**EPFL**

COM-516     **Markov chains and algorithmic applications**

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| Cursus | Sem. | Type |
|---|---|---|
| Cybersecurity | MA1, MA3 | Opt. |
| Data Science | MA1, MA3 | Opt. |
| Génie électrique | | Opt. |
| Informatique | MA1, MA3 | Opt. |
| SC master EPFL | MA1, MA3 | Opt. |

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|---|---|
| Language | English |
| Credits | 4 |
| Session | Winter |
| Semester | Fall |
| Exam | Written |
| Workload | 120h |
| Weeks | 14 |
| **Hours** | **4 weekly** |
| Lecture | 2 weekly |
| Exercises | 2 weekly |
| **Number of positions** | |

**Summary**

The study of random walks finds many applications in computer science and communications. The goal of the course is to get familiar with the theory of random walks, and to get an overview of some applications of this theory to problems of interest in communications, computer and network science.

**Content**

Part 1: Markov chains (~6 weeks):
- basic properties: irreducibility, periodicity, recurrence/transience, stationary and limiting distributions,
- ergodic theorem: coupling method
- detailed balance
- convergence rate to the equilibrium, spectral gap, mixing times
- cutoff phenomenon
Part 2: Sampling (~6 weeks)
- classical methods, importance and rejection sampling
- Markov Chain Monte Carlo methods, Metropolis-Hastings algorithm, Glauber dynamics, Gibbs sampling
- applications: function minimization, coloring problem, satisfiability problems, Ising models
- coupling from the past and exact simulation

**Keywords**

random walks, stationarity, ergodic, convergence, spectral gap, mixing time, sampling, Markov chain Monte Carlo, coupling from the past

**Learning Prerequisites**

**Required courses**

Basic probability course
Basic linear algebra and calculus courses

**Recommended courses**

Stochastic Models for Communications (COM-300)

**Important concepts to start the course**

Good knowledge of probability and analysis.
Having been exposed to the theory of Markov chains.

**Learning Outcomes**

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

- Analyze the behaviour of a random walk
- Assess / Evaluate the performance of an algorithm on a graph
- Implement efficiently various sampling methods


**Teaching methods**

ex-cathedra course


**Expected student activities**

active participation to exercise sessions and implementation of a sampling algorithm


**Assessment methods**

midterm (20%), mini-project (20%), final exam (60%)


**Resources**

**Bibliography**

Various references will be given to the students during the course, according to the topics discussed in class.


**Ressources en bibliothèque**

- Probability and random processes / Grimmett


**Notes/Handbook**

Lecture notes will be provided


**Websites**

- https://moodle.epfl.ch/course/view.php?id=15016


**Prerequisite for**

This course is not so to speak a prerequisite for other courses, but could complement well the course COM-512 on Networks out of control, as well as other courses in statistics.