Structural Reliability

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Lecture –69
Monte Carlo Simulations (Part - 01)

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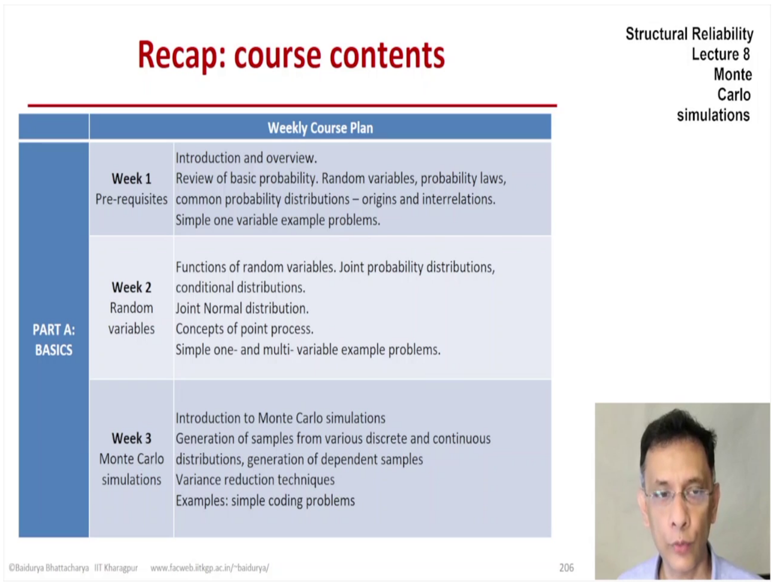

Monte Carlo simulations with this we come to the last topic of the part A basics of our course syllabus. Let us just review it for a second we have looked at the basics of probability, random variables, and distributions. We have looked at several univariate distributions and then moved on to joint probability distributions, conditional distributions, derived distributions, joint normal's and also convergence of a sequence of random variables.

We did borrow one lecture from this week the third week to complete the discussion on random variables and joint distributions.

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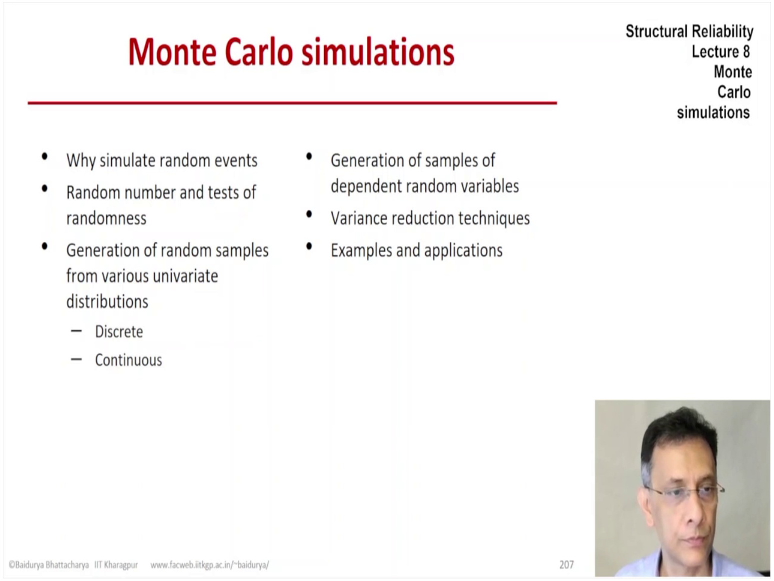

So, we have two lectures on Monte Carlo simulations and in these two lectures I would like to cover the basics of why we research simulations and Monte Carlo simulations in particular. How we get random numbers and how to test for randomness, how to generate random samples from various universe distributions both discrete and continuous and then generation of samples of dependent random variables and then a few words on variance reduction techniques in Monte Carlo simulation.

And as we have done all through we will solve examples and see applications during these lectures.

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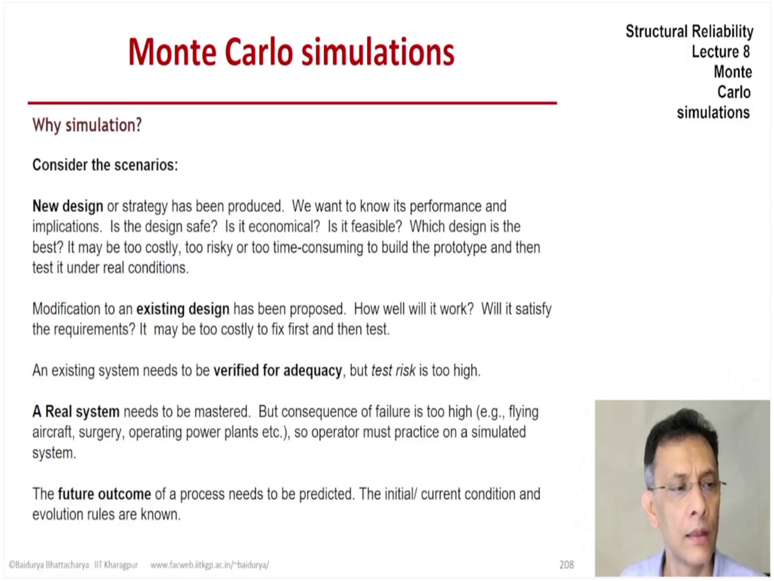

Now the first question is why why simulation let us consider a few scenarios. Let us say a new design has been proposed a new strategy has been proposed and we would like to know what the performance the implications of this new design is. What about its safety its economy its feasibility if there are more than one designs which one would be the best. And instead of building the prototype we probably we would like to we would like to restart the simulation first because of the cost and the time involved.

