UNIVERSITÀ
DEGLI STUDI DI MILANO-BICOCCA

SYLLABUS DEL CORSO

Thermal Physics

2627-1-E3004Q003-E3004Q00302

Aims

This course provides students with knowledge of the basic principles and fundamental laws of thermodynamics, thermodynamic potentials, statistical mechanics, and heat transfer mechanisms. In addition, it fosters the ability to model a phenomenon by identifying the fundamental laws that rule it, as well as apply them to solve various types of problems.

In particular:

- Knowledge and understanding: by the end of the course, the student will have acquired a solid understanding of fundamental laws and principles of thermodynamic, an introduction to statistical mechanics and heat transfer mechanisms.
- Applying knowledge and understanding: the student will be able to apply the aforementioned concepts to describe the dynamics of thermodynamic transformation of ideal gasses, thermal machines and their operation, entropy variations and chemical potentials
- Communication skills: the student will be able to build analytical reasoning with clarity and precision, both in written form and orally. They will be also able to explain all the logical steps needed to describe a phenomenon and extract an analytical prediction / modellization of its behaviour.
- Learning skills: the student will learn new concepts and develop the ability to apply them in different contexts while solving exercises. This course serves as a foundation for more advanced studies in physics.

Contents

- Thermodynamic variables, state functions, thermal equilibrium
- Ideal gases and their thermodynamic transformations
- First and second law of thermodynamics
- Thermal cycles and entropy
- Real gases and phase transitions

- Thermodynamic potentials
- Open systems and entropy of mixing
- PVT systems and Maxwell relations
- Heat transfer mechanisms
- Kinetic theory of gases, microscopic view of entropy and temperature
- Introduction to wave mechanics

Detailed program

- *Introduction:* thermodynamic systems, thermometric observables, thermodynamic state variables and functions, thermal equilibrium.
- *Calorimetry:* heat sources, heat capacity, thermal expansion, latent heats.
- *Thermodynamic transformations:* work and heat, internal energy, first law of thermodynamics, reversible and irreversible processes.
- *Ideal gases:* state equation, reversible transformations (isovolumetric, isobaric, isothermal, adiabatic) and representation in the P-V plane, Joule free expansion, Mayer's law.
- *Thermal cycles:* heat engines and efficiency, refrigerators and heat pumps.
- *Second law of thermodynamics:* Carnot and Clausius theorems, definition of entropy, reversible and irreversible transformations.
- *Applications:* entropy variations during transformation of ideal gases, heat exchange bodies or heat sources, temperature changes in solids or liquids, phase transitions.
- *Real gases:* Van der Waals and Clapeyron's equations.
- *Thermodynamic potentials:* enthalpy, Gibbs and Helmholtz free energy, chemical potential and applications.
- *Entropy of mixing and open systems*
- *PVT systems:* Maxwell relations, thermal expansion and compressibility coefficients, phase transitions, critical and triple points, Joule-Thomson expansion.
- *Basics of statistical mechanics:* kinetic theory of ideal gases, Boltzmann-Maxwell distribution, mean free path.
  Statistical interpretation of temperature and entropy, energy equipartition principle.
- *Heat transfer mechanisms:* convection, conduction, and radiation.
- *Wave Mechanics:* elastic waves, the d'Alembert equation and its solutions, longitudinal and transverse waves, pressure waves in a gas (sound), transported energy, standing waves, and wave packets.

Prerequisites

Students must have basic knowledge of mathematics and physics, as covered in the first-semester courses of "Calculus I" and "Mechanics."

Teaching form

- 34 hours of Lectures given in "expository teaching": 16 hours to be attended in person and 18 hours online. Video recordings of lectures will be available online.
- 14 hours of Exercises given in "interactive teaching" during which students are involved in solving proposed problems: 8 hours to be attended in person and 6 hours online. Video recordings of lectures will be available online.

Textbook and teaching resource

Reference books for this course are:

- A.M. Steane, “Thermodynamics: A complete undergraduate course”, Oxford Academic (x)
- A. Rex, C.B.P. Finn, “Thermal Physics”, CRC Press
- E. Fermi, “Thermodynamics”, Dover Books
- S.J. Blundell, “Concepts in Thermal Physics”, Oxford University Press (x)

(x) Also available in e-book format through the university library

Semester

Second semester

Assessment method

- A written test is scheduled, focusing on solving thermodynamics exercises / problems. Only if passed with a grade above the threshold, the written test will be followed by an oral exam. The oral exam consists of a discussion on the course topics and may also include solving short exercises.
- After passing the written test, students can take the oral one in any session within the same academic year. The result of the written test remains valid even if the oral one is not passed.
- Oral tests are held starting from a few days after the publication of the written results, according to a calendar that will be posted on the e-learning page of the course. Students can therefore register to a session when they feel ready.

The final grade is not a simple arithmetic average of the written and oral test but is determined based on:

- Accuracy, precision, and clarity in solving the exercises of the written exam.
- Knowledge of the main topics of the course, ability to apply fundamental laws, and communication skills shown during the oral exam (use of appropriate terminology, clarity, and responsiveness)

Office hours

The professor is always available for discussions, however the presence in office for discussion time is guarantee only if arranged either via a discussion in the classroom or by e-mail

Sustainable Development Goals

QUALITY EDUCATION | DECENT WORK AND ECONOMIC GROWTH | INDUSTRY, INNOVATION AND INFRASTRUCTURE