

Subject card

Subject name and code	Algebra, PG_00182291						
Field of study	Physics						
Date of commencement of studies	October 2025		Academic year of realisation of subject		2025/2026		
Education level	Bachelor's studies		Subject group		Obligatory subject group in the field of study		
Mode of study	full-time studies		Mode of delivery		at the university		
Year of study	1		Language of instruction		Polish Classes may be conducted in English in the following cases: - when the course is taught by an English-speaking instructor, - when a non-Polish-speaking international student is present in the group, - when the course is delivered by an invited external expert, - at the request of the students in the group.		
Semester of study	2		ECTS credits		8.0		
Learning profile	academic		Assessment form		exam		
Conducting unit							
Name and surname of lecturer (lecturers)	Subject supervisor		dr hab. Adam Rutkowski				
	Teachers						
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	45.0	45.0	15.0	0.0	0.0	105
	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	105		0.0		100.0	205
Subject objectives	The aim of the course is to familiarize students with fundamental concepts of algebra that allow the introduction and analysis of linear spaces and linear mappings between them. The course covers topics related to matrices and determinants, systems of linear equations, dual spaces, eigenvalue problems, and quadratic forms. The lectures provide a clear presentation of these concepts and theorems using finite-dimensional vector spaces, whose generalizations play a key role in Hilbert space theory. Understanding these topics facilitates the later introduction of ideas relevant to physical applications.						

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 concepts of linear and abstract algebra, such as matrices, determinants, vector spaces, groups, rings, and fields. They understand the properties of algebraic operations and the relationships between algebraic structures solving physical problems.	[SW4] test/exam - oral or written [SW1] oral statement/conversation/discussion [SW2] presentation/project/paper/report [SW3] text preparation/written work [SW5] implementation of a problem task
	[FIZL3_U01] can use advanced mathematical formalism to define, describe, and solve problems in physics	The student can perform operations on matrices, calculate determinants, eigenvalues, and eigenvectors. They can examine the properties of groups, rings, and fields and apply them to solve algebraic problems. They can use the tools of linear and abstract algebra to model physical and mathematical problems. They can prove simple algebraic theorems and justify the correctness of their solutions.	[SU1] oral statement/conversation/discussion [SU3] text preparation/written work [SU4] test/exam - oral or written [SU5] implementation of a problem task

1. Linear spaces

- Definition and basic properties of linear spaces
- Subspaces, linear dependence and independence of vectors
- Spanning, basis, and dimension of a linear space
- Isomorphisms of linear spaces

2. Homomorphisms of linear spaces

- Definition of a homomorphism of linear spaces
- Algebra of endomorphisms of a linear space
- Matrix representation of endomorphisms
- Properties of endomorphisms, eigenvectors, and eigenvalues
- Change of basis

3. Functionals and forms

- Linear and bilinear functionals and forms
- Quadratic functionals and forms
- Quadratic functionals and forms in real spaces

4. Euclidean spaces

- Scalar product and definition of Euclidean space
- Euclidean spaces as normed and metric spaces
- Orthonormal bases
- Isomorphisms and endomorphisms of Euclidean spaces
- Self-adjoint and orthogonal endomorphisms

5. Elements of the tensor product for physicists

Prerequisites and co-requisites	The student should know: 1. Basic operations on real and complex numbers, powers, and roots. 2. Properties of elementary functions. 3. Fundamentals of mathematical logic and theorem proving. 4. Basics of linear algebra at an introductory level (vectors, matrices, systems of linear equations).														
Assessment methods and criteria	<table><tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr><tr><td></td><td>51.0%</td><td>10.0%</td></tr><tr><td></td><td>51.0%</td><td>40.0%</td></tr><tr><td></td><td>51.0%</td><td>50.0%</td></tr></table>	Subject passing criteria	Passing threshold	Percentage of the final grade		51.0%	10.0%		51.0%	40.0%		51.0%	50.0%		
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Recommended reading	Basic literature	1. A. Mostowski, M. Stark Algebra liniowa, PWN, Warszawa 1976. 2. W. Banaszak, W. Gajda Elementy algebry liniowej, cz. I i II, WNT, Warszawa 2002. 3. H. Arodź, K. Rościszewski Algebra i geometria analityczna w zadaniach, Znak, Kraków 2005. 4. Sheldon Axler Linear Algebra Done Right, Springer, 4th ed., 2021. 5. Gilbert Strang Introduction to Linear Algebra, WellesleyCambridge Press, 5th ed., 2016. 6. Steven Roman Advanced Linear Algebra, Springer, 4th ed., 2023.													
	Supplementary literature	• David C. Lay, Steven R. Lay, Judi J. McDonald Linear Algebra and Its Applications, Pearson, 5th ed., 2016. • Howard Anton, Chris Rorres Elementary Linear Algebra with Applications, Wiley, 12th ed., 2019. • Jim Hefferon Linear Algebra, 4th ed., 2023 .													
	eResources addresses														
Example issues/ example questions/ tasks being completed															
Work placement	Not applicable														

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