you have to study the system. You may have to study very coarsely when only few components needs to be examined or may be that you may have to find large number of parameters and their effects. So, that is level of detail whether it is easy whether it is quite complex or so or there are many.

Similarly, you have the entity, attribute and activity. So, that we will discuss further, what is the entity?

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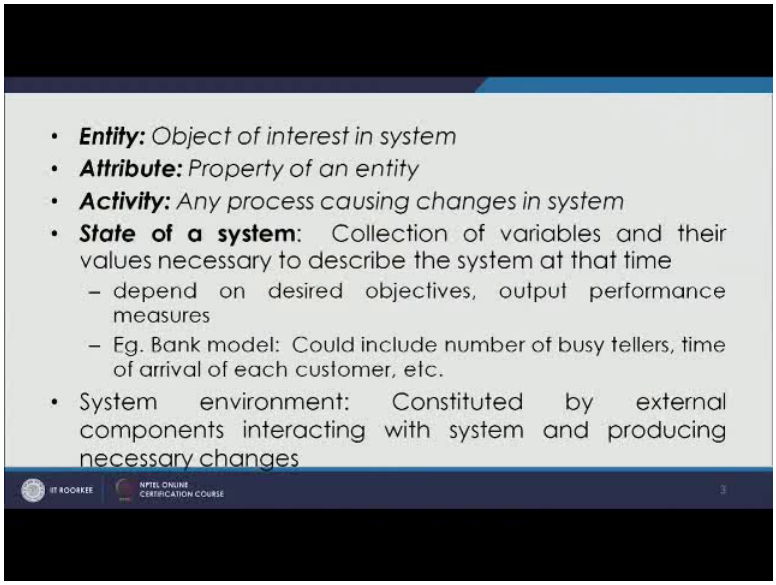

So, entity is nothing but the object of interest in the system whatever you see that is. So, any object of interest that is entity. So, in the bank a customer is an entity server is an entity. So, whatever is there that is basically; an entity similarly attribute. So, attribute is the property of an entity likes the server, it may be busy, it may be not busy, it may be idle. So, these are the attributes of the entity the person maybe in the queue the person may get the service the person after the service may go out of the system these are the attributes with the entity. So, these terms will come when will discuss about the systems or the models; similarly activity; what is activity; activity is any process causing changes in the system. So, any process which occurs because of which there is change in the system like in the bank a customer is coming.

So, that has made the changes in the system the person who are waiting in the queue have increased by one. So, this is an activity similarly a person getting the service coming out that an activity because this activity has changed the state of the system. So, they have create some changes in the system that is that is known as an activity in the system a state of the system. So, collection of variables and their values necessary to describe the system at that time so that is known as the state of the system; what is the

state of that system that basically will be that collection of variable. So, what is what are the variables and their values? So, that at that particular time it tells about its state.

So, that is known as state of the system and that depends on desired objectives and output performance measures. So, that will be the state like in the bank model it can include number of busy tellers or time of arrival of which customer this these are the examples of that similarly you have system environment. So, you have as we know that you have a system boundary; so, constituted by external components interacting with system and producing necessary changes so that is known as so certainly as you know once you are studying a system; how it will interact with the outside world. So, that is known as system environment. So, that is; so, when we study the system, we have to see that how it interacts and around the boundary how its behavior is that is known as system environment.

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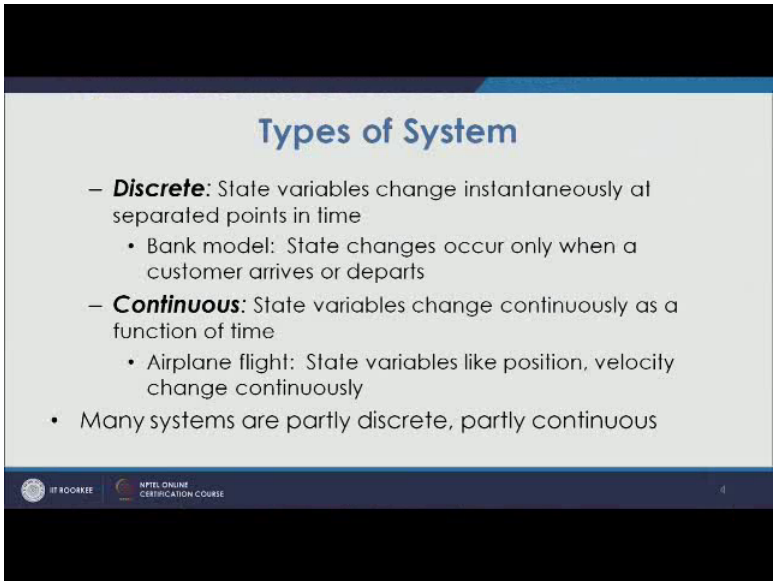

