# Probability Theory and Stochastic Processes (COMP0045)

## Description

**Aims:**
A systematic introduction to probability theory and stochastic processes as well as some of their applications, with worked-out exercises and without stressing too much the measure-theoretical aspects and other mathematical formalisms. The main target is students with an undergraduate degree in physics, engineering, computer science and the like, who have a good basis in calculus and linear algebra and may have already come into contact with aspects of probability and statistics for ad hoc applications like data analysis, transport equations, and quantum mechanics, but have not attended yet a dedicated course on this subject. The material unfolds with references to its historical development and early applications in gambling, physics and engineering, ending with current-day applications in finance.

**Learning outcomes:**
Familiarity with probability theory, stochastic processes in discrete and continuous time, stochastic calculus, and basic applications in physics, engineering and finance.

**Content:**
Elementary probability:
- Probability space, Kolmogorov’s axioms;
- Joint and conditional probability, independent events;
- Total probability theorem, Bayes’ theorem;

Random variables:
- Random variables; probability distribution and density functions;
- Multivariate, marginal and conditional distribution and density functions;
- Transformation of random variables, sum, product;
- Mean, variance, covariance, correlation, moments;
- Chebyshev inequality, law of large numbers;
- Median, mode, skewness, kurtosis, entropy, mutual information;
- Fourier transform, characteristic function, moment- and

## Key information

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<th><strong>Year</strong></th>
<th>2019/20</th>
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<tr>
<td><strong>Credit value</strong></td>
<td>15 (150 study hours)</td>
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<tr>
<td><strong>Delivery</strong></td>
<td>PGT L7, Campus-based</td>
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<td><strong>Reading List</strong></td>
<td>View on UCL website</td>
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<tr>
<td><strong>Tutor</strong></td>
<td>Dr Guido Germano</td>
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<td><strong>Term</strong></td>
<td>Term 1</td>
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<td><strong>Timetable</strong></td>
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## Assessment

- Written examination (main exam period): 60%
- Written examination (departmentally managed): 40%

## Find out more

For more information about the department, programmes, relevant open days and to browse other modules, visit [ucl.ac.uk](http://ucl.ac.uk).

**Disclaimer:** All information correct as of August 2019. Please note that aspects of the module may be subject to change. UCL will make best efforts to inform applicants of major changes.
cumulant-generating functions;
-Central limit theorem, Lévy stable distributions;
-Gaussian, Poisson and exponential distributions;

Random functions or stochastic processes:
-Definitions, auto- and cross-covariance/correlation, stationarity, Wiener-Khinchin theorem;
-Ergodicity, classification with respect to memory, martingales and semimartingales;
-Markov and semi-Markov processes, Chapman-Kolmogorov equation;
-Forward ad backward time-evolution equations;
-Jump processes: the master equation;
-Diffusion processes: the Fokker-Planck equation;
-Deterministic processes: the Liouville equation;
-Random telegraph signal, random walk, hidden Markov model;
-Poisson, compound Poisson and renewal processes, continuous-time random walk;
-Wiener and Ornstein-Uhlenbeck processes;
-Langevin equation, stochastic differential equations, Feynman-Kac theorem;
-Laplace transform, solution of the standard diffusion equation in Fourier-Laplace space;
-Stochastic integral: Ito and Stratonovich, Ito's formula;
-Geometric Brownian motion, Black-Scholes equation;
-Feller square-root, Rayleigh and Bessel processes;

Requisites:
In order to be eligible to select this module, a student must be registered on a programme for which it is a formally-approved option or elective choice AND must have knowledge of calculus and linear algebra.

Please see the maths part of "Introduction to Mathematics and Programming for Finance".