2025/26 - PHYS-201(d)/General physics III: electromagnetism (& waves & concepts of fluid mechanics)

Teacher: Prof. Dr. Dirk Grundler

EPFL › STI › IMX › **LMGN** English

LABORATORY OF NANOSCALE MAGNETIC MATERIALS AND MAGNONICS LMGN

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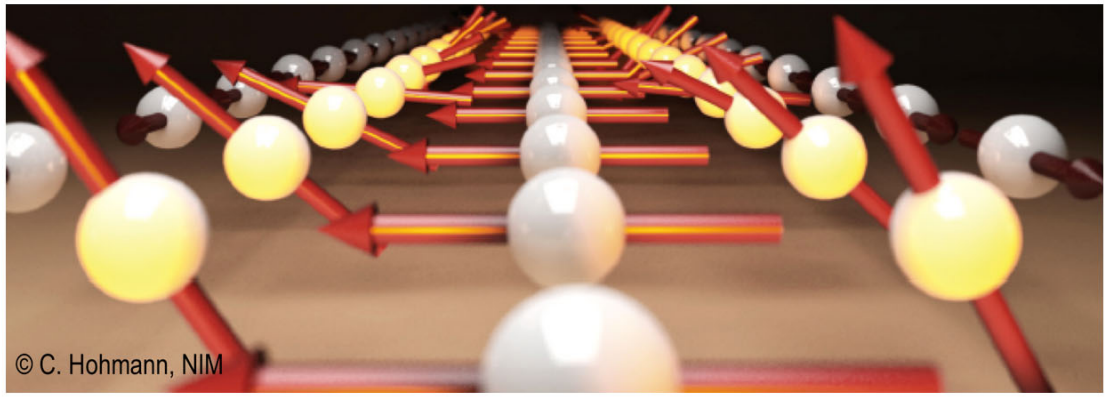
Welcome to LMGN

The **Laboratory of Nanoscale Magnetic Materials and Magnonics (LMGN)** explores magnetic nanomaterials for applications in information technology (data processing, transmission, logic), sensing and multifunctional devices. We prepare and investigate individual ferromagnetic nanostructures such as **nanotubes**, periodic and aperiodic nanomagnet arrangements such as **magnonic crystals**, artificial spin ice and **quasicrystals** as well as **skyrmion** lattices. We study their fundamental properties and search for novel functionalities.



Competences and Objectives

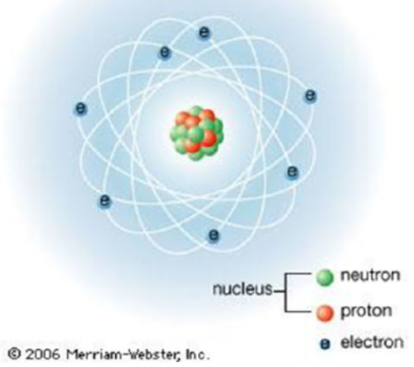
Magnetic properties of nanostructured materials
Nanofabrication and cleanroom processing
Microwave properties of magnetic nanomaterials
GHz spectroscopy
Magnonics
Spintronics
Skyrmionics

EPFL

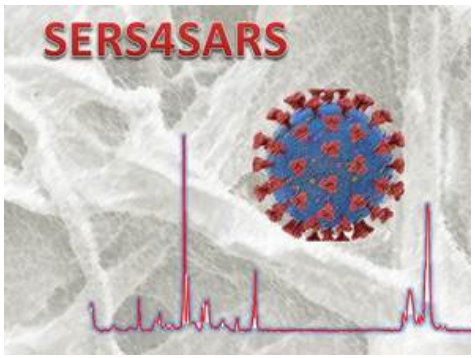
Why to study electromagnetism/electrodynamics?

The phenomena and concepts addressed in PHYS-201(d) are of utmost importance for our daily lifes as well as materials science and electrical engineering.

