12998-344 (16) Simulation and Inference in Stochastic Systems (3L, 3P)

2019

Course summary:

Simulation and numerical inference of key stochastic systems such as random walks. Information-based probability and core probabilistic concepts, deduction and induction, Bayes' Theorem. Characterisation and calculation with distributions and data, transformations, generating functions, connections to statistical physics.

Method of assessment: Flexible assessment

Prerequisite module:

- *Mathematics 214 or Applied Mathematics 214*

Language policy:

Afrikaans and English in the same class groups:
During each lecture, all information is conveyed at least in English. Summaries and/or explanation of the core concepts will also be given in Afrikaans. Questions in Afrikaans and English will, at the least be answered in the language of the question. Students will be supported in Afrikaans and English during a combination of appropriate facilitated learning opportunities.

Module relevance in programme:

Simulation and inference play a key role in understanding systems and data in physics an in general. The underlying statistical concepts and Monte Carlo algorithms are used extensively in numerical work, including high-dimensional integrals, complicated systems of interacting particles, data compression and analysis and many others. A Monte Carlo method is not only a numerical solution tool, but a means of performing numerical experiments from which much physics of many-particle systems can be learned (such as about phase transitions). Here we introduce the necessary computational and statistical tools and concepts to write such codes and to analyse the data they produce. The simulations will be of benefit to students following honours statistical physics (Physics 721), complementing the analytical approaches there. The third-year module, Physics 314, introduces some of the ideas relevant to this module, but also exposes students to the nature of the physical systems that we would want to study using computer simulations. This module is also relevant to all data science related environments and programmes.

Outcomes of course:

- Insight and competency in the concepts and methods of stochastic systems.
- Insight and competency in the concepts and methods of inference.
- Appreciation of the importance and role played by random number generators and their pitfalls.
- Working knowledge of Monte Carlo simulation and its applications in physics and beyond.
- Familiarity with the operating system currently used in the module and a numerical computer language.
- The ability to write and debug computer simulations.
- Developed skills in compiling and maintaining a record of own work and thoughts.

Lecturer:

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Mentor:

The Department of Physics has appointed a staff member as mentor for each year of its physics programme to be available to students for consultation. Students should feel free to discuss general issues related to the physics programme or specific modules in the programme with the relevant mentor, in addition to usual consultations with their individual lecturers of modules.

The mentor for honours programme and its modules is Dr P Neethling pietern@sun.ac.za

Course content:

Introduction to deduction and induction as the basis of stochastic system simulation and general inference. Introduction to key probabilistic concepts, basic probability theory. Bayes' Theorem, parameter inference and model comparison. Computer simulation of key stochastic systems and analysis of simulated and real data.

Tutorials:

One afternoon per week. Please see time tables

Study material:

Lecture notes

Assessment:

Methods of Assessment
Continuous Assessment, based on

- evaluation of students' workbooks and computer programs.
- homework assignments and tests based on the analytical work covered.

Venue and time of assessment opportunities
At least four evaluations, spread evenly throughout the semester.

Availability of marks:
Turnaround time is typically one week. Feedback is given in terms of written and oral commentary as soon as possible.

Calculation of class mark:
40-60 percent of mark: numerical work.
40-60 percent of mark: analytical work covered.