COURSE UNIT (MODULE) DESCRIPTION

Course unit (module) title	Code
Nonlocal Mathematical 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 mathematical physics, 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 methods of Green's functions, integral equations, integral trnasformations, special functions, fractional integration and differentiation, processes of anomalous diffusion, percolation, fractional classical and quantum mechanics and fractional relaxation processes.		
Learning outcomes of the course unit (module)	**Teaching and learning methods**	**Assessment methods**
Understand the causality principles of mathematical problems, locality of mathematical operations, and nonlocality concept	Lectures, practices, seminars, self-studying.	Evaluation of seminars and written exam
Understand the symmetry relations of mathematical functions		
Understand the fractional integration and differenciation. Application of these operations in describing real physical processes.		

Content: breakdown of the topics	Contact hours							Self-study work: time and assignments	
	Lectures	Tutorials	Seminars	Exercises	Laboratory work	Internship/work placement	**Contact hours**	**Self-study hours**	**Assignments**
1. **Theory of Green's functions.** Eigenfunction problems, conjugate differential equations, homogeneous and non-homogeneous problems, Green's functions, their types.	2			2			**4**	**7**	Read literature on the topic
2. **Special functions.** Bessel and Hankel functions, Legendre functions, Laguerre and Chebyshev polynomials. Recurrent relations, orthogonality.	2			2			**4**	**7**	Read literature on the topic
3. **Integral transformations.** Fourier and Laplace transformations, properties of convolution, Transformations of special functions.	2			2			**4**	**7**	Read literature on the topic
4. **Integral equations.** Classification, application of integral transformations, Neuman expansion, relation to Green's functions.	2			2			**4**	**7**	Read literature on the topic
5. **Non-local relations.** Principles of Volterra, nonlocality in time and space.	3			3			**6**	**7**	Read literature on the topic
6. **The class of power-law functions.** Self-similarity. Lon-lived memory effects, self-similarity in space, effects in geometry.	3			3			**6**	**7**	Read literature on the topic
7. **Principles of fractional calculus.** Extension of Leiblitz rule, four definitions of fractional derivatives, definition based on finite differences, nonlocality of fractional derivative.	3			3			**6**	**7**	Read literature on the topic
8. **Fractional integration.** Definitions of Liouville and Riemmann, Liouville Caputo and Riemmann Caputo. Relation to differentiation.	3			3			**6**	**7**	Read literature on the topic
9. **Application of fractional calculus:** fractional harmonic oscillator, wave equations.	3			3			**6**	**7**	Read literature on the topic
10. **Extension of quantum mechanics.** Canonical quantization, fractional schroedinger equation, radial functions, quantum harmonic oscillator, fractional cosmology.	3			3			**6**	**7**	Read literature on the topic
12. **Review of the current scientific problems.**	6			6			**12**	**14**	Read literature on the topic
Total	**32**			**32**			**64**	**76**	

Assessment strategy	Weight,%	Deadline	Assessment criteria
Seminar	40 %	15-16 week of the semester	Excellence in problem solution, scientific literature overview, presentations. Maximum 4 points
Exam	60 %	Exam session	Perfect knowledge of the subject. Maximal evaluation – 6 points
Final evaluation			Seminar eval. + exam evaluation

Author	Year of publication	Title	Issue of a periodical or volume of a publication	Publishing place and house or web link
Compulsary reading				
R. Herrmann	2014	Fractional calculus: an introduction for physicists		World Scientific
V. V. Uchaikin	2013	Fractional Derivatives for Physicists and Engineers		Springer
G. Arfken, H. Weber, F. E. Harris	2012	Mathematical Methods for Physicists		Academic press
Papildoma literatūra				
Optional reading				