

PHYS-645

**Physics of random and disordered systems**

Müller Markus

| Cursus  | Sem. | Type |
|---------|------|------|
| Physics |      | Opt. |

|                            |           |
|----------------------------|-----------|
| Language of teaching       | English   |
| Credits                    | 3         |
| Session                    |           |
| Exam                       | Oral      |
| Workload                   | 90h       |
| <b>Hours</b>               | <b>42</b> |
| Lecture                    | 42        |
| <b>Number of positions</b> |           |

**Frequency**

Every year

**Remark**

Next time: Postponed to Fall 2024

**Summary**

Introduction to the physics of random processes and disordered systems, providing an overview over phenomena, concepts and theoretical approaches. Topics include: Random walks; Roughening/pinning; Localization; Random matrix theory; Spin glasses; Disorder and critical phenomena

**Content**

This course provides an overview of salient phenomena, concepts and theoretical approaches to a wide variety of random processes and disordered systems, with an emphasis on intuition and physical insight.

## 1) Random processes:

- Random walks, diffusion
- Directed polymers in random media,
- Roughening and pinning of interfaces

## 2) Localization of particles and waves:

- Weak and strong (Anderson) localization
- Many-body localization: concepts, ideas, phenomenology
- Strong randomness approach

## 3) Random matrix theory:

- Classification of random matrix models, matrix ensembles.
- Distribution of eigenvalues, semicircle law, resolvent method.
- Level spacing statistics: Wigner's surmise, Poisson vs Wigner-Dyson,
- (Coulomb gas method)

## 4) Spin glasses:

- Concepts, phenomenology, order parameters; random energy model, trap model
- Theory: droplets, replicas
- Mean field theory:

replica symmetry and its breaking;  
cavity approach / message passing

5) (depending on time) The role of disorder in critical phenomena:

- Imry-Ma argument
- Harris criterion

### Keywords

disordered systems, random processes, random matrix theory, localization, spin glasses

### Learning Prerequisites

#### Required courses

Statistical physics I and II

#### Recommended courses

Quantum mechanics

### Learning Outcomes

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

- Have an overview over and physical understanding of the phenomena in disordered systems
- Know and explain the concepts, basic techniques and approaches to the main topics

### Resources

#### Bibliography

There will be a Moodle link for this course

#### Moodle Link

- <https://go.epfl.ch/PHYS-645>