EPFL
LABORATORY OF MATERIALS DESIGN AND SIMULATION

COURSE OUTLINE

ME-351 THERMODYNAMICS AND ENERGETICS II

SPRING 2025

TEACHER: Prof. Anirudh Raju Natarajan
E-MAIL: anirudh.natarajan@epfl.ch
LECTURES: 15:15 - 17:00 (MAA112)
EXERCISES: 17:15 - 18:00 (MAA112)
OFFICE HOURS: By appointment

ASSISTANTS: Deepak Somani (deepak.somani@epfl.ch) & Damien Lee (damien.lee@epfl.ch)

COURSE DESCRIPTION

This course will discuss advanced topics in thermodynamics with a focus on studying gas phases, mixtures, phase transformations and combustion. The application of these principles to various practical systems such as batteries, fuel cells etc. will be discussed.

COURSE CONTENT

- Review of the mathematical structure of thermodynamics
- Characteristic potentials for arbitrary boundary conditions
- Introduction to phases and phase diagrams
- Thermodynamics of mixtures, gases and phases
- Thermodynamics of stressed solids
- Combustion
- Statistical Mechanics
- Applications of thermodynamics to batteries, fuel cells, shape-memory, piezoelectric materials etc.

LEARNING OUTCOMES

By the end of the course, students will be able to construct characteristic potentials for arbitrary boundary conditions, compute thermodynamic quantities, construct phase diagrams, have a basic understanding of statistical mechanics and apply thermodynamic principles to the study of real-world applications.

ASSESSMENT METHOD

- Mid-term exam (40%)
- Final exam (60%)

Date and location of the final exam will be available on IS-Academia. You will have access to a single formula sheet that is provided along with the exam. No other papers/exam aids are allowed or required.

TEXTBOOK AND COURSE MATERIAL

Suggested Texts

- *Principles of Classical Thermodynamics: Applied to Materials Science Didier de Fontaine*
- Introduction to the Thermodynamics of Materials : David R. Gaskell, David E. Laughlin

Other interesting texts

- Fundamentals of engineering thermodynamics : Moran and Shapiro
- An Introduction to Statistical Thermodynamics : D. Chandler
- *Thermodynamics and an Introduction to Thermostatistics : Herbert B. Callen*

TENTATIVE SCHEDULE

Week	Topics
February 18	Introduction, overview, basic definitions Equilibrium & state variables Reversible work *No exercise session*
February 25	First law, heat capacity Second law of thermodynamics
March 4	Mathematical structure of thermodynamics *No exercise session*
March 11	Equilibrium criteria
March 18	Phase transformations *No exercise session*
March 25	*No class - exercise session will be from 15:15 - 16:45*
April 1	Multi-phase systems *No exercise session*
April 8	Solution equilibria - I
April 15	**Midterm examination**
April 22	*Mid-semester break*
April 29	Solution equilibria - II
May 6	Multicomponent phase diagrams
May 13	Intro to statistical mechanics
May 20	Canonical ensemble, probability distributions, partition function
May 27	Statistical mechanical interpretation of entropy General structure of statistical mechanics

PEDAGOGIC NOTE

The conceptual complexity of thermodynamics 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.