

Course title:

Probability calculus and elements of stochastic modelling

Duration [number of hours]: **24**

PhD Program [MERC/MPHS/SPACE]: **MERC**

Name and Contact details of unit organizer(s):

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Course Description [max 150 words]:

The objective of the course is to provide the students with the fundamentals of probability calculus and (few) elements of stochastic modelling, as well as with their use in the engineering field and science. Starting from the basics of probability theory, the course will cover elements of stochastic modelling such as models of random variables, basics of Markov chains, and Poisson processes. The lectures will be much more focused on the application aspects. For this reason, the students are required to form small teams of 2/3 people and work on assignments that will be given every week. The solutions to the assignments will be discussed during the lectures. The assignments will also require the students to work on MatLab (or R, depending on their preference). On successful completion of the course, the students are expected to obtain the necessary knowledge in stochastic and probabilistic models to apply them and develop new methods in the applicative domains of their interest. The course consists of 12 lessons of 2 hours each.

Syllabus [itemized list of course topics]:

- Elements of Set Theory; definitions of probability, and some practical calculation criteria; basics combinatorial calculus.
- Independence; Conditional probability; Total probability law; Bayes theorem; Conditional Independence
- Random variables; Cumulative Probability Distributions and Related properties; Models of Random Variables
- Expectation; Variance; Covariance; Higher Order Moments; Convergence of Random Variables;
- Basics of Conditional Expectations; Definition of Stochastic Process; Markov Chains and their elementary properties;
- Counting Processes; Time-Homogeneous Poisson Process; Time-inhomogeneous Poisson Process;

Assessment [form of assessment, e.g., final written/oral exam, solutions of problems during the course, final project to be handed-in, etc.]:

Throughout the duration of the course, students will engage in a series of practical exercises designed to reinforce the concepts covered during class sessions. As the course culminates, each student, either individually or as part of a collaborative group, will undertake a comprehensive project. This project will involve the preparation of oral presentation followed by a written report encompassing the realms of probability theory and stochastic processes, showcasing their application in personal research or in challenges selected in consultation with instructors and tailored to match the students' unique academic backgrounds.

Suggested reading and online resources:

Notes and slides will be provided during the course.

Suggested books:

1. S. Ross, Stochastic Processes, 2nd ed., 1983, John Wiley and Sons.
2. S. Ross, Introduction to probability models, 2014, Academic Press.
3. A Papoulis, S. U. Pillai, Probability, Random Variables and Stochastic Process, 4th ed., 2002, McGraw Hill

Further References will be possibly given during the lectures.