



Faculty of Health, Science and Technology
Physics

Syllabus

Thermodynamics and Statistical Physics

Course Code:	FYGB02
Course Title:	Thermodynamics and Statistical Physics <i>Termodynamik och statistisk fysik</i>
Credits:	7.5
Degree Level:	Undergraduate level
Progressive Specialisation:	First cycle, has less than 60 credits in first-cycle course/s as entry requirements (G1F)

Major Field of Study:

FYA (Physics)

TKA (Engineering Physics)

Course Approval

The syllabus was approved by the Faculty of Health, Science and Technology 2023-09-04, and is valid from the Autumn semester 2024 at Karlstad University.

Prerequisites

Registered for Physics, 22.5 ECTS Credits, and Mathematics, 30 ECTS Credits

Learning Outcomes

The aim of the course is for students to acquire the fundamentals of classic thermodynamics for closed systems in equilibrium, statistical physics, and statistical thermodynamics. The course also provides the background to significant technical applications and a basis for discussions of energy issues.

Upon completion of the course, students should be able to:

- give an account of the phases of pure substances and describe phase transitions
- analyse processes of closed systems as regards the first and second laws of thermodynamics, especially in relation to pure substances and ideal gases

- apply and describe the consequences of the second law in realistic situations
- calculate thermodynamic properties based on different forms of free energy
- give an account of links between classic and statistical thermodynamics
- give an account of the microscopic significance of entropy
- calculate the microcanonical and canonical ensembles of simple multiparticle systems
- calculate the state sum and free energy of a canonical ensemble
- give an account of the implication of Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac statistics, and apply the corresponding distribution functions.

Content

Instruction is in the form of lectures, exercises, and mandatory laboratory sessions.

Classical Thermodynamics (4.5 ECTS cr)

Basic concepts: thermodynamic systems, state, equilibrium, process, cycle. Temperature and the zeroth law of thermodynamics, internal energy, pressure, enthalpy, work, heat. The phases of pure substances and phase transitions, state diagrams and phase diagrams. Ideal and non-ideal gases. The first law of thermodynamics for closed systems. Changes in the internal energy and enthalpy of ideal gases, heat capacity. Heat reservoir, heat engine, heat pump, and cooling process, the second law of thermodynamics. Reversible and irreversible processes, the Carnot cycle, the thermodynamical temperature scale, reversible heat engines, heat pumps, and cooling processes. Entropy, the principle of increasing entropy, changes in entropy for ideal gases. Analysis of heat engines, ideal cycles. Thermodynamical potentials, Helmholtz and Gibbs free energies, Maxwell's relations.

Statistical Physics (3 ECTS cr)

Kinetic theory for ideal gases. Probability distribution, mean, and deviation. Bernoulli processes and binomial distribution. Normal distribution, the law of large numbers, the central limit theorem, the connections between macroscopic properties and statistical mechanics. Macrostates and microstates, ensembles. Isolated systems and the microcanonical ensemble, the equiprobability principle, the entropy of isolated systems. Systems in thermal equilibrium with heat reservoirs and the canonical ensemble, the Boltzmann distribution, state sum, response functions and heat capacity, and entropy and the third law of thermodynamics. Free energy and statistical thermodynamics. Entangled particles, the Pauli principle, bosons and fermions. Classic and quantum mechanical ideal gas; the Maxwell-Boltzmann, Bose-Einstein, and Fermi-Dirac distributions; black body radiation.

Reading List

See separate document.

Examination

Assessment is based on written hand-in assignments, completed individually and in groups, and two written exams.

If students have a decision from Karlstad University entitling them to Targeted Study Support due to a documented disability, the examiner has the right to give such students an adapted examination or to examine them in a different manner.

Grades

One of the grades Distinction (VG), Pass (G), or Fail (U) is awarded in the examination of the course. For Engineering students, one of the grades 5 (Pass with Distinction), 4 (Pass with Some Distinction), 3 (Pass), or U (Fail) is awarded in the examination of the course.

Quality Assurance

Follow-up relating to learning conditions and goal-fulfilment takes place both during and upon completion of the course in order to ensure continuous improvement. Course evaluation is partly based on student views and experiences obtained in accordance with current regulations and partly on other data and documentation. Students will be informed of the result of the evaluation and of any measures to be taken.

Course Certificate

A course certificate will be provided upon request.

Additional information

The local regulations for studies at the Bachelor and Master levels at Karlstad University stipulate the obligations and rights of students and staff.