GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Modern atomic and molecular physics, PG_00069091		
Field of study	Technical Physics, Materials Engineering, Mathematics, Nanotechnology, Nanotechnology		
Date of commencement of studies	October 2024	Academic year of realisation of subject	2025/2026
Education level	second-cycle studies	Subject group	Optional subject group
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	1.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Division of Computational Chemical Physics -> Institute of Physics and Applied Computer Science -> Faculty of Applied Physics and Mathematics -> Wydziały Politechniki Gdańskiej		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. Jan Franz	
	Teachers	dr hab. Jan Franz	

Lesson types and methods of instruction

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	15.0	0.0	0.0	0.0	0.0	15
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	15	2.0	8.0	25

Subject objectives

The aim is to develop fundamental knowledge of the structure and behaviour of atoms and molecules through quantum mechanics and to investigate how this knowledge explains spectroscopic phenomena, chemical bonding and interactions with electromagnetic fields, providing a basis for applications in physics, chemistry and materials science.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W01] has extended and systematized knowledge of the leading of physics.	Students will demonstrate structured and in-depth knowledge of key concepts and methods in atomic and molecular physics.	[SW1] Assessment of factual knowledge
[K7_K01] knows limitations of own knowledge, understands the need to learn and improve professional and personal competencies	Students will be able to recognize the limitations of their current knowledge in atomic and molecular physics and critically assess areas requiring further development.	[SK5] Assessment of ability to solve problems that arise in practice

Subject contents	1. Fundamentals of quantum mechanics 2. Mathematical methods 3. Angular momentum 4. Simple atoms (hydrogen and helium) 5. Multi-electron atoms 6. Molecular structure 7. Molecular symmetry 8. Molecular orbitals 9. Molecular rotation 10. Molecular vibrations 11. Electronic states of molecules 12. Electrical properties of molecules 13. Magnetic properties of molecules 14. Further directions of development and applications 15. Summary
Prerequisites and co-requisites	Knowledge of the basics of quantum mechanics.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
Homework	50.0%	100.0%

Recommended reading	Basic literature	H. Haken, H. Ch. Wolf, Molecular Physics and Elements of Quantum Chemistry,2nd edition, Springer-Verlag, Berlin, 2004. P. W. Atkins, J. Paula, J. Keeler, Physical Chemistry, 12th edition, Oxford University Press, Oxford, 2022. P. W. Atkins, R. S. Friedman, "Molecular Quantum Mechanics", Oxford University Press, 5th edition, Oxford, 2010.

	Supplementary literature	L. Piela, "Ideas of Quantum Chemistry, Volume 1", 3rd edition, Elsevier, Amsterdam, 2020. L. Piela, "Ideas of Quantum Chemistry, Volume 2", 3rd edition, Elsevier, Amsterdam, 2020. F. Jensen, Introduction to Computational Chemistry, 3rd edition, Wiley, Chichester, 2017. J. Harvey, "Computational Chemistry", Oxford University Press, Oxford, 2018.
	eResources addresses	
Example issues/ example questions/ tasks being completed	1. Explain the difference between vibrational and rotational energy levels in a diatomic molecule. 2. How does the bond length of a diatomic molecule affect its rotational spectrum? Explain in terms of the moment of inertia. 3. How would the rotational spectrum of a molecule change if the molecule were to undergo isotopic substitution (e.g., replacing H with D in HCl)? Justify your answer with appropriate equations. 4. Explain the Born-Oppenheimer approximation. What assumptions are made about the motion of the nuclei and electrons in the molecule?	
Work placement	Not applicable	