Atoms/molecules



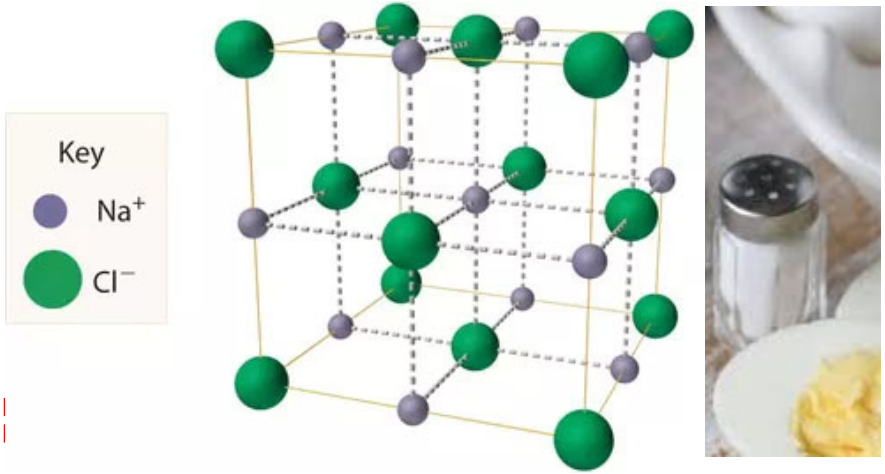
Materials characterization



Safety

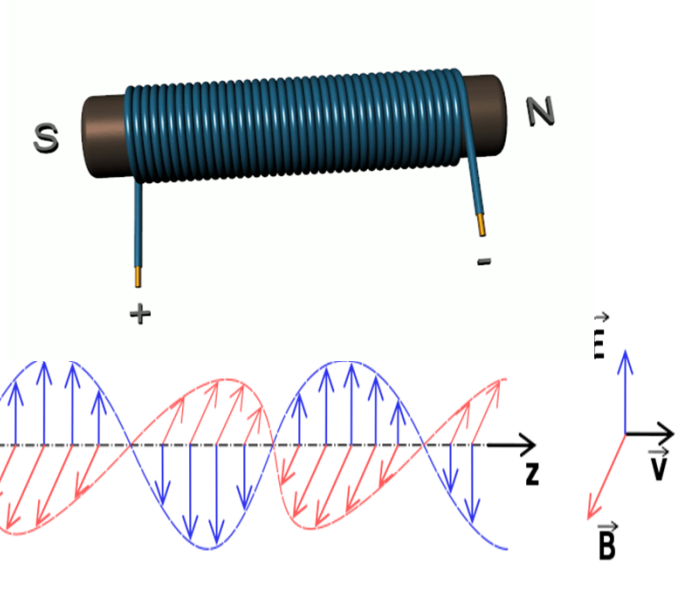
What is missing?

Adhesion of solids (sodium chlorid)



Chapters of the lecture

1) Electrostatics
2) Capacitance and dielectrics
3) Moving charges in conductors
4) Magnetostatics
5) Magnetodynamics
6) Electromagnetic aspects of AC circuits
7) Electromagnetic waves (incl. general aspects of waves)
8) Electromagnetic waves interacting with matter
9) Concepts of fluid mechanics



Learning outcomes

Learning Outcomes

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

- Integrate topics of the course
- Manipulate equations given in the course
- Apply concepts given in the course to practical problems
- Solve problems using the concepts given in the course
- Choose appropriate method for solving a problem
- Deduce properties on the basis of fundamental laws
- Analyze quantitatively consequences of a charge moving in a magnetic field, radiation of an electromagnetic wave from an antenna, reflection of photons at a metal surface, etc.

Transversal skills

- Use a work methodology appropriate to the task.
- Communicate effectively, being understood, including across different languages and cultures.
- Give feedback (critique) in an appropriate fashion.

Which is the particular challenge?

Electromagnetism/fluid mechanics require mathematical concepts of Analysis III

How to address this challenge?

- Learning by note taking in lectures, Q&A, by “doing”, i.e., solving the problems in the exercise class (with and without TAs)

Lecture hours/Exercise class/Homework

The course PHYS-201(d): Electromagnetism is a 6 ECTS course and considers
- 4 x 45 min lectures per week,
- 2 x 45 min exercise class per week.

As a 6 credits course the additional homework equals 6 x 45 min as well, e.g., by
elaborating on concepts discussed in the lecture and exercise classes, solving problems, review of uploaded solutions and completing lecture notes.