Now we will discuss about the type of systems. So, the type of systems is broadly classified in 2 ways; one is discrete system, another is continuous system. So, as you see the discrete system is the one where the state variables are changing instantaneously at separated points in time while in cases; as we know discrete means a countable and you can very much say you can very much separate it at different points of time it is doable. So, in those cases, it is known as discrete system like as we have seen the example of

bank in the bank as we know whenever there is an arrival of the customer then the there is change in the system.

So, that; so, as one person comes, there will be change one person goes then they will be change and that is countable that is at a particular time instantaneously it goes and that changes whenever there is that process going on then only there will be change in the system. So, that is known as discrete system otherwise things are same up to that. So, in between 2 processes the things are all constant. So, these are known as discrete systems all these are the discrete kind of systems. Similarly, you have continuous system in continuous system the state variables change continuously as a function of time. Now in this case, the change is continuous with time like the velocity or the position of the aircraft is moving in the space.

So, state variables like position velocity they are changing continuously and you cannot tell in a discrete manner these positions like the falling position of the liquid in the container which is coming down. So, this is not the discrete you know kind of change it is a continuous change. So, these kinds of studies are the continuous changes. Now in discrete, you have different; you know examples you have the ticket counters these studies and then you have manufacturing applications you have conveyor belts use of them or in fact, you have the automated guided vehicles used in manufacturing up systems applications these are all they are there in countable terms. So, they are the example of discrete systems. Similarly in these cases the temperature pressure velocity calculations all these things are example of continuous systems now many systems are.

So, one you have the discrete system another you have continuous system, but in between you have also the partly discrete and partly continuous system like when we talk about fuel station where the truck brings the fuel keeps in the container, if you see the study of the trucks which are coming and going, if we talk about the trucks that is a discrete change your trucks are coming and going; so, when truck will be coming and then going. So, that will be a change. So, if we focus our interest on the trucks that is basically discrete kind of change, but if we focus on the changes of the oil level which is coming down with time or filling and the level is increasing with time. So, this is a continuous change.

So, if we see this is a kind of study that is partly continuous and partly discrete. So, many of the processes are basically partly continuous and partly discrete and you will have to judge how you are going to study the discrete fashion or continuous fashion in those cases. So, this is way you have the different kinds of systems been defined know how you are going to study a system.

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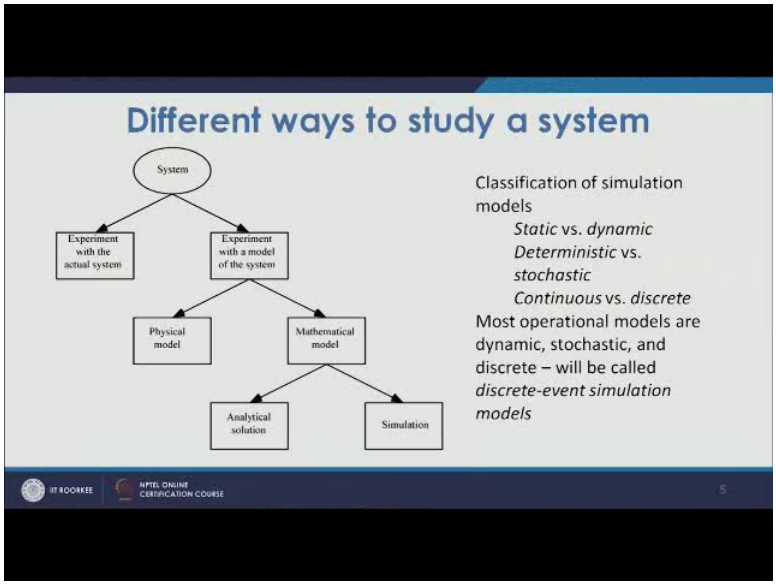

So, as we see the system is studied either with by experimentation with actual system or experimentation with a model of the system. So, experimentation with actual system; it may be feasible, but in many cases it is not feasible because of many kinds of constraints specially the time constraints resources constraints you cannot always do the experimentation with the actual system.

