COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
Nonequilibrium statistical physics	

Lecturer(s)	Department(s) where the course unit (module) is delivered
Coordinator: prof. Darius Abramavičius **Other(s):**	VU Fizikos fakultetas, Saulėtekio al. 9/III, Vilnius

Study cycle	Type of the course unit (module)
second	optional

Mode of delivery	Period when the course unit (module) is delivered	Language(s) of instruction
auditorial	1-th semester	Lithuanian/english

Requirements for students	
Prerequisites: Students must have completed courses on methods of mathematical physics, thermodynamics, statistical physics, quantum mechanics	**Additional requirements (if any):**

Course (module) volume in credits	Total student's workload	Contact hours	Self-study hours
5	140	64	76

Purpose of the course unit (module): programme competences to be developed		
Student will be acquinted with theoretical description of open quantum systems, mathematical methods that are applied for solution of such problems: application of perturbation theory, projection operators, stochastic methods.		
Learning outcomes of the course unit (module)	**Teaching and learning methods**	**Assessment methods**
Understand the origin of relaxation processes in microscopic quantum systems.	Lectures, seminars, self-studying.	Written exam
Connection of thermodynamics and quantum mechanics		
Get equations of motions describing open quantum systems by using the theory of reduced density matrix and from the theory of fluctuating wavepackets.		
Be able to compute relaxation rates for various physical model systems.		

Content: breakdown of the topics	Contact hours							Self-study work: time and assignments	
	Lectures	Tutorials	Seminars	Exercises	Laboratory work	Internship/work	**Contact hours**	**Self-study hours**	**Assignments**
1. Extended quantum systems. Open and closes quantum systems. Control mass and control volume systems. Concept of conditional probability in physics. Chapman-Kolmogorov relation. Master equation. Fokker-Planck equation.	3		0				**3**	**7**	Read literature on the topic
2. Open classical system. Characteristics of the environment. Fluctuation-dissipation relation. Relation between Langevin equation and Fokker-Planck equation.	3		0				**3**	**7**	Read literature on the topic
3. Interpretations and representations in quantum mechanics. Coherent states. Entanglement. Problem of detection. Decoherence. Environmentally-induced decoherence.	3		0				**3**	**7**	Read literature on the topic
4. Time dependent perturbation theory in the density matrix method. Markovian Redfield equation.	2		4				**6**	**7**	Read literature on the topic
5. General Markovian equation. Lindblad equation. Relation with the Redfield equation.	3		0				**3**	**7**	Read literature on the topic
6. Spin-boson model. Born Markov equation. Effects of diagonal and off-diagonal fluctuations.	3		5				**8**	**7**	Read literature on the topic
7. Projection operator method. Nakajima-Zxanzig equation. Relation with the perturbation theory.	3		4				**7**	**7**	Read literature on the topic
8. Path integrals. Stationary states of the open quantum system. Polarons. Pointer states.	3		5				**8**	**7**	Read literature on the topic
9. Application of the time dependent variational approach. Langevin equation for coherent states. Fixed points of the equations of motion.	3		4				**7**	**7**	Read literature on the topic
10. Hierarchies of equations for the density operators and for wave functions.	3		5				**8**	**7**	Read literature on the topic
11. Principles of quantum thermodynamics.	3		5				**8**	**6**	Read literature on the topic
Total	**32**		**32**				**64**	**76**	

Assessment strategy	Weight,%	Deadline	Assessment criteria
Exam	100%	Exam session	Perfect knowledge of theory. Maximal evaluation – 10 points

Author	Year of publication	Title	Issue of a periodical or volume of a publication	Publishing place and house or web link
Compulsary reading				
L. Valkunas, D. Abramavičius, T. Mancal	2013	Molecular excitation dynamics and relaxation		Wiley-VCH
M. Schlosshauer	2008	Decoherence		Springer

N. G. van Kampen	2008	Stochastic processes in physics and chemistry		Elsevier
Papildoma literatūra				
Optional reading				
H. P. Breuer, F. Petruccione	2010	The theory of open quantum systems		Oxford