Schedule of exercise classes/assistants

Exercise classes: On Wednesdays, 08h15 to 10h00 am, in INM201,202

Problems will be uploaded to moodle and should be solved
independently or in a work group (recommended).
(From Sept. 12 on, problems will be put on moodle some days before the relevant exercise class.)

We will provide the solutions after the exercise class such that you can check (remaining) problems/solutions. Questions about solutions can be asked anytime in the exercise class or via email.

Assistants (PhD students):
Ms. Mihaescu, **Mr. Deenen,**
Ms. Oujin, Mr. Posva, Ms. Dalifoski, Mr. Krsic
And AEs:
Mr. Vincent, Mr. Pralong

The written exam contains problems similar to the ones shown in the exercise class on Wednesday mornings. It is essential to take part!

Background knowledge for PHYS-201(d)

General Physics I

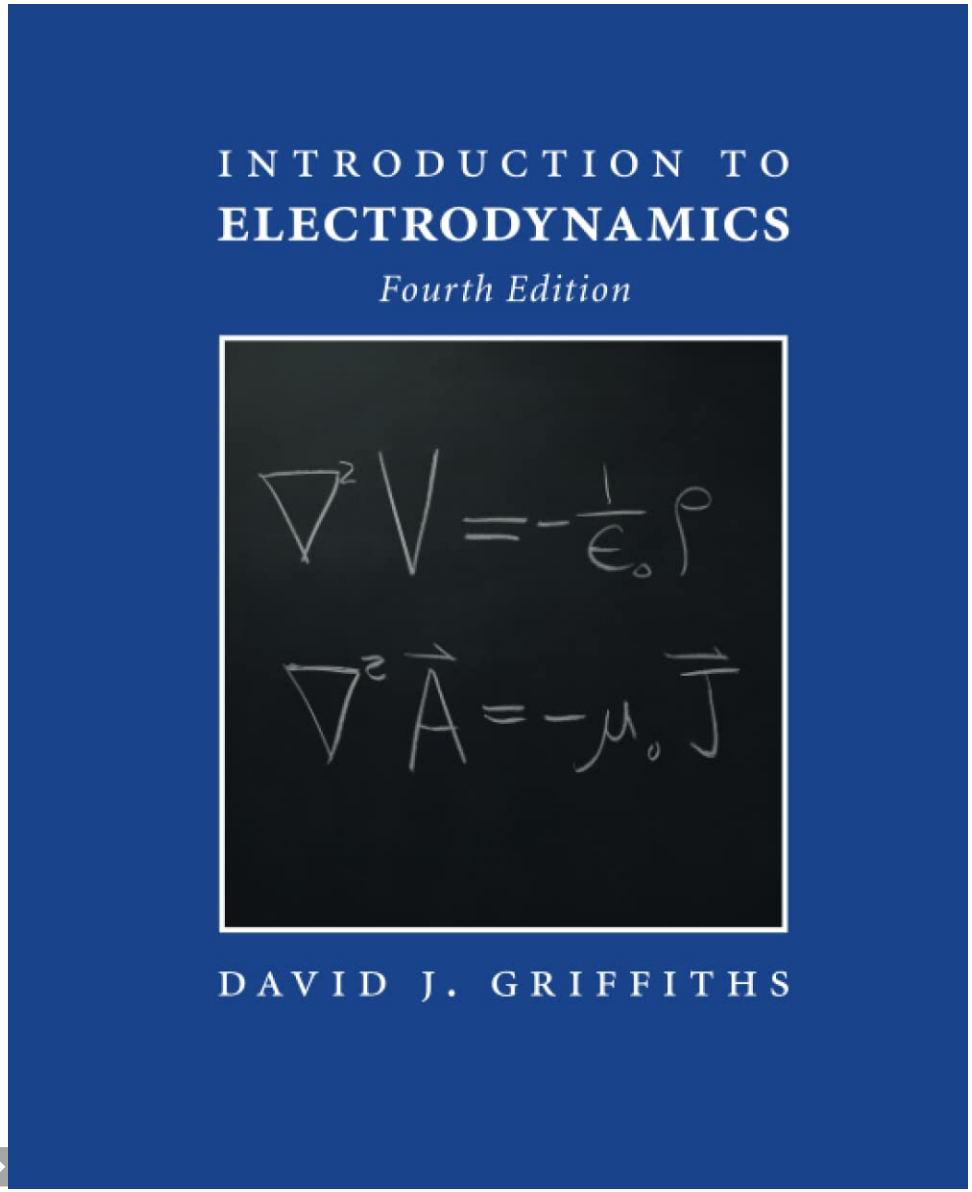
Contenu

Introduction et Cinématique : référentiels, trajectoire, vitesse, accélération, coordonnées cartésiennes et cylindriques.
Dynamique du point matériel : quantité de mouvement, lois de Newton, forces fondamentales, empiriques et de liaison, mouvement oscillatoire, moment cinétique.
Travail, puissance, énergie : énergies cinétique, potentielle, mécanique, lois de conservation, mouvements gravitationnels, collisions.
Changement de référentiels : dynamique dans les référentiels non inertiels
Dynamique des systèmes : centre de masse, moment cinétique, énergie
Solide indéformable : moment cinétique, moment d'inertie, effets gyroscopiques

=> First exercise class (this wednesday morning)

Recommended Book:

Extremely
helpful
for the
physics and
mathematical
