

# MATH0102 Applied Stochastic Methods

<i>Year:</i>	2021–2022
<i>Code:</i>	MATH0102
<i>Level:</i>	7(UG)/7(PG)
<i>Normal student group(s):</i>	UG Year 3 and 4 Mathematics degrees PG MSc Mathematical Modelling
<i>Value:</i>	15 credits (= 7.5 ECTS credits)
<i>Term:</i>	2
<i>Assessment:</i>	90% examination, 10% coursework
<i>Normal UG Pre-requisites:</i>	MATH0010 and MATH0011 <i>Useful but not required:</i> MATH0056, MATH0031, MATH0065, MATH0057
<i>Lecturer:</i>	Prof G Esler

## *Course Description and Objectives*

This module aims to introduce the main analytical techniques and concepts used in the application of stochastic differential equation models to physical, chemical and biological systems.

## *Recommended Texts*

- (i) C. W. Gardiner, *Stochastic Methods A Handbook for the Natural and Social Sciences*, Springer, 2009.
- (ii) H. Risken, *The Fokker-Planck Equation; Methods of Solution and Applications*, Springer, 1996.
- (iii) N. Van Kampen, *Stochastic Processes in Physics and Chemistry*, North Holland, 2007.
- (iv) B. Øskandal, *Stochastic Differential Equations. An introduction with applications.*, Springer, 2007.
- (v) G. Pavliotis, *Stochastic Processes and Applications: Diffusion Processes, the Fokker-Planck and Langevin Equations*. Springer, 2014.

## *Detailed Syllabus*

- Introduction to applied stochastic methods: Brownian motion and stochastic differential equations. Fokker-Planck and backward Kolmogorov equation. First passage time and exit problems. Feynman-Kac formula and stochastic representations of general linear parabolic and elliptic PDE problems.
- Asymptotic methods: Langevin equation. Adiabatic elimination of fast variables (e.g. Kramers to Smoluchowski equation). Hamiltonian systems perturbed by weak noise. Brownian motion in a potential well, Kramer’s method for calculating the escape time. Arrhenius formula. Large-deviation scalings.
- Linear response theory: Linear response problems for SDEs, susceptibility. Fluctuation-dissipation theorem. Green-Kubo formulae.
- Special topics. One or more from:

- (a) Freidlin-Wentzel theory of large-deviations. Rare events and instantons.
- (b) Stochastic filtering problems.
- (c) Stochastic control theory.
- (d) Jump processes including Lévy flights.

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