Subject card

Subject name and code	Mathematical Methods of Physics, PG_00182297					
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 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	3		ECTS credits		8.0	
Learning profile	academic		Assessment form		exam	
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	45.0	45.0	0.0	0.0	0.0	90
	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	90		0.0	110.0	200
Subject objectives	Familiarizing students with basic concepts, theorems and methods of complex analysis, elements of the theory of analytical functions and the basics of harmonic analysis. Familiarizing the student with the concept of the measure integral, including the Lebesgue integral.					

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[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 topological properties of the complex plane; the concept of holomorphic functions; the concept of line integrals of complex functions; equivalent conditions for holomorphicity; analyticity, the concept of Laurent series; the residue theorem and its application to calculating integrals of real functions; the concept of trigonometric series and Fourier series of real functions, formulas for the coefficients of Fourier series; Bessel's inequality and Parseval's identity; theorems on the convergence of Fourier series; the definition and properties of the Fourier transform.	[SW4] test/exam - oral or written [SW1] oral statement/ conversation/discussion [SW3] text preparation/written work
	[FIZL3_U01] can use advanced mathematical formalism to define, describe, and solve problems in physics	The student is able to: investigate the convergence of complex sequences and the continuity of functions with a complex domain; examine the holomorphic nature of a complex function from definition and by using Cauchy-Riemann equations; calculate derivatives and line integrals of complex functions, expand them into power series and determine the radius of convergence of that series; analyze the type of singular point and expand a meromorphic function into a Laurent series; compute residues, apply the residue theorem to calculate improper integrals of real functions; determine the coefficients of the Fourier series expansion of a real function and assess its convergence.	[SU1] oral statement/conversation/ discussion [SU3] text preparation/written work [SU4] test/exam - oral or written

Subject contents	1. Complex functions. Derivative of a complex function 2. Holomorphic functions. Cauchy-Riemann equations and their relationship to holomorphic functions 3. Cauchy's integral theorem, Cauchy's integral formula 4. Analytic and meromorphic functions. Laurent series 5. Singularities, residua, and calculating integrals with them 6. Elements of Hilbert's space theory and space L^2 7. The Fourier series and its convergence. Orthogonal polynomials 8. Fourier transform, its properties and applications
Prerequisites and co-requisites	Knowledge of linear algebra and mathematical analysis at the level of the first two semesters of studies in the field of Physics.

Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	Exam	51.0%	50.0%
	Classwork	51.0%	50.0%

Recommended reading	Basic literature	1. F. Leja, *Funkcje zespolone*, PWN, Warszawa 2006 2. L. Grafakos, *Classical Fourier Analysis*, Springer, New York 2008 3. W. Rudin, *Real and complex analysis*, PWN Warszawa 1998
	Supplementary literature	1. G. M. Fichtenholz, *Rachunek różniczkowy i całkowy*, t. I, II, III, PWN, Warszawa 1972 2. H. Rasiowa, *Wstęp do matematyki współczesnej*, PWN Warszawa 1973 3. K. Kuratowski, *Rachunek różniczkowy i całkowy*, PWN Warszawa 1973 4. F. Leja, *Rachunek różniczkowy i całkowy*, PWN Warszawa 1971 5. A. W. Bicadze, *Równania fizyki matematycznej*, PWN Warszawa 1984
	eResources addresses	

Example issues/ example questions/ tasks being completed	Exemplary exam questions: 1. Characterize the derivative of a complex function and the concept of a holomorphic function. Provide necessary and sufficient conditions for holomorphicity of a function. 2. Define the integral of a complex function along a path in the complex plane. Characterize the relationship between the integral along a path and the antiderivative. 3. State Cauchy's integral theorem for holomorphic functions. 4. Characterize the concept of Laurent series for analytic functions in a circular ring. Provide a formula for the coefficients of the expansion in series. 5. Define singular points and provide their classification. Characterize the concept of a residue of a function and formulate the residue theorem. 6. Characterize the concept of an integral with respect to a measure. Provide examples. Exemplary class problems: 1. Study of various properties of the complex plane. Sets in the plane and their closedness. 2. Verifying the convergence of sequences in the complex plane and calculating limits. Verifying the existence of limits of complex functions and calculating them. 3. Checking the holomorphicity of complex functions. Cauchy-Riemann equations. 4. Integrating complex functions along contours with and without using Cauchy's integral theorem. Parameterizing curves. 5. Calculating residues of meromorphic functions and integrating using the residue theorem. Investigating singular points of functions. 6. Calculating coefficients of the expansion of functions in a Fourier series.
Work placement	Not applicable