Applied statistical physics - course description

General information

Course name	Applied statistical physics
Course ID	13.2-WF-FizD-ASP-S18
Faculty	Faculty of Physics and Astronomy
Field of study	WFiA - oferta ERASMUS
Education profile	-
Level of studies	Erasmus programme
Beginning semester	winter term 2023/2024

Course information

Semester	2
ECTS credits to win	5
Course type	obligatory
Teaching language	english
Author of syllabus	• prof. dr hab. Andrzej Drzewiński

Classes forms

The class form	Hours per semester (full-time)	Hours per week (full-time)	Hours per semester (part-time)	Hours per week (part-time)	Form of assignment
Lecture	30	2	-	-	Credit with grade
Class	30	2	-	-	Credit with grade

Aim of the course

Familiarize students with the development of concepts and methods related to the thermodynamics and statistical physics. Presentation of their applications to the description of equilibrium states and non-equilibrium states in physics, biology or sociology.

Prerequisites

Student should attend the courses "Fundamentals of Physics 1 and 2" (the first-cycle studies in physics).

Scope

LECTURE:
- Introduction: microstates and macrostates, entropy and information, non-equilibrium and equilibrium systems, the principle of maximum entropy, entropic forces, intensive and extensive quantities, the ergodic hypothesis, non-ergodic systems in nature
- Cellular automata: various cell neighborhoods, evolution simulations, Schelling's urban segregation model
- Kinetic theory of gases: reversible and irreversible processes, particle collisions and the state of equilibrium, Maxwell-Boltzmann distribution, an average energy per particle and temperature, the theorem of equipartition of energy
- Phenomenological thermodynamics: state functions, state equations, the laws of thermodynamics, the thermodynamic description of phase transitions, the role of the fluctuation and sky blue
- Classical statistical mechanics: the ergodic hypothesis, the microcanonical ensemble, the equation of state for an ideal gas and for real gas, the thermal bath and canonical ensemble, the equivalence of thermodynamic ensembles, elements of phase transitions and critical phenomena, the critical opalescence, critical exponents and universality, the Ising model
- Stochastic processes: Markov chains, equilibrium conditions, the Master equation, the diffusion equation

CLASS:
Probability: discrete and continuous probability distributions, the binomial distribution, the normal distribution, the Poisson distribution, the Central Limit Theorem, some applications in physics and everyday life
Cellular automata: between chaos and order (playing in "Life"), a Mexican wave, a falling sand simulation
Kinetic theory of gases: Boltzmann's H-theorem, the root-mean-square speed and temperature/pressure, the mean free path
Phenomenological thermodynamics: work and energy, thermodynamic processes, the Carnot cycle and heat pump, the Otto cycle, thermodynamics of elastic bodies
Classical statistical mechanics: the Gibbs paradox, thermodynamic potentials, a partition function and thermodynamical functions, paramagnetism and the Curie's law, the Ising model of human behavior
Stochastic processes: a random walk, the Master equation and Brownian motion, a particle in a gravitational field and the barometric equation

Teaching methods

Classes are in the form of lectures when the student is encouraged to ask questions. On the exercises, students analyze and solve problems with a teacher.

Learning outcomes and methods of theirs verification

Outcome description	Outcome symbols	Methods of verification	The class form

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The student knows the basics of statistical physics and is able to use them for qualitative and quantitative analysis of simple physical problems		• a final test • an observation and evaluation of activities during the classes	• Lecture • Class
At the basic level, the student is able to determine for real systems the scope and method of problem analysis based on statistical physics methods		• a final test • an observation and evaluation of activities during the classes	• Lecture • Class
The student knows and can apply the principles of thermodynamics for qualitative and quantitative analysis of simple physical problems		• a final test • an ongoing monitoring during classes	• Lecture • Class

Assignment conditions

LECTURE:
The final test is conducted in writing. Student receives four issues to consider requiring the knowledge of the issues and ability to combine different phenomena. For each task, one can get from 0 to 5 points. Received a positive rating requires at least 8 points (a sufficient for 8-10.5 points, a plus sufficient for 11-13.5 points, a good 14-16, a plus good 16.5-18.5 points, a very good 19-20 points).
CLASS:
The final grade will be affected by the following factors:
- activity at classes (40%)
- the result of the final test (60%) that will be based on problems similar, but not identical, to the problems studied during the classes

The classes must be completed prior to the final test.
The lecture grade will comprise 60% of the final grade while the class grade will comprise 40% of the final grade.

Recommended reading

[1] R. Feynman „Wykłady z mechaniki statystycznej", PWN Warszawa 1980
[2] K. Huang, „Podstawy Fizyki Statystycznej", PWN, Warszawa, 2006
[3] N. van Kampen „Procesy stochastyczne w fizyce i chemii", PWN Warszawa 1990.
[4] L. Peliti, „Statistical Mechanics in a Nutshell", Princeton University Press, 2011

Further reading

[1] J.J. Binney, N.J. Dowrick, A.J. Fisher, M.E.J. Newman, "Zjawiska krytyczne. Wstęp do grupy renormalizacji", PWN, Warszawa 1998
[2] R K Pathria , P. D. Beale, „Statistical Mechanics", Elsevier, Amsterdam, 2011
[3] B. Poirier, „A conceptual guide to thermodynamics", John Wiley & Sons Ltd, UK, 2014
[4] F. Reif, „Fundamentals of Statistical and Thermal Physics", McGraw-Hill, New York, 1965
[5] J. P. Sethna, "Entropy, Order Parameters, and Complexity", Oxford, 2006

Notes

Modified by dr Marcin Kośmider (last modification: 28-06-2023 22:19)