

**Structural Reliability**  
**Prof. Baidurya Bhattacharya**  
**Department of Civil Engineering**  
**Indian Institute of Technology, Kharagpur**

**Lecture –01**  
**Introduction (Part - 01)**

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**Contents**

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Introduction

Weekly Course Plan	
PART A: BASICS	<b>Week 1</b> Pre-requisites Introduction and overview. Review of basic probability. Random variables, probability laws, common probability distributions – origins and interrelations. Simple one variable example problems.
	<b>Week 2</b> Random variables Functions of random variables. Joint probability distributions, conditional distributions. Joint Normal distribution. Concepts of stochastic process. Simple one- and multi- variable example problems.
	<b>Week 3</b> Monte Carlo simulations Introduction to Monte Carlo simulations Generation of samples from various discrete and continuous distributions, generation of dependent samples Variance reduction techniques Examples: simple coding problems

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Now let us look at the content of our course this will be a 12-week plan and I have split this course into four parts. Part A deals with the basics the first week will be an introduction and overview of some of the prerequisite items like a review of basic probability, random variables probability laws. The second week would be a little more advanced topics we will look at functions of random variables, joint distributions with emphasis on the joint normal distribution.

And some introduction to the concept of stochastic process because we are going to look at time dependent reliability during the course and while doing that we will solve simple problems, in the third week we will introduce Monte Carlo simulations which will be very helpful in solving many problems that cannot be solved in enclosed form. So, we will discuss generation of samples from various discrete and continuous distributions using pseudorandom number generators, generation of dependent variants which have a lot of practical utility.

We will discuss variance reduction techniques also because basic Monte Carlo simulation can be rather inefficient and we will practice some coding problems as well.

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Weekly Course Plan		
PART B: FUNDAMENTALS OF RELIABILITY	<b>Week 4</b> Basic definitions	Reliability – historical development, applications, different measures of reliability. Component vs. system reliability. Probabilistic formulation of civil engineering problems. Concepts of performance requirements and definitions of failure.
	<b>Week 5</b> Systems reliability	General formulation of system reliability problems - representation of failure, series and parallel systems, redundancy, fault trees, cut sets. How structural systems are different.
	<b>Week 6</b> Time to failure	Time to failure based formulation of reliability problems – components and systems. Reliability and hazard functions. Poisson processes.

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Part B will be the introduction of fundamental concepts of the subject of reliability. It is not a very old discipline it is about 70 years old. So, it came into its own during the and after the Second World War. So, we will discuss briefly the historical development and the growth of the subject while discussing that we will talk about how the civil engineering problems in reliability came up and got defined with and especially with regard to structures.

And then how structured reliability grew as a discipline. In week 5 we will look at systems how systems are modeled as a logical arrangement of components and how the system and how system failure is expressed in terms of component failures. And while doing that we will also point out how structural systems have some features that make them a bit different and sometimes difficult to solve.

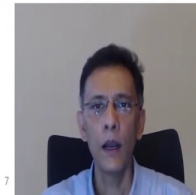
Week six will be at the end of Part B we will end it with a time to failure based approach to reliability.

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Weekly Course Plan		
PART C: RELIABILITY OF STRUCTURES	<b>Week 7</b> Capacity- demand-time	Capacity-demand-time formulation for structural components: limit states. Closed form solutions of simple limit state probabilities. Concept of first passage problem.
	<b>Week 8</b> Approximate solutions	Approximate solutions to component reliability problems: FORM, SORM, MCS Examples: Solution of benchmark problems
	<b>Week 9</b> Structural systems reliability	Formulation of and approximate solutions to structural system reliability problems. System reliability bounds
	<b>Week 10</b> Maintenance	Reliability-based maintenance. Perfect and imperfect repair – effect on reliability and hazard functions.

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Part C will delve deeply into structural reliability we will introduce the capacity demand time formulation which is common for structural systems and touch on the first passage concept. We will discuss at length the concept of limit states try to solve some problems in closed form and those that cannot be solved in closed form which is most problems. In week 8 we will discuss approximate solutions the very elegant FORM First Order Reliability Method and its extension to SORM Second Order Reliability Method and then Monte Carlo simulations.

In week 9 we will look at structural systems reliability and we will end Part C with reliability based maintenance.

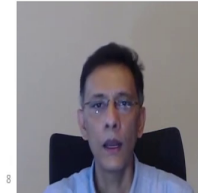
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Weekly Course Plan		
PART D: RELIABILITY BASED DESIGN	<b>Week 11</b> Design codes	Probability-based design and design codes – partial factors of safety. Examples.
	<b>Week 12</b> Reliability & society	Determination of target reliabilities. Concepts of robustness and resilience.

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In Part D we will first look at how probability based design codes are developed and in the last week we will venture into the interface of structural reliability and society. Try to answer the question how safe is safe enough and concepts that are becoming more and more relevant are those of robustness and resilience.

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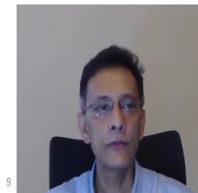
## Books

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### Recommended texts:

- Probability and Statistics for Engineering, Hines et al. , Wiley, 2008 (ISBN 9788126516469)
- *Probability Concepts in Engineering*, A. H-S Ang and W. H. Tang, Wiley, 2006 (ISBN: 978-0-471-72064-5)
- *Structural Reliability Analysis and Prediction*, RE Melchers and AT Beck, Wiley 2018 (ISBN 9781119266105)
- More suggested references at the end of modules/bottom of slides

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In terms of textbooks and recommended books that I have listed 3 here the book by Heinz et al is a very nice Basic Prop Stats book for engineers. The book by Ang and Tang probability concepts in engineering that is an excellent book and as is Structural Liability Analysis and Prediction by

Malchest and Beck but there will be obviously more books more suggested references that I will list at the end of modules or at the bottom of slides including articles and papers.

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## Course format

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- Four parts (equivalent contact hours)
  - A: Basics (9)
  - B: Fundamentals of reliability (9)
  - C: Reliability of structures (12)
  - D: Reliability based design (6)
- Lecture mode
  - Powerpoint slides
  - Voiceover and inset
  - Some slides may be dense ☹
- Modules
  - Approx 5 modules per “hour”
  - 10-15 modules per part
- Solved examples
  - Within each module
  - At the end of each module
- Homeworks
  - At the end of each week
  - Answers listed separately
- Tests
  - At the end of each part (optional)
  - At the end of the course

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The course format is as I said there will be 4 parts in terms of equivalent contact hours Part A will have 9, Part B which is fundamentals of reliability we will have another 9 and then Part C which is reliability of structures that would have 12 equivalent contact hours and then Part D which is reliability based design would have another 6. The lecture mode will be like this Power Point slides with a voiceover and an inset picture and on the top right.

You will see which week we are covering and what the main subject of that is. So, it will help you locate the lectures. Some slides this course is a parts of it are quite mathematical in nature. So, some slides will be a bit dense and I am sorry about that but please pause the lecture and take notes if you would like for those slides. There will be modules um roughly about 5e per hour of lecture and each of these parts would be something like 10 or 15 or a few more modules in these parts.

They will be solved examples I will put a lot of emphasis on that during each module and at the end of each module I will also try to work through some examples. There will be homeworks at the end of each week and answers should be listed separately and tests there will be optional tests

the end of each part and a required test at the end of the course.