

MICRO-470

Scaling laws in micro & nanosystems

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Cursus	Sem.	Type
Microtechnics	MA1, MA3	Opt.

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

Summary

This class addresses 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:** Dielectrophoresis and electrophoresis, 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 understand 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>