GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Molecular physics, PG_00068822		
Field of study	Biomedical Engineering, Biomedical Engineering