
MSE-483 ADVANCED PHASE TRANSFORMATIONSFALL 2024

TEACHER:	Prof. Anirudh Raju Natarajan	LECTURES:	09:15 - 11:00 (MXF1)
E-MAIL:	anirudh.natarajan@epfl.ch	EXERCISES:	13:15 - 14:00 (MXF1)

ASSISTANTS: Lorenzo Piersante (lorenzo.piersante@epfl.ch)

COURSE DESCRIPTION

This course provides an overview of the phenomenological concepts and mathematical tools that have been developed to study the thermodynamics, kinetics and mechanics of solid-state phase transformations. We will focus on phase transformations in metallic alloys, energy storage materials, ceramics, electronic materials etc.

COURSE CONTENT

- Review of the mathematical structure of thermodynamics.
- Thermodynamics of first-order and second-order phase transitions.
- Order parameters for phase transformations.
- Thermodynamic descriptions of inhomogeneous systems.
- Kinetics of phase transformations
- Martensitic phase transitions

LEARNING OUTCOMES

Analyze the thermodynamics, kinetics and mechanics of phase transformations

ASSESSMENT METHOD

Final exam during the exam month. Date and location will be announced as soon as they are available. Students will be provided with a single formula sheet along the with the exam. No other papers/exam aids are allowed or required.

TEXTBOOK AND COURSE MATERIAL**Course Material**

- Course notes will be posted on moodle after class
- Problem sets also posted on the moodle site

Suggested Texts

- Principles of Classical Thermodynamics: Applied to Materials Science Didier de Fontaine
- Theory of Structural Transformations in Solids, Khachaturyan, Dover
- Kinetics of Materials, Balluffi, Allen, Carter, Wiley 2005
- Phase Transformations in Metals and Alloys, Porter and Easterling

TENTATIVE SCHEDULE

Week	Topics
September 12	Introduction, Course overview Thermodynamics of phase transitions <i>Lecture instead of exercise session</i>
September 19	Mathematical structure of thermodynamics <i>Lecture instead of exercise session</i>
September 26	Equilibrium conditions and phase transitions in unary systems
October 3	Clausius-Clapeyron relation
October 10	Kinetics of phase transitions
October 17	Kinetics of phase transitions
October 24	<i>Mid-Semester Break</i>
October 31	Phenomenological theories of spinodal decomposition
November 7	Phenomenological theories of spinodal decomposition
November 14	Descriptors of phase transitions and phase-field models
November 21	Classical Nucleation Theory
November 28	Phase transformations with interfaces
December 5	<i>No lecture, only exercise session</i>
December 12	Diffusionless phase transitions
December 19	Diffusionless phase transitions

PEDAGOGIC NOTE

The conceptual complexity of phase transformations will require you to spend some time thinking and analyzing the topics we discuss in class. Lectures will be structured so that we all learn the subject *together*. The collaborative learning experience will be greatly enhanced if you regularly engage with me by asking questions or raising discussion points. It is very likely that *your question* will be on someone else's mind as well! Exercise sessions are aimed at reinforcing concepts discussed during the lecture. It is very important that you attempt to solve the problems by yourself. Inputs you receive from the teaching assistants or your friends on getting started with a problem are often the most difficult steps in the exercises. Some problems have many ways of solving them and I encourage you to explore these alternate solutions.