University of Gdańsk

Subject card

Subject name and code	Applications of Group Theory in Physics, PG_00182322		
Field of study	Physics		
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 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	1	Language of instruction	Polish
Semester of study	2	ECTS credits	5.0
Learning profile	academic	Assessment form	exam
Conducting unit			
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. inż. Marek Krośnicki	
	Teachers	dr hab. inż. Marek Krośnicki Rashi Adhikari	

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	0.0	65.0	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
[FIZMU2_U01] is able to apply the scientific method in solving physical problems, conducting experiments and reasoning	"Able to apply the formalism of group theory in calculations and in the interpretation of experimental results.	[SU4] test/exam - oral or written
[FIZMU2_K01] knows the limitations of his own knowledge and skills; can formulate questions precisely; understands the need for further education and other	Understands the limitations of their knowledge and skills in group theory, can formulate precise questions for further development	[SK1] oral statement/conversation/ discussion
[FIZMU2_U09] can work independently or in a team	Able to work independently or in a team on problem-solving tasks involving the application of group theory in physics.	[SU5] implementation of a problem task
[FIZMU2_W05] knows the theoretical foundations of computational methods and IT techniques used to model and simulate physical systems	The student knows the theoretical foundations of symmetry-based computational methods used for modeling and simulation of physical systems, can apply group theory to analyze the energy structure of simple atomic, molecular, and crystalline systems.	[SW3] text preparation/written work
[FIZMU2_W04] knows the principle of operation of measuring systems and research equipment specific to the area of physics related to the selected specialization or knows advanced methods of theoretical and mathematical physics	The student is able to use group theory methods in analysis of the results of a spectroscopical experiment	[SW4] test/exam - oral or written
[FIZMU2_W02] has in-depth knowledge in mathematics as well as mathematical and computational methods, necessary to solve physical problems of high complexity and in-depth in the selected area of physics	Knows the theoretical foundations of symmetry-based computational methods and is able to use selected computational tools to model electronic structure of molecular systems.	[SW3] text preparation/written work
[FIZMU2_W01] has advanced knowledge of general physics and in-depth knowledge of various areas of physics; knows the history of the development of physics and its importance for the progress of exact and natural sciences, cognition of the world and social development	Understands advanced methods of group theory in theoretical physics and can indicate their applications to the study of atoms, molecules, and crystals.	[SW3] 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

Basic quantum mechanics,

<table>
<tr><td>Assessment methods and criteria</td><td colspan="3"><table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>Oral exam</td><td>51.0%</td><td>50.0%</td></tr>
<tr><td>“completion of 2 problem-solving tasks</td><td>51.0%</td><td>20.0%</td></tr>
<tr><td>2 written assignments completed during class</td><td>51.0%</td><td>30.0%</td></tr>
</table></td></tr>
<tr><td rowspan="3">Recommended reading</td><td>Basic literature</td><td colspan="2">J.F. Cornwell, Group Theory in Physics: An Introduction, Academic Press, 1997.

D.M. Bishop, Group Theory and Chemistry, Dover, 1993</td></tr>
<tr><td>Supplementary literature</td><td colspan="2">M.S. Dresselhaus,G. Dresselhaus,A. Jorio Group Theory
Application to the Physics of Condensed Matter, Springer-Verlag, 2008</td></tr>
<tr><td>eResources addresses</td><td colspan="2"></td></tr>
<tr><td>Example issues/ example questions/ tasks being completed</td><td colspan="3"></td></tr>
<tr><td>Work placement</td><td colspan="3">Not applicable</td></tr>
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