

Subject card

Subject name and code	Mathematical Methods of Physics II, PG_00182571						
Field of study	Physics						
Date of commencement of studies	October 2025		Academic year of realisation of subject		2026/2027		
Education level	Bachelor's studies		Subject group		Obligatory subject group in the field of study Optional subject group Subject group related to scientific research in the field of study		
Mode of study	full-time studies		Mode of delivery		at the university		
Year of study	2		Language of instruction		Polish		
Semester of study	4		ECTS credits		4.0		
Learning profile	academic		Assessment form		credit		
Conducting unit	Division of Mathematical Methods of Physics -> Institute of Theoretical Physics and Astrophysics -> Faculty of Mathematics, Physics and Informatics -> Rector						
Name and surname of lecturer (lecturers)	Subject supervisor		dr Krzysztof Szczygielski				
	Teachers						
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	15.0	0.0	0.0	0.0	45
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours		Self-study	SUM
	Number of study hours	45		0.0		55.0	100
Subject objectives	Familiarizing students with basic notions, theorems and methods of functional analysis and their applications in physics.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[FIZL3_U01] can use advanced mathematical formalism to define, describe, and solve problems in physics	The student is able to: provide and characterize the basic concepts of Hilbert and Banach space theory; use the conceptual apparatus of functional analysis in Hilbert space; characterize the eigenvalue problem of an operator and the concept of spectrum and justify the significance of self-adjoint operators in quantum mechanics; define the concept of distributions and provide examples of them; define the concept of orthogonal polynomials and provide examples of them.	[SU1] oral statement/conversation/discussion [SU3] text preparation/written work [SU4] test/exam - oral or written
	[FIZL3_W04] knows the methods of higher mathematics, including differential and integral calculus of functions of one and many variables, and the basics of algebra to the extent necessary to describe physical phenomena and solve physical problems	The student knows: the basic structures used in linear algebra, topology, and measure theory; the fundamentals of Banach space theory: the concept of metric, norm, completeness; the Hölder and Minkowski inequalities; the basics of Hilbert space theory; the concept of dual space and linear functional, Riesz's representation theorem; the definition and examples of linear mappings, bounded operators; the concept of resolvent operator, operator spectrum, the eigenvalue problem, and decomposition of the spectrum; properties of self-adjoint and unitary operators; applications and properties of orthogonal polynomials; elements of distribution theory.	[SW4] test/exam - oral or written [SW1] oral statement/conversation/discussion [SW3] text preparation/written work
Subject contents	1. Theory of Banach and Hilbert spaces 2. Linear operators and functionals 3. Spectrum of linear operator, eigenvectors and eigenvalues 4. Self-adjoint and unitary operators 5. Compact, trace class and Hilbert-Schmidt operators 6. Orthogonal polynomials. Properties and applications 7. Elements of theory of distributions with applications		
Prerequisites and co-requisites	Knowledge of linear algebra and mathematical analysis at the level of the first three semesters of studies in the field of Physics. Earlier completion of the course <i>Mathematical Methods of Physics I</i> .		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	Classwork	51.0%	100.0%
Recommended reading	Basic literature	1. J. Conway, <i>A Course in Functional Analysis</i> , Springer Science 1985 2. J. Conway, <i>A course in Operator Theory</i> , AMS 1991 3. W. Rudin, <i>Functional analysis</i> , PWN 2001	

	Supplementary literature	1. W. A. Majewski, <i>Matematyczne metody fizyki 1</i> , UG 1989 2. W. A. Majewski, <i>Wstęp do fizyki matematycznej</i> , UG 1990 3. L. Górniewicz, R. Ingarden, <i>Analiza matematyczna dla fizyków</i> , t. 1. i 2., PWN 1981
	eResources addresses	
Example issues/ example questions/ tasks being completed	Sample exam topics: 1. Define the concept of a topological vector space. 2. Characterize Banach and Hilbert spaces and provide examples of them. 3. Characterize the concept of a dual space. Provide Riesz's representation theorem. 4. Define the concept of a bounded operator and operator norm. Describe the relationship between continuity and boundedness. 5. Provide the definition of a resolvent operator, regular value, and operator spectrum. Describe the classification of the spectrum. 6. Formulate the spectral theorem for a normal operator on a Hilbert space. Sample tasks covered during classes: 1. Investigating selected algebraic and topological properties of various linear spaces and algebras, e.g., ℓ^p and L^p spaces. 2. Verifying properties of metrics, norms, and inner products. 3. Investigating selected linear operators on Hilbert and Banach spaces and their properties, such as symmetry and self-adjointness. Basic spectral analysis.	
Work placement	Not applicable	

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