Professor	Michele Bufalo
Master degree	"Statistics and Methods for Economics and Finance"
Course	**Applied Probability and Stochastic Processes**
Academic year	2024/2025
Period	II semester
CFU	6
Scientific sector	MAT/06

Requieremements:

Basic knowledges of mathematical analysis, integral calculus and probability.

Targets to be achieved:

This course is an introduction to stochastic processes and probabilistic models often used to study real phenomena. From a mathematical point of view, it will be used a stepwise approach, in order to facilitate the students who have less knowledge of mathematics.

Program:

1) **Random variables**
   Basic knowledge of probability calculus, conditioned probability, stochastic independency, Bayes theorem, prior probability, functions of random variables. Discrete random variables (Bernoulli, binomial, geometric, Poisson and negative binomial distribution). Continuous random variables (uniform, normal, lognormal, exponential, Gamma, beta and t-student distribution). Exercises.
2) **Multivariate distributions:**
   Random arrays, marginal distributions, operations between random variables and their distributions, function of random arrays. Exercises.
3) **Conditioned expectation:**
   Definition of expected value, variance, covariance matrix, correlation, and their properties. Moments of random variables, conditioned moments. Exercises.
4) **Generating functions:**
   Moment generating functions and related properties, convergence of sequence of random variables, law of averages, central limit theorem, Monte Carlo methods. Exercises.
5) **Introduction to stochastic processes:**
   Random walk, Markov chains, Chapman-Kolmogorov equations, stationarity and states classification, limit distributions, stopping times, martingale and related properties. Exercises.
6) **Poisson processes:**
   Alternative definitions of Poisson process, sum of Poisson processes, thinning of Poisson process. Exercises.
7) **Brownian motion:**
   Alternative definitions of Brownian motion, properties of Brownian motion, first and second order variation of a Brownian motion, reflection principle, first passage time, geometric Brownian motion and related properties. Exercises.

8) **Financial applications:**
Derivative instruments, arbitrage, binomial model, Ito-Doeblin formula, Girsanov theorem, Black-Scholes model, numerical aspects. Exercises.

Bibliography:

1. Sheldon M. Ross, Introduction to Probability models (9th edition), Elsevier, USA, 2007.
2. S. Shreve, *Stochastic Calculus for Finance II: Continuous-Time Models*, Springer-Verlag, New York, 2004.
3. Professor lecture notes.

Didactic organizazion:

• Intermediate exams: Yes

• Esxercising: Yes

• Seminars: Yes

• Laboratories: No

• Project work: No

Examination test : written test.