Faculty of Health, Science and Technology
Mathematics

Syllabus

Data-driven inference for stochastic dynamics

Course Code:	MAAD35
Course Title:	Data-driven inference for stochastic dynamics *Datadriven inferens för stokastisk dynamik*
Credits:	7.5
Degree Level:	Master's level
Progressive Specialisation:	Second cycle, has only first-cycle course/s as entry requirements (A1N)

Major Field of Study:
MAA (Mathematics)

Course Approval
The syllabus was approved by the Faculty of Health, Science and Technology 2024-09-05, and is valid from the Spring semester 2025 at Karlstad University.

Prerequisites
90 ECTS credits in Mathematics, including 30 ECTS credits at the G2F level, and upper secondary level English 6, or equivalent

Learning Outcomes
Upon completion of the course, students should be able to:
- give an account of key concepts in stochastic dynamics, estimation for SDEs and Markov chains, and Bayesian filtering,
- use and implement algorithms and approximation methods relevant to the course (such as Euler-Maruyama, Milstein, MCMC, and Metropolis-Hastings),
- simulate stochastic processes,
- use data to estimate parameters,
- identify situations suitable for stochastic approaches and reasoning,
- select appropriate models based on industrial data, and

- propose suitable decisions based on industrial data.

Content
Module 1: Stochastic Dynamics
The module treats the basic theory and practice of stochastic dynamics. Theoretical key concepts include: stochastic integral, Itô formula, stochastic differential equations (SDE), existence and uniqueness of strong solutions, martingales, Markov property. Practical implementation (in R or Python) of Euler-Maruyama and Milstein methods for numerical solution of SDEs.

Module 2: Estimation for SDEs and Markov Chains
The module covers the theory of maximum likelihood and quasi-maximum likelihood estimations as well as Bayesian inference. Practical implementation (in R or Python) of Markov Chain Monte Carlo methods and the Metropolis-Hastings algorithm and its variants.

Module 3: Bayesian Filtering
The module treats the theory and practice of filtering. Theoretical key concepts include Kalman filters, extended Kalman filters, particle filters, and nonlinear filtering. Practical implementation (in R or Python) of filters with various datasets and models.

Reading List
See separate document.

Examination
Assessment is based on written and oral presentations of an individual project.

If students have a decision from Karlstad University entitling them to Targeted Study Support due to a documented disability, the examiner has the right to give such students an adapted examination or to examine them in a different manner.

Grades
One of the grades Distinction (VG), Pass (G), or Fail (U) is awarded in the examination of the course.

Quality Assurance
Follow-up relating to learning conditions and goal-fulfilment takes place both during and upon completion of the course in order to ensure continuous improvement. Course evaluation is partly based on student views and experiences obtained in accordance with current regulations and partly on other data and documentation. Students will be informed of the result of the evaluation and of any measures to be taken.

Course Certificate
A course certificate will be provided upon request.

Additional information
The local regulations for studies at the Bachelor and Master levels at Karlstad University stipulate the obligations and rights of students and staff.