MSE-487 **Mathematical methods for materials science**

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Cursus	Sem.	Type
Materials Science and Engineering	MA1, MA3	Opt.

Language of teaching	English
Credits	4
Session	Winter
Semester	Fall
Exam	Written
Workload	120h
Weeks	14
Hours	**4 weekly**
Lecture	2 weekly
Exercises	2 weekly
Number of positions	

Summary

The aim of the course is to review mathematical concepts learned during the bachelor cycle and apply them, both conceptually and computationally, to concrete problems commonly found in engineering and Materials Science in particular.

Content

In this course, we will briefly review the origins of important mathematical concepts, the main results and theorems, and train on how to apply them in a concrete way in relevant core problems found in materials science. We will review the concepts in class and have exercise sessions to deepen understanding and apply them to engineering problems.
We will also have exercise modules on a computational approach (using Mathematica or other languages) to solve engineering / Materails Science problems using mathematical concepts seen in class. During these modules, students will follow a tutor to code themselves the resolution of the problem.
This class is hence also a good review of some aspects of materials science core concepts such as diffusion, wave propagation, materials structure, mechanical properties, statistical and quantum mechanics, with an emphasis on setting up a problem mathematically and solving it.
Note that this course is not a mathematics class focused on theory and demonstrating theorems, but rather on mathematical methods to express and solve engineering problems. It is particularly suited for students who feel they need to learn better how to apply mathematical concepts to practical problems. It can also be interesting to revisit and bring practical mathematical skills up to speed for an engineering education at the Master and PhD level. FInally, it wil refresh important tools to visualize and treat mathematcial problems computationnally.
The concepts that we will revisit include:

- Usual functions and differentiation: Taylor expansion, manipulation of log, exponential, hyperbolics etc.. : examples in thermally activited phenomena, optics and semiconductor physics.
- Complex numbers: examples from Optical waves propagation to rheology.
- Integral calculations and Fourier / Laplace transforms: examples in crystallography and quantum mechanics.
- Differential equations: examples in diffusion, wave equation, etc..
- Probability and Statistics: examples in Thermodynamics, and statistical and solid state physics.
- Linear algebra and Matrices: review basic concepts and go deeper in Hilbert spaces and self-adjoint operators as a support to the solid state physics class. Examples in mechanical properties of materials and quantum mechanics / solid states physics.

Keywords

Mathematical Concepts and Methods
Computaional skills
Materials Science
Engineering

Learning Prerequisites

Required courses

Algebra 1 Analysis 1 to 4, and probability and Statistics classes of the EPFL BA curriculum, or equivalent. Basic computational skills using Mathematica, Python or others.

Learning Outcomes

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

- Formulate a problem into a mathematical model / equations
- Exploit basics mathematical concepts needed to address common materials science problems
- Solve the mathematics of common problems in Materials science

Transversal skills

- Continue to work through difficulties or initial failure to find optimal solutions.
- Demonstrate a capacity for creativity.

Teaching methods

Ex cathedra classes (around 2hrs / week) with exercise sessions (around 1 hr per week) supported by the professor and assistants to deepen the understanding and discover the mathematcis of materials sceince / engineering problems. Around 1 hour per week exercise modules with a professor to explore the computational approach of an engineering based on the mathematcial concepts learned.

Assessment methods

The final grade will be obtained over a written exam at the exam session.
2 take-home homework during the semester, each counting for 10% of the grade

Supervision

Office hours	Yes
Assistants	Yes
Forum	No

Resources

Notes/Handbook

Detailed lecture slides with references will be made available as well as in-depth exercise corrections. Reference of books will be given.

Moodle Link

- https://go.epfl.ch/MSE-487

Videos

- http://Classes will be in person but recording of the classes wil be provided.