DIM-SAP-231 Thermal Physics

SEMESTER: Spring

CREDITS: 3 ECTS (4 hrs. per week / 2 months)

LANGUAGE: English

DEGREES: SAPIENS program

Course overview

The objective of this course is to develop a working knowledge of the laws and methods of thermodynamics and elementary statistical mechanics and to use this knowledge to explore various applications. Many of these applications will relate to topics in materials science and the physics of condensed matter. The three laws of classical thermodynamics, which deal with the existence of state functions for energy and entropy, and the value of entropy at the absolute zero of temperature, are developed along phenomenological lines; the existence and properties of the entropy; different thermodynamic potentials and their uses; phase diagrams; introduction to statistical mechanics and its relation to thermodynamics; treatment of ideal gases.

Prerequisites

- Students are expected to have a good understanding of:
- classical mechanics (Newton's Laws, work and energy, systems of particles, and rotations;
- basic fluid mechanics (static properties and fluids, oscillations, transverse waves);

Course contents

1. Energy in Thermal Physics. Thermal Equilibrium. The Ideal Gas. Microscopic Model of an Ideal. Equipartition of Energy. Heat and Work. Compression of an Ideal Gas. Heat Capacities. Latent Heat; Enthalpy. Rates of Processes. Heat Conduction; Conductivity of an Ideal Gas.
2. Irreversibility and the Second Law of Thermodynamics. Two-State Systems. The Two-State Paramagnet. The Einstein Model of a Solid. Interacting Systems. Large Systems. The Ideal Gas. Interacting Ideal Gases. Entropy. Reversible and Irreversible Processes.
3. Ideal-Gas Heat Engines. Heat Engines The Carnot Cycle. Refrigerators. Real Heat Engines. Internal Combustion Engines. Real Refrigerators.

4. Boltzmann Distribution. The Boltzmann Factor. Paramagnetism. Elasticity in Polymers. Harmonic Oscillator. Particle States in a Classical Gas. Maxwell- Boltzmann Distribution. Global Warming.
5. Free Energy and Chemical Thermodynamics. Free Energy as Available Work. Free Energy as a Force toward Equilibrium. Phase Transformations of Pure Substances. Phase Transformations of Mixtures. Dilute Solutions. Chemical Equilibrium. Ionization of Atoms. Law of Mass Action: Doped Semiconductors. Carrier Densities in a Semiconductor.
6. Adsorption of Atoms and Phase Transitions. Adsorption of Atoms on a Solid Surface. Oxygen in Myoglobin. Why Gases Condense. Solid/Liquid/Gas Phase Transitions.
7. Quantum Statistics. The Gibbs Factor. Bosons and Fermions. Blackbody Radiation. Bose-Einstein Condensation.

Textbook

- Wolfe, J.P. (2011). *Elements of Thermal Physics.* 4th Edition. Hayden-McNeil Publishing.
- Schroeder, D.V. (1999). *An Introduction to Thermal Physics*. 1st Edition. Addison Wesley.

Grading

The grade will be determined by two midterms (25% each), homework (10%), and a final examination (40%). The exams are all closed notebook, closed textbook and no calculator. The course will not be graded on a curve, i.e., there is no bound on the numbers of A's, B's, C's etc.

Students will have the chance to retake the exam. The resulting grade will be calculated as follows: 30% of the midterms and 70% of the final exam.