Math 106: Stochastic processes and uncertainty quantification

ORC syllabus

Stochastic modeling and uncertainty quantification are central to the study of many problems in physics, engineering, finance, evolutionary biology and medicine. This course introduces theoretical concepts in probability theory and key methods for stochastic processes and uncertainty quantification.

The topics of this course will alternate between odd and even years. In even years, topics will include basic concepts of probability, generating functions, Markov chains, random walks, Markov and Non-Markov processes, and diffusion theory. Applications to the natural sciences will be made. In odd years, the course will focus on data-driven methods, with applications in data science, machine learning, and numerical weather prediction. Topics will include statistical inference, random sampling, stochastic processes, polynomial chaos, and data assimilation. The course will also introduce standard computation libraries in MATLAB and Python.

Even years:

References.


Stochastic processes with applications

1. Basic concepts of probability and generating function approach

2. Applications of generating function approach

3. Markov chains

4. Random walks

5. Continuous time Markov processes

6. Diffusion theory

7. Birth and death processes
Odd years:

References.

1. K. Law, A. Stuart, K. Zygalakis, *Data Assimilation*.


Stochastic processes and uncertainty quantification.

1. **Introduction**: Uncertainty and data-driven quantification, review of probability, information theory.

2. **Statistical Inference**: Parametric inference, nonparametric inference, Bayesian inference.

3. **Random Sampling**: Monte Carlo, importance sampling, Markov Chain Monte Carlo.

4. **Special Topics**: Hilbert space, smoothing using orthogonal functions.


7. **Data Assimilation**: Kalman filter, approximate Gaussian filters.

8. **Advanced Data Assimilation**: Ensemble square root filter, particle filter, localization and inflation.

9. **Challenges of High-dimensional Spaces**: Sampling in high-dimensional spaces, data assimilation in high-dimensional spaces.