



Subject card

Subject name and code	Thermodynamics, PG_00071198						
Field of study	Nanotechnology						
Date of commencement of studies	October 2026	Academic year of realisation of subject				2026/2027	
Education level	second-cycle studies	Subject group				Obligatory subject group in the field of study	
Mode of study	Full-time studies	Mode of delivery				at the university	
Year of study	1	Language of instruction				English	
Semester of study	1	ECTS credits				3.0	
Learning profile	general academic profile	Assessment form				assessment	
Conducting unit	Institute of Nanotechnology and Materials Engineering -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology						
Name and surname of lecturer (lecturers)	Subject supervisor		prof. dr hab. inż. Jarosław Rybicki				
	Teachers		prof. dr hab. inż. Jarosław Rybicki				
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	15.0	0.0	0.0	0.0	45
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours		Self-study	SUM
	Number of study hours	45		2.0		28.0	75
Subject objectives	<p>The aim of the course is to present phenomenological thermodynamics as a coherent universal system of laws based on hard empirical facts: Born's theorem, the postulate of the existence of internal energy, the postulate of the existence of entropy as a state function (Caratheodory's theorem). From these three axioms, all thermodynamic properties of matter can be calculated, which will be illustrated with examples of complex systems: dielectrics, dia-, para-, and ferromagnets, superconductors, plasma, and surface phenomena in a state of weightlessness.</p> <p>The classes are aimed at deepening the skills of practical application of thermodynamic formalism in the analysis of physical models and deriving relationships between state functions.</p>						
Learning outcomes	Course outcome		Subject outcome		Method of verification		
	[K7_W04] has theoretical and practical knowledge of physical and chemical experimental methods in nanotechnology and understands the principles of their application in processes occurring throughout the life cycle of technical systems		Presentation of axiomatic phenomenological thermodynamics and showing how effectively theory applies to technical systems		[SW1] Assessment of factual knowledge		
[K7_U06] is able to apply acquired specialist knowledge to problems in other physical, natural, or technical sciences and to critically analyze and evaluate the functioning of the adopted solutions		Thermodynamics laws are verified in any phenomena and processes in nature. The above will be illustrated and stressed.		[SU2] Assessment of ability to analyse information [SU3] Assessment of ability to use knowledge gained from the subject [SU4] Assessment of ability to use methods and tools			

Subject contents	<p>Course content – lecture</p> <p>The concepts of thermodynamic system, thermodynamic phase, uniform and non-uniform phase, homogenous and heterogeneous phase. The concept of thermodynamic equilibrium at macro- and micro-scale. The concepts of the adiabatic boundary and diathermic boundary. Born's theorem. The empirical temperature. Quasi-static processes. The postulate of the existence of internal energy (Axiom I). Hess's and Kirchhoff's laws. Specific heat at constant volume and at constant pressure. The thermal and caloric state equations of the ideal gas. Carathéodory's theorem. The second law of thermodynamics (Axiom II). Thermodynamic potentials <math>U(V,S)</math>, <math>H(S,p)</math>, <math>F(V,T)</math>, <math>G(p,T)</math>. The Maxwell's equations. The Einstein model of heat capacity of crystals. The equilibrium density of Schottky and Frenkel defects in crystals. The main differences between thermodynamic properties of diamagnets and paramagnets. The magnetostriction effect. The magnetoelastic effect. Magnetic cooling. Thermodynamic functions for chemical systems. Chemical potential. Chemical activity and Lewis activity coefficients. Ideal, ideal perfect and non-ideal phases. Equilibrium relative to interphase transition of components in a multi-phase multi-component system. The Gibbs phase rule. Give examples of systems with zero, one and two degrees of freedom. Law of equilibrium shifts in thermodynamic systems. The Clausius-Clapeyron law, Kirchhoff's law on heat of solvation, azeotropy, Wullners law, Gibbs adsorption law.</p>		
	<p>Course content – exercises</p> <p>Numerical calculations illustrating the lecture.</p>		
Prerequisites and co-requisites	University courses in mathematics and physics		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	written test in problem solving	51.0%	50.0%
	written test in theory	51.0%	50.0%
Recommended reading	Basic literature	<p>Jeremy Dunning-Davies, CONCISE THERMODYNAMICS, Principles and Applications in Physical Science and Engineering</p> <p>Syczev, Thermodynamics of complex systems</p>	
	Supplementary literature	<p><b>Dilip Kondepudi</b>, INTRODUCTION TO MODERN THERMODYNAMICS, ISBN 978-0-470-01598-8</p>	
	eResources addresses		

<p>Example issues/ example questions/ tasks being completed</p>	<ol style="list-style-type: none"> <li>1. Define and discuss the concept of thermodynamic equilibrium at macro- and micro-scale.</li>   <li>1. Define the concepts of the adiabatic boundary and diathermic boundary.</li>   <li>1. Formulate the so-called zeroth law of thermodynamics (Born's theorem). Define the empirical temperature and explain its meaning.</li>   <li>1. Discuss in detail the concept of quasi-static processes. Explain their importance in thermodynamics.</li>   <li>1. Formulate and discuss the postulate of the existence of internal energy. Formulate the first law of thermodynamics (Axiom I).</li>   <li>1. Discuss the concepts of elementary work and heat. What is the relation of these quantities and infinitesimal changes in internal energy? Pay attention to the mathematical nature of the discussed small increments.</li>   <li>1. Give the Plancks classic (counter)example proving that elemental heat <math>Q_{el}</math> is not an exact differential.</li>   <li>1. Define the concept of enthalpy. Formulate the first law of thermodynamics with the help of enthalpy.</li> <li>1. Discuss the direct conclusions arising from the first law of thermodynamics applied to isochoric transformations in single-phase systems.</li> </ol> <p>ETC, ETC, ...</p>
<p>Practical activities within the subject</p>	<p>Not applicable</p>

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