So, what you do is you may have the model with which to the experiments likewise you might have heard about the setups like the; you know when we do the wind tunnel experiments. So, we cannot actually do the experiment with actual system. So, that is why we make a wind tunnel and do the experiment whenever experimentation is not possible with actual size you are making a model and then you do the experiment now once you make a model and do the system do the study of the system not this model maybe either physical or mathematical. So, the model maybe a physical model review scale model a live model which is there and you work with them or you have a

mathematical model where are you define the system you make a model in terms of different mathematical expressions.

And then you try to interpret the relationship between the different parameters and try to predict the behavior of the system. So, you have a mathematical model in those cases where you have the presence of these mathematical expressions and so, now as we discussed in the case of mathematical models, you have either the analytical solution or the simulation. So, we discussed that the solution very easy in many cases you have the doable solution the solution is easy you can get the unique solution. So, that is analytical result, but when the interactions are complex there is large amount of time involved and you see you feel that large amount of time is required for solving you use the computers to solve the set of equations the large number of equations to be solved by forming the matrixes then you have to interpret the results you have to interpret the results in many ways by post processing the simulation result or so.

So, that is known as the simulation. So, in this way you are going to study the simulation or a system. Now once you go for simulation models in the end; what you see not this simulation models can be either static or dynamic.

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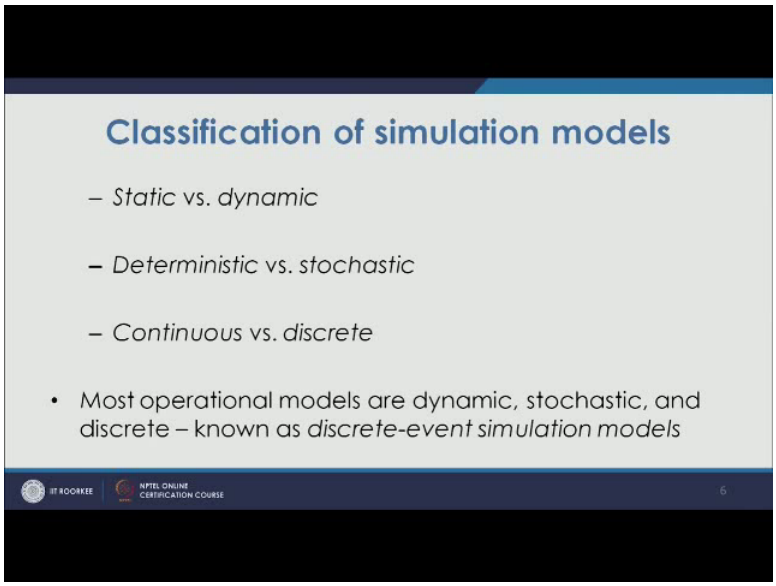

As we see you have either a static or dynamic when we talk about static we are doing the study at a particular time. So, time does not come into picture in those cases we are going to study the behavior of the system at a particular time and when we talk about dynamic

it means it tells you that changes with respect to time. So, static means you can say that something like Monte Carlo analysis or so as we will discuss later in those cases we are not discussing about the time. So, that is known as a static system and dynamic system where we are going to study about the system with time changes.

So, if you are going to study about the behavior of a queue from morning till noon, then it is a dynamic system with time, it will say that how the system has changed how the variables have changed with time. So, that is a dynamic system similarly you have deterministic verses stochastic. So, many times you have you have something with does not have the stochastic component or randomness you can have the fixed values when we solve this equations when we solve this differential equations that time you have we have the deterministic results, we do not have any randomness in that when we predict something through these equations we say that this is the result which is going to happen where as sometimes you have the randomness or probabilities associated you are not sure of the outcome you can only predict that most probably; this will going is going to happen and or having something happening has very little probability.

So, this a way that those kind of you know models where are these random components are there these are known as stochastic components then you have continuous verses discrete as we have already discussed about these models; you have continuous and discrete simulation models where the study will be based on the continuous simulation technique or you have a continuous system and you have a discrete system and when we study about by using the different modeling principal or simulation tool, then about the systems that it will be a continuous simulation model or you have is discrete simulation model. So, mostly you have a dynamic stochastic and discrete model and that will be known as the discrete event simulation model. So, when you have the; you and you are studying the system over time as a time proceeds, then it has this stochastic component it has the randomness associated and also it is discrete.

So, such system which of these 3 components they are termed as discrete event simulation models and we are going to study about such models in this course which have the dynamic that is which is we are going to study the changes with time, then the randomness is there in this models and also it is discrete the variables are changing at instantaneous moment or that particular time when there is whenever there is a change I mean whenever there is any arrival or departure or. So, there will be changes in the

variables. So, that way you will have the dynamic stochastic and discrete the combination of these 3 makes the discrete event simulation models.

