MICRO-470 **Scaling laws in micro & nanosystems**

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| Cursus | Sem. | Type |
|---|---|---|
| Electrical and Electronical Engineering | MA1, MA3 | Opt. |
| Microtechnics | MA1, MA3 | Opt. |

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| Language of teaching | English |
| Credits | 2 |
| Session | Winter |
| Semester | Fall |
| Exam | Oral |
| Workload | 60h |
| Weeks | 14 |
| **Hours** | **2 weekly** |
| Lecture | 2 weekly |
| **Number of positions** | |

## Summary

This class adresses scaling laws in MEMS/NEMS. The dominant physical effects and scaling effects when downsizing sensors and actuators in microsystems are discussed, across a broad range of actuation principles.

## Content

The following topics are introduced and **analytical modeling** and **scaling laws** are discussed.
- **Introduction to scaling laws**: Scaling of classical mechanical systems, scaling of classical electrical systems, breakdown in scaling, quantum breakdown
-**Thermal effects:** conduction, convection, dynamics, breakdown, thermal micro-actuators.
- **Mechanical scaling**: Mass-spring model, mechanical noise, squeeze film effects. Lumped element
- **Electrical scaling**: electrostatic micro-actuators, electrostatic breakdown, tunnel sensors, coils and inductors, electromagnetic micro-actuators, magnetic beads.
**- Microfluidics & Nanofluidics**: Liquid flow, gas flow, mixing, surface tension, chromatography.
- **Electrokinetics**: Dielectriphoresis and electrophresis, EHD and MHD pumps, electrowetting.

## Keywords

Micro-Electro-Mechanical Systems (MEMS)
Nano-Electro-Mechanical Systems (NEMS)
Scaling
Lumped Element Model (LEM)
Electrostatics
Electromagnetic
Microfluidic

## Learning Prerequisites

### Important concepts to start the course

Students MUST have strong background in microfabrication: we assume students undestand how MEMS are fabricated
solid grasp of electromagnetics, electrostatics, fluid dynamics
knowledge of analysis of electrical circuits

## Learning Outcomes

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

- Analyze MEMS / NEMS design
- Predict performance of MEMS

- Exploit scaling laws in MEMS
- Compare different MEMS principles and designs
- Choose appropriate designs
- Estimate performance of MEMS

## Transversal skills

- Plan and carry out activities in a way which makes optimal use of available time and other resources.
- Respect the rules of the institution in which you are working.
- Demonstrate the capacity for critical thinking
- Use a work methodology appropriate to the task.

## Assessment methods

oral exam

## Resources

### Moodle Link

- https://go.epfl.ch/MICRO-470