MATH-616 **Numerical methods for random PDEs and uncertainty**

Invited lecturers (see below), Nobile Fabio, Vanzan Tommaso

| Cursus | Sem. | Type |
|---|---|---|
| Mathematics | | Opt. |

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|---|---|
| Language of teaching | English |
| Credits | 3 |
| Session | |
| Exam | Oral presentation |
| Workload | 90h |
| **Hours** | **52** |
| Courses | 24 |
| Project | 28 |
| **Number of positions** | **20** |

## Frequency

Only this year

## Remark

Fall semester

## Summary

The course focuses on mathematical models based on PDEs with random parameters, and presents numerical techniques for forward uncertainty propagation, inverse uncertainty analysis in a Bayesian framework and optimal control under uncertainty.

## Content

When building a mathematical model to describe the behavior of a physical system, one has often to face a certain level of uncertainty in the proper characterization of the model parameters and input data. The increasing computer power and the need for reliable predictions have pushed researchers to include uncertainty models, often in a probabilistic setting, for the input parameters of otherwise deterministic mathematical models.
The course will focus on mathematical models based on Partial Differential Equations with random parameters, and presents numerical techniques for forward uncertainty propagation, including Monte Carlo, Multilevel Monte Carlo, polynomial chaos and rational approximation techniques; inverse uncertainty analysis in a Bayesian framework and Markov Chain Monte Carlo methods; optimal control under uncertainty.
Particular attention is devoted to addressing the case of a large (even infinite) number of input parameters thus leasing to High Dimensional Approximation problems and presenting recent results such as the "Cohen-Devore" theory on polynomial approximation in infinite dimensions.

## Keywords

Random PDEs, Forward Uncertainty Propagation, Bayesian Inverse Problems, Optimization Under uncertainty; Monte Carlo, Multi Level Monte Carlo, Polynomial Chaos, Sparse grids, rational approximations

## Learning Prerequisites

### Required courses

The students are expected to have basic knowledge on probability theory, approximation theory, Partial Differential Equations, numerical analysis in general and finite element analysis in particular.

## Resources

### Bibliography

A. Cohen, R. DeVore â##Approximation of high-dimensional parametric PDEsâ##. Acta Numer. 24 (2015).
A. Stuart, â##Inverse problems: a Bayesian perspectiveâ##. Acta Numer, 19 (2010).
D. Kouri, A. Shapiro, â##Optimization of PDEs with uncertain inputs.â## in Frontiers in PDE-constrained optimization, 41â##81, IMA Vol. Mat. Appl., 163, Springer, 2018.

### Ressources en bibliothèque

- Approximation of high-dimensional parametric / Cohen & DeVore
- Inverse problems: a Bayesian perspective / Stuart
- Optimization of PDEs with uncertain inputs / Kouri & Shapiro

### Moodle Link

- https://go.epfl.ch/MATH-616