

Subject card

Subject name and code	Applications of Group Theory in Physics, PG_00209695						
Field of study	Mathematics						
Date of commencement of studies	October 2026		Academic year of realisation of subject		2026/2027		
Education level	Master's studies		Subject group		Obligatory subject group in the field of study Optional subject group		
Mode of study	full-time studies		Mode of delivery		at the university		
Year of study	1		Language of instruction		Polish		
Semester of study	2		ECTS credits		5.0		
Learning profile	academic		Assessment form		credit		
Conducting unit							
Name and surname of lecturer (lecturers)	Subject supervisor		dr hab. inż. Marek Krośnicki				
	Teachers						
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	30.0	0.0	0.0	0.0	60
	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	60		3.0		62.0	125
Subject objectives	Introduction to the formalism and structure of groups, along with the elements of representation theory. Introduction to point groups, space groups, and Lie groups. Familiarization of the student with the applications of the groups SU(2), SU(3), and O(3). Demonstrating to the student how the symmetry properties of a system (molecule, crystal) determine the nature of its internal energy structure and allow (partially) the prediction of the systems response to an external perturbation (e.g., light); training the student to apply group theory to the analysis of the properties of simple systems.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[MATMU2_W01] knows and understands in depth the theory of selected areas of mathematics or related fields, the complex relationships between them and their development trends	The student knows: 1) selected definitions, concepts, and theorems of group theory. 2) symmetry operations and symmetry elements in point groups. 3) selected types of point groups. 4) the rotation group R(3). 5) the role of group theory in predicting the physical properties of molecules and crystals. 6) mechanisms of chemical bond formation. 7) SU2, Su3 groups.	[SW4] test/exam - oral or written [SW2] presentation/project/paper/report
	[MATMU2_U05] is able to apply new or adapt existing methods and tools from a selected field of mathematics and information and communication technologies in related fields	The student is able to: 1) use group theory to find non-zero matrix elements of a given matrix and independently derive selection rules for the appropriate molecule 2) build a character table for a selected point group representation 3) construct symmetry orbitals 4) investigate the splitting of energy levels of an atom in the presence of a crystal field 5) investigate the splitting of energy levels of an ion in the presence of a ligand field 6) determine the types of symmetry of normal vibrations 7) deal with double groups (half-angular momentum)	[SU3] text preparation/written work
Subject contents	1. Introduction and fundamentals of group theory -Definition of a group, examples of finite and infinite groups, elements of notation. -Subgroups, conjugate elements, classes, homomorphisms. 2. Structure of groups -Abelian and non-Abelian groups. -Permutation groups. -Point groups in physics. -Space groups. -Particularly important examples: SU(2), SU(3), O(3). 3. Lie groups and their representations -Definition and examples of Lie groups. -Lie algebras and their role in physics. 4. Representation theory in quantum mechanics 5. Applications -Selection rules and state degeneracies. -Use of symmetry to simplify quantum-mechanical calculations of electronic states. -Examples of applications in atomic physics, molecular physics, and solid-state physics.		
Prerequisites and co-requisites	Linear algebra and basic mathematical analysis		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	Oral exam	51.0%	50.0%
	“completion of 2 problem-solving tasks	51.0%	20.0%
	2 written assignments completed during class	51.0%	30.0%
Recommended reading	Basic literature	J.F. Cornwell, Group Theory in Physics: An Introduction, Academic Press, 1997.	
		D.M. Bishop, Group Theory and Chemistry, Dover, 1993	
	Supplementary literature	M.S. Dresselhaus,G. Dresselhaus,A. Jorio Group Theory Application to the Physics of Condensed Matter, Springer-Verlag, 2008	
	eResources addresses		
Example issues/ example questions/ tasks being completed			
Work placement	Not applicable		

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