concepts



Summary: Ways to transfer/acquire knowledge

Strategies/tools to stimulate/allow for acquisition of new knowledge:

- **Slides** provided by the lecturer on moodle for taking notes and **to be completed by the student**
- **Mathematical tool boxes** (uploaded to Moodle)
- **Problem solving in exercise classes** supported by assistants
- **Turning Technologies** questions for fast feedback (www.responseware.eu, ttpoll.eu)
  Session ID: **phys201d**
- **Experiments** in lectures
- **Moodle website** for documents, information, Q&A forum
- **In-depth discussion** with the lecturer and assistants (in lecture hall, exercise class, office upon request)
- Email for questions: maxwell@groupes.epfl.ch

Questions:

First part: Electromagnetism

Why «electro + magnetism»?

2020 – 200 years of electromagnetism

HC Oersted (1820)

the birth of electromagnetism

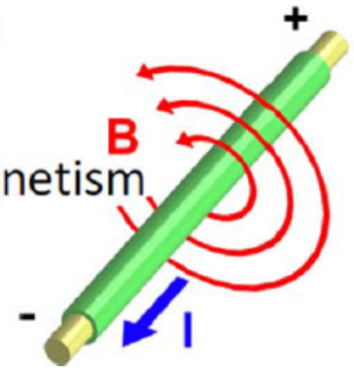
Electricity

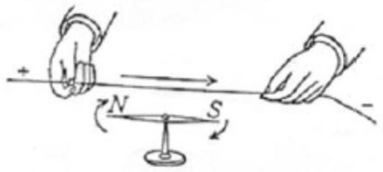
+

Magnetism

=

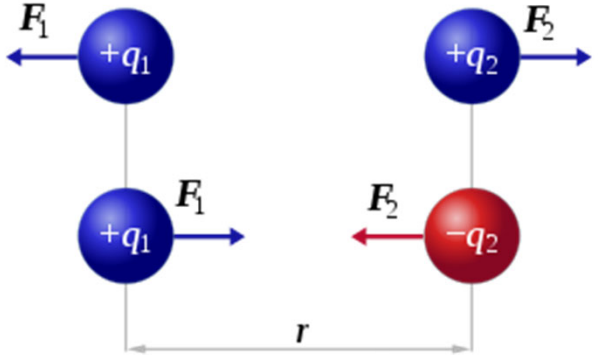
Electromagnetism





A unified description was achieved by Maxwell (classical electromagnetism) (~1865)

Before: **Coulomb law** (1785)
(force between electrical charges)



and magnetic attraction (B.C.)
(here lodestone, Fe_3O_4)

were considered **separately**.

Chapters addressing electromagnetism (EM)

Criterion by which topics are ordered:

Charges at rest

Phenomena become faster

Charges move ultrafast in 8)

1) Electrostatics: individual charges, charge distributions, forces
2) Capacitance and dielectrics
3) Moving charges in conductors
4) Magnetostatics
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