ME-469

Nano-scale heat transfer

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Cursus	Sem.	Type
Mechanical engineering minor	E	Opt.
Mechanical engineering	MA2, MA4	Opt.
Microtechnics	MA2, MA4	Opt.

Language of teaching	English
Credits	4
Withdrawal	Unauthorized
Session	Summer
Semester	Spring
Exam	During the semester
Workload	120h
Weeks	14
Hours	**4 weekly**
Courses	2 weekly
Exercises	1 weekly
Project	1 weekly
Number of positions	

Il n'est pas autorisé de se retirer de cette matière après le délai d'inscription.

Summary

In this course we study heat transfer (and energy conversion) from a microscopic perspective. First we focus on understanding why classical laws (i.e. Fourier Law) are what they are and what are their limits of validity. Next we discuss emerging opportunities in nanoengineering energy devices.

Content

Part I: Fundamentals (8 weeks)
In the first part of the course we introduce the basic theory to understand heat transfer and energy conversion from a microscopic perspective. In particular, we will derive classical laws (i.e. Fourier's law, Ohm's law) from this microscopic perspective in oder to understand their limit of validity.

1. Energy states

- From classical to quantum harmonic oscillators: material waves and energy quantization (wave-particle duality)
- Energy states in solids (Band structure of crystals, Phonons, Density of states)
- Fundamentals of statistical thermodynamics

2. Energy Transport

- Energy transfer by waves (reflection/transmission and tunneling, energy and momentum of electromagnetic fields)
- Particle description of transport processes (Fourier's law and Ohm's law)
- Thermoelectric effects

Part II: Size Effects and Nanostructures for Energy Conversion Devices (6 weeks)
In the second part of the course we study the effect of device miniaturization on heat transfer and energy conversion. Subsequently, starting from recent literature results, we analyze the functioning of selected state-of-the art systems and emerging concepts for energy conversion devices.
3. Classical Size Effects: how energy transport changes in nano-/micro-scale systems

4. Thermoelectric devices & materials
5. Nanophotonic Engineering for Energy Devices

- radiative heat transfer & radiative cooling
- plasmonic nanostructure for solar fuels

• nanoscale heat sources

6. Liquids and Interfaces

• electrokinetic effects in nanochannels
• hydrovoltaic devices

Keywords

Nanotechnology
Energy devices

Learning Prerequisites

Important concepts to start the course

Wave equation

Learning Outcomes

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

• Contextualise heat transfer processes
• Compare energy devices

Transversal skills

• Communicate effectively with professionals from other disciplines.

Teaching methods

Frontal lectures, group projects, laboratory experiences

Assessment methods

• Mid-term Exam 30%
• Project Report (mid-term submission) 30%
• Final Assignment (end-of-semester submission) 40%

Supervision

Assistants	Yes

Resources

Moodle Link

• https://go.epfl.ch/ME-469