The next the next scenario is let us say some modifications to an existing system or structure has been proposed. We would like to know how well that modification would work would serve the purpose but it may be too costly or too risky to fix first and then test. The next situation could be that an existing system like an existing structure a bridge structure needs to be verified for adequacy for continued service.

But the test risk is too high which means the load at which we would know something useful could be. So, high that there is an appreciable failure probability associated with that that stress. So, that the test risk could be too high and we would like to do some simulation. The next scenario could be that a real system needs to be learned or mastered and there are quite a few examples you see and but to learn on the job it might be too risky. So, some sort of simulation would be preferred.

The last scenario is that there is a there is a process whose evolution law we know whose initial conditions we know and then we need we would like to know what happens how it evolves in the future what the end point is. So, we would need to simulate the process uh.

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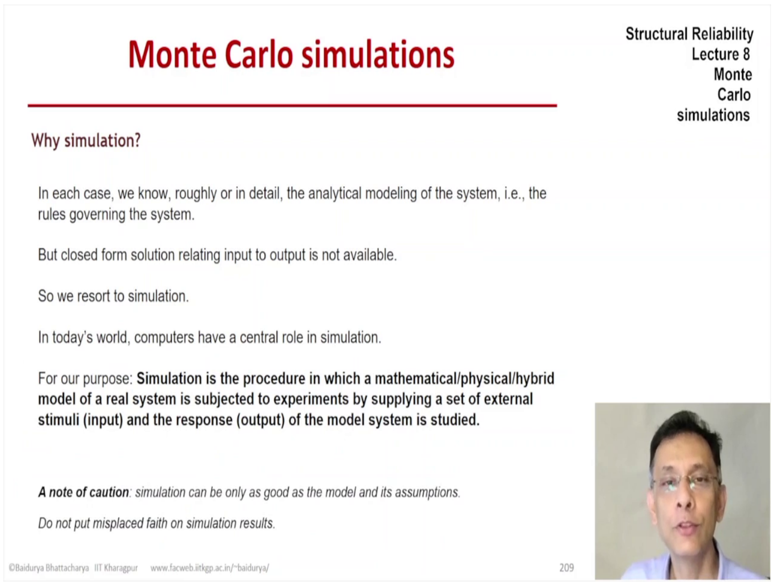

So, the common theme running through all of this is that we know the the rules governing the system but there is no closed term solution which relates the input with the output. And in today's world when we undertake simulation the computers have a central role in fact some simulations are performed entirely in the computer. For for our purpose therefore is it is the process of having creating a mathematical or a physical or a mathematical physical hybrid model of a real system and then subjecting it to experiments by supplying a set of inputs and then studying the output of the response of the model.

So, that is simulation. Now once more let us have a bouncing animation just to underline the fact that any simulation can only be as good as as the model and its assumption. So, one should be careful about putting misplaced faith on the on the simulation results.

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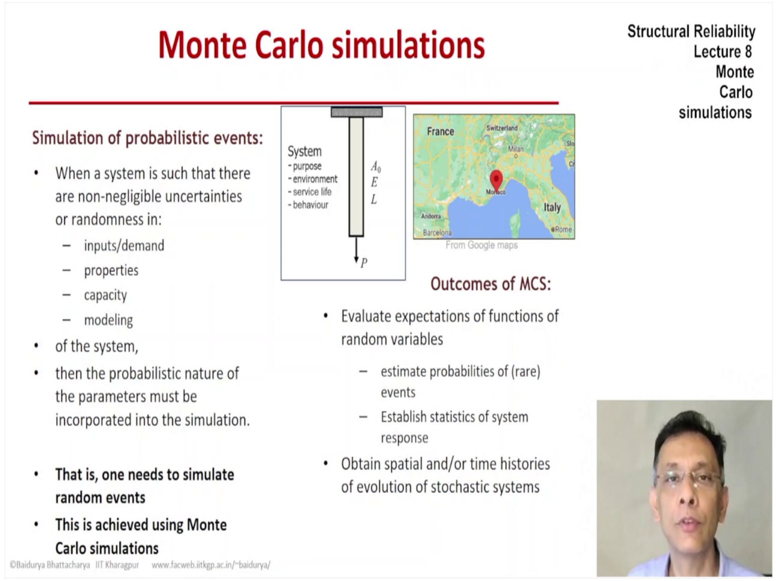

Now simulation of probabilistic events that is what this lecture is about. So, we have seen this this description of a concept system it might have uncertainties in one or more aspects namely inputs properties the capacity and the model of the system and if that is. So, then we need to when we simulate the system we need to incorporate the random aspects of the problem. So, we need to be able to simulate random events.

And that is what is achieved through Monte Carlo simulations and Monte Carlo is is a famous district in the principality of Monaco in the south of France and it is famous for its gambling casino. So, that is that is where the the name comes from now the outcomes of Monte Carlo simulation is basically it lets us evaluate the expectations of functions of random variables and in our case this often takes a form of estimation of rare probabilities like probabilities of failure.

Or the expectation could be used to establish statistics of a system response mean variance etc or just the evolution of of a random system which could be random both in space and or time and obviously this is relevant very relevant when closed some solutions are not available. So, Monte Carlo simulations is one of the best ways to tackle such problems.