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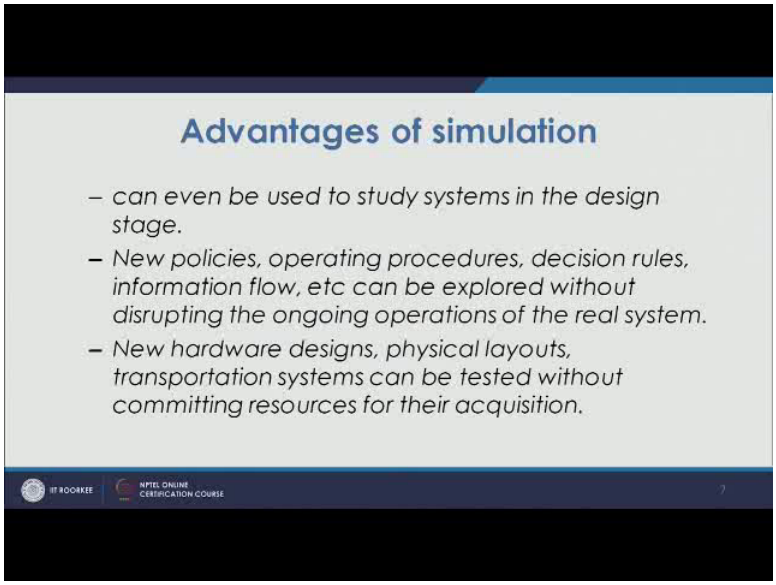

Now, we will discuss about the advantages of simulation. So, as we had discussed that when we should use similarly we have different kinds of advantages of these simulation models.

Now, can even be used to study systems in the design stage as we discussed that simulation models are to be used even in the design stage you need not go later you first design there itself you decide whether it is going to be beneficial or not and then you can implement them for getting better results. So, in the design stage itself you must work on the models you try to get maximum of the outcomes predict them and get the better results which are going to be beneficial for the organization or so. New policies operating procedures decision rules information flow etc can be explored without disrupting the ongoing operations of the real system now many times a real system is going on and the management me think of doing certain changes.

But the management is not sure as to if they do the changes in the system if they do certain changes whether it is going to be beneficial or whether it is going to be harmful for that either they do not have any way either they can try; if they try they are not sure whether it is going to be beneficial or it will be harmful. So, that if it is harmful then it is going to be very much counterproductive. So, in those cases, these tools are very much

advantages you can predict properly you can study the system behavior you can do the simulation and they can suggest you that yes, you can go for these changes they are likely to give you better results the simulation results. So, that if we they do these changes then this is going to be beneficial.

So, while the process is going on we can have those changes and these changes can be put in while the process is going on. So, there is no discontinuity in the process the process is itself on and most likely if the simulation tool is go good then it is going to be productive. So, this way you do not have any kind of you know stop or any kind of break new hardware designs physical layouts transportation systems can be tested without committing resources for their acquisition. So, many a times; when you think of predicting something or getting some new results you may have to go for acquiring new resources do a lot of invest investments; new hardware designs may be required may be new physical layouts are required for positioning new machines new places and that involves a lot of manpower lot of resources.

Now, they can be basically avoid it. They can be tested without really doing that and that leads to lot of savings otherwise.

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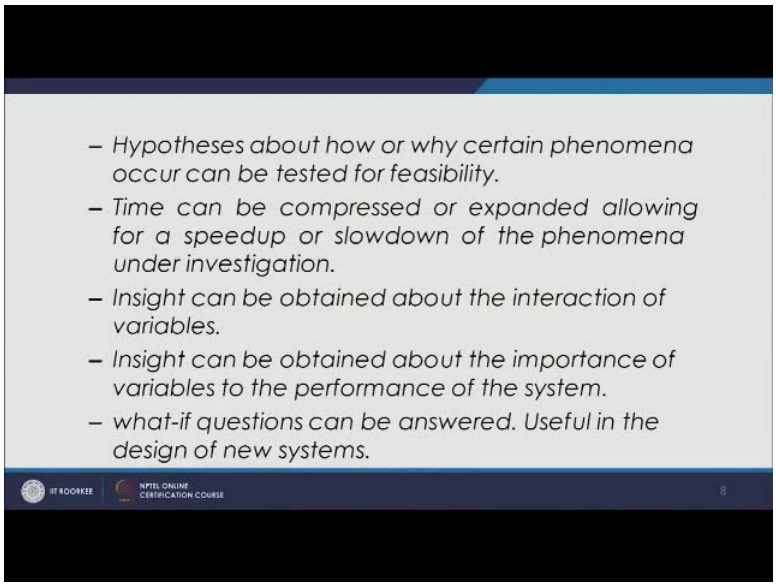

So, all these things are the advantage of doing the simulation hypothesis about how or why certain phenomena occur can be tested for feasibility. So, many a times you need to know more in a detailed manner how it works or why it works. So, that can be studied by

simulation. So, that is one of the advantage of simulation; you will have more knowledge about the system and you can work with more interest for the system time can be compressed or extended allowing for a speed up or slow down of the phenomena under investigation.

