COURSE UNIT DESCRIPTION

Course unit title	Code
Quantum statistical physics (Kvantinė statistinė fizika)	

Annotation
This is a one-semester master-level course on statistical physics, a continuation of the undergraduate course on Statistical physics. Basic knowledge of principles of statistical mechanics, partition functions, thermodynamic potentials and classical statistics is assumed. Core topics examined in this course are: quantum statistics, systems of identical particles, Bose-Einstein condensation, critical phenomena, scaling and renormalization group.

Lecturer(s)	Department, Faculty
Coordinating: prof. dr. Egidijus Anisimovas **Other:**	Faculty of Physics Institute of Theoretical Physics and Astronomy

Study cycle	Type of the course unit
second	optional

Mode of delivery	Semester or period when it is delivered	Language of instruction
face-to-face	spring semester	English / Lithuanian

Requisites	
Prerequisites: familiarity with Statistical physics, Quantum mechanics, Linear algebra	**Co-requisites (if relevant):** none

Number of ECTS credits allocated	Student's workload (total)	Contact hours	Individual work
5	140 hours	64 hours	76 hours

Purpose of the course unit: programme competences to be developed

The purpose of the course is to develop the following subject-specific competences:

- ability to propose and analyze subject-specific models;
- ability to plan and carry out research tasks, evaluate results, formulate conclusions;

and generic competences:

- ability to perform literature search and analysis, acquire new knowledge, apply in practical situations;
- ability to work independently and in a team;
- ability to analyze and systematize information, apply knowledge in a broader context.

Learning outcomes of the course unit	Teaching and learning methods	Assessment methods
Students will be familiar with models of many-particle systems and methods of their analysis	Problem-based teaching, independent study, seminar discussions	Exam, independent problem solving, seminar presentation
Students will be able to apply methods of statistical mechanics to quantum systems	Problem-based teaching, independent study, seminar discussions	Exam, independent problem solving, seminar presentation
Students will understand and will be able to analyse collective phenomena and the critical state	Problem-based teaching, independent study, seminar discussions	Exam, independent problem solving, seminar presentation

Course content: breakdown of the topics	Contact hours							Individual work: time and assignments	
	Lectures	Tutorials	Seminars	Workshops	Laboratory work	Internship/work	**Contact hours,**	**Individual work**	**Assignments**
1. Methodology of statistical mechanics. Statistical ensembles. Entropy. Indistinguishability of identical particles and quantum statistics.	4	-	4	-	-	-	**8**	**10**	Independent problem solving.
2. Lattice models. Spin models, lattice systems of free fermions and bosons, Hubbard and Bose-Hubbard models.	6	-	6	-	-	-	**12**	**14**	Literature studies, independent problem solving.
3. Systems of ideal bosons and fermions. Bose-Einstein condensation. Degenerate atomic gases.	6	-	6	-	-	-	**12**	**18**	Literature studies, independent problem solving, work on presentation.
4. Phase transitions and critical phenomena. Vicinity of the critical point, critical exponents. Exact results, analytical, mean-field and numerical methods.	6	-	6	-	-	-	**12**	**14**	Literature studies, independent problem solving, work on presentation.
5. Scaling transformations. Renormalization group. Statistical field theory.	10	-	10	-	-	-	**20**	**20**	Literature studies, work on presentation.
Total	**32**	**0**	**32**	**0**	**0**	**0**	**64**	**76**	

Assessment strategy	Weight %	Deadline	Assessment criteria
Seminar presentation	20	during the semester	Clear presentation of the content, answers to qustions, participation in discussions.
Independent problem solving	40	during the semester	Timely solutions.
Exam	40	final examination session	Clarity, ability to concisely present the essential information.

Author	Publishing year	Title	Issue of a periodical or volume of a publication; pages	Publishing house or internet site
Required reading				
L. E. Reichl	2016	A modern course in statistical physics		Wiley-VCH Verlag
R. K. Pathria, P. D. Beale	2011	Statistical mechanics, 3rd edition		Elsevier
D. Tong	2016	Statistical field theory		http://www.damtp.cam.ac.uk/user/tong/sft.html
J. P. Sethna	2011	Statistical mechanics: Entropy, order parameters, and complexity		Clarendon Press, Oxford
Recommended reading				
M. Kardar	2007	Statistical physics of fields		https://doi.org/10.1017/CBO9780511815881
D. Tong	2012	Statistical physics		http://www.damtp.cam.ac.uk/user/tong/statphys.html

H. E. Stanley	1999	Scaling, universality and renormalization: Three pillars of modern critical phenomena		http://dx.doi.org/10.1103/RevModPhys.71.S358
C. J. Pethick, H. Smith	2008	Bose-Einstein condensation in dilute gases		Cambridge University Press