

MATH-414

**Stochastic simulation**

Nobile Fabio

Cursus	Sem.	Type
Computational science and Engineering	MA1, MA3	Opt.
Ing.-math	MA1, MA3	Opt.
Mathématicien	MA1, MA3	Opt.
Statistics	MA1, MA3	Opt.

Language of teaching	English
Credits	5
Session	Winter
Semester	Fall
Exam	Oral
Workload	150h
Weeks	14
<b>Hours</b>	<b>4 weekly</b>
Lecture	2 weekly
Exercises	2 weekly
<b>Number of positions</b>	

**Summary**

The student who follows this course will get acquainted with computational tools used to analyze systems with uncertainty arising in engineering, physics, chemistry, and economics. Focus will be on sampling methods as Monte Carlo, quasi Monte Carlo, Markov Chain Monte Carlo.

**Content**

- Random variable generation
- Simulation of random processes
- Simulation of Gaussian random fields.
- Monte Carlo method; output analysis
- Variance reduction techniques (antithetic variables, control variables, importance sampling, stratification)
- Rare events simulations
- Quasi Monte Carlo methods
- Markov Chain Monte Carlo methods (Metropolis-Hasting, Gibbs sampler)

Other topics that may be addressed if time allows:

- Stochastic optimization (stochastic approximation, simulated annealing)
- Estimation of derivatives
- Filtering problem; particle filters

**Keywords**

Simulation of random variables and processes; Monte Carlo; Quasi Monte Carlo; Markov Chain Monte Carlo

**Learning Prerequisites****Required courses**

basic Probability and Statistics; Numerical Analysis;

**Recommended courses**

Applied Stochastic Processes (or equivalent)

**Important concepts to start the course**

Knowledge of basic courses in mathematics, probability, statistics and numerical analysis. Some experience of computer programming is assumed.

**Learning Outcomes**

By the end of the course, the student must be able to:

- Analyze the convergence of sampling algorithms
- Implement sampling methods for different stochastic processes
- Compare the efficiency of different sampling algorithms
- Choose appropriate sampling algorithms
- Propose efficient sampling methods for different stochastic problems

### Transversal skills

- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Demonstrate a capacity for creativity.
- Demonstrate the capacity for critical thinking
- Write a scientific or technical report.

### Teaching methods

course ex-cathedra + exercise sessions and computer labs

### Expected student activities

Active participation to the course and practical sessions

### Assessment methods

Project + oral exam (presentation of the project + questions on the course)

Dans le cas de l'art. 3 al. 5 du Règlement de section, l'enseignant décide de la forme de l'examen qu'il communique aux étudiants concernés.

### Supervision

Office hours	Yes
Assistants	Yes
Forum	No

### Resources

#### Virtual desktop infrastructure (VDI)

No

### Bibliography

S. Asmussen and P. Glynn, Stochastic Simulation: Algorithms and Analysis. Springer-Verlag, 2007

D. Kroese, T. Taimre and Z. Botev, Handbook of Monte Carlo Methods, Wiley 2011

G. Robert and G. Casella, Monte Carlo statistical methods, Springer 2004

### Ressources en bibliothèque

- [Stochastic simulation Asmussen](#)
- [Handbook of Monte Carlo Methods](#)
- [Monte Carlo statistical methods](#)

### Notes/Handbook

lecture notes available on the webpage

**Moodle Link**

- <https://go.epfl.ch/MATH-414>