So, in this case, if you have good machines you have lesser time available then you can do the simulation. So, this way depending upon the time you can speed up the process or you can have the time more. So, you can study more elaborately the system so that facilities given to you and you can have the study at your own will. So, that feasibility is there inside can be obtained about the interaction of variables. Now as we discussed the variables of the system interact among themselves; how they are interacting; how this interaction is going to be beneficial or how it is going to give the result that basically insight its insight can be given by the simulation process it can also be obtained about the importance of variables to the performance of the system. So, that also insights can be given that how it is going to affect the performance of the system what if questions can be answered useful in the design of new systems many a times in the case of new systems these questions like.

What if comes very often what if this component does not work or what if we place a new machine in this place or how what if the 2 machines are interchanged. So, these things many a times in practical scenario is not possible where as in simulation you have the flexibility to study these things. So, these are the advantages of simulation.

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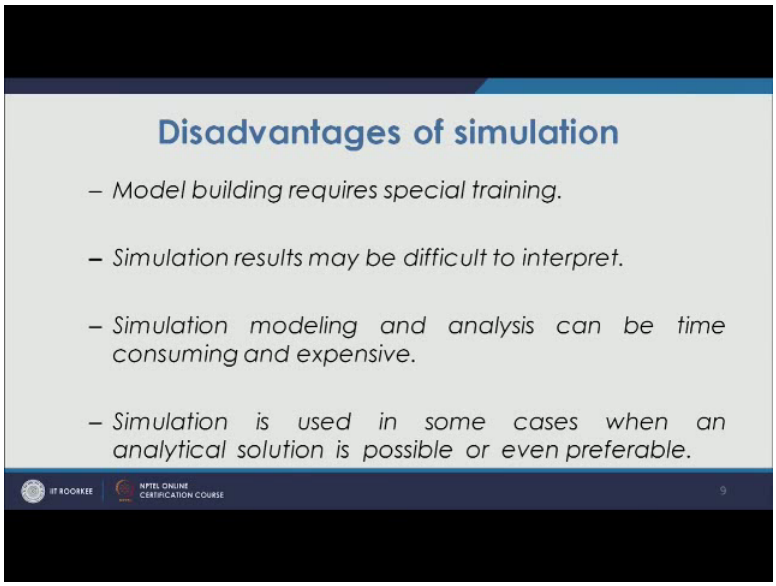

Coming back to the disadvantage of simulation, apart from the advantages simulation also has certain disadvantages and we must know simulation is not the one which will be solution for everything, it must have certain disadvantage because of certain limitation one is model building requires special training as we know that when we make models, we need to have proper understanding about the behavior of the system; how it works what are the different mathematical expressions how they are interacting with each other.

So, if we do not know that we are not able to have good model when these models are to be put in and they are to be studied in a proper manner for that you need to have a specially trained persons who are expects in this simulation and modeling work. So, you need a properly trained person if he is not properly trained he can interpret the results in different way he can analyze the work or you can do the simulation in a different way and that may not that may be far away from the reality. So, that will be detrimental. So, you need a person who is trained many times you need the expect persons to interpret the results. So, the results may be difficult to interpret you need the person once you get the results the result will be in different terminologies.

So, you need the person who can interpret the results in a proper manner. So, for that also you need a knowledgeable person that simulation modeling and analysis can be time consuming and expensive as we know that is requires time to solve the set of equations you also require specially designed a specially you know oriented tools specially

developed tools that requires the resources requires money and also you need to have time to study these things. So, that is that is why there expense associated and most of the time it is expensive for only for the long run applications you should think of it or if you have that set up you can go for even smaller things.

But then the cost is always there; it is used in some cases when analytical solution is possible or even preferable. So, as we discussed that if you are using for those cases where the simulation analytical solution is even possible then there is no use of it there is no point in using for those cases when you can easily solve it you can easily get the analytical results. So, there is no point in going for that.

So, these are the disadvantages of the simulation process that is all about this lecture will go to next lecture.

Thank you.