Course unit (module) title	Code
SYNERGETICS	

Lecturer(s)	Department(s) where the course unit (module) is delivered
Coordinator: assoc. prof. dr. O. Rancova **Other(s):**	Vilnius University, Faculty of Physics

Study cycle	Type of the course unit (module)
Full-time studies (2nd stage)	Compulsory/selective

Mode of delivery	Period when the course unit (module) is delivered	Language(s) of instruction
Lectures, exercises	I/III semester	Lithuanian/English

Requirements for students

Prerequisites: The students should contain the general knowledge of physics and mathematics.	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

- Ability to understand and explain the principles of the structure and functioning of living systems in molecular, cellular and system level by applying the concepts of complex systems, open systems thermodynamics, modern Biophysics.

Learning outcomes of the course unit (module)	Teaching and learning methods	Assessment methods
• understanding and ability to explain the principles of the functioning of living and other complex systems from the viewpoint of physics and thermodynamics laws; • ability to integrate biophysical topics and data from molecular, cellular and systems level.	Teaching modes: lectures, seminars, practical work. Methods: problem teaching, solving of tasks	Written examination, student's presentations, term paper

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. Main features of living systems, ecological perspective. **Nonlinear systems and complexity**: Open non-equilibrium systems. Selforganization. Common features of various nonlinear systems. Feedback and selfregulation. Historic overview of the structure formation and evolution in the nonlinear and nonequilibrium systems.	8		2				**8**	**16**	Reading lecture material, and scientific literature
2. **Basics of synergetics**: Phase space and phase trajectories. Fixed points and their classification. Autooscillations. Limited cycle. Bifurcations. Mechanical, electrical, chemical and biological autooscillations. Laser generation. General theory of the structure formation in nonequillibrium conditions. Benard effect. Progogine – Lefever – Nicolis model. Autowaves. Spreading fronts.	14		8				**14**	**28**	Reading lecture material, and scientific literature

Spreading impulses. Dissipative structures in biology. Morphogenesis. Nerve impulses. Stochastic models. Markov processes. Master equation. Fokker – Planck equation. Langevin equation. Nonequilibrium phase transitions. Transition probability between stable fixed states. Dynamic chaos. Logistic representations. Self-organized criticality. Development scenarios of the dynamic chaos. Geometry of nature – fractals.										
3. **Life**: Networks, their realization and patterns of life. Autopoiesis – the organization of the living. Modelling of autopoietic networks. Dissipative structures. Gaia hypothesis. Novel view of evolution. Scenario of the terrestrial chemical and biological evolution. Prebiotic evolution. Mathematical modelling of evolution. The minimal form of life. Chemical elements of life. Micelles, membranes, protocells. Genetics, DNA and proteins. Catalysis and complexity. Exchanges of the genetic information. Symbiosis. Networks of life. Nucleated cells, organells. Evolution of plants and animals. Human evolution. Santiago theory of cognition. Consciousness and its social dimension. Structure of biological and social systems. Social networks. Organizations of the living systems. Globalisation and ecological conception.	10		6				**10**	**20**	Reading lecture material, and scientific literature, preparation for discussions and seminars
4. **Practical training**. Mathematical modeling of living systems and processes. Practical solutions of the model systems.				16			**16**	**8**	Reading lecture material, and scientific literature preparation for discussions and seminars
Total	**32**		**16**	**16**			**64**	**72**	

Assessment strategy	**Weight,%**	**Assessment period**	**Assessment criteria**
Written examination	30	Exam session	3 open questions evaluated separately. Final evaluation is in 10 grades system. Minimum 5 points.
Term paper	30	During semester	Solutions of mathematically formulated problems. 2 problems evaluated separately. Final evaluation is in 10 grades system. Minimum 5 points.
Term paper	30	During semester	3 open questions evaluated separately. Final evaluation is in 10 grades system. Minimum 5 points.
Presentation	10+	During semester	By presenting on the suggested or students selected topics student may collect additional points to compensate the grades obtained from the term papers. Active students may collect more that 10% of the final evaluation
Total	100		Final mark is based on cummulative score

Author	**Year of publication**	**Title**	**Issue of a periodical or volume of a publication**	**Publishing place and house or web link**
Compulsory reading				

J. J. Kaladė and L. Valkūnas	2009	Matematinis modeliavimas ir sinergetikos pagrindai ("Mathematical modeling")		Vilnius
H. Haken	2006	Information and Self-Organization: A Macroscopic Approach to Complex Systems		Springer Verlag
H. Haken	2004	Synergetics: Introduction and Advanced Topics		Springer Verlag
J. Schopf	2002	Life's Origin: The Beginnings of Biological Evolution		University of California Press LTD
N. Lahay	1999	Biogenesis: Theories of Life's Origin		Oxford university Press
F.J.Dyson	2000	Origins of Life,		Cambridge university Press
F.Capra	1996	The Web of Life, A New Scientific Understanding of Living Systems		Bantum Inc
F.Capra	2002	The Hidden connections: Integrating the biological, cognitive and social dimensions of life into a science of sustainability		Doubleday
Optional reading				
I. Prigogine	1997	The End of Certainty, Time`s Flow and the Laws of Nature		The Free Press
Prigogine and I. Strengers	1984	Order out of Chaos. Man`s new dialogue with nature		Heinemann
V. I. Sugakov	1998	Lectures in Synergetics		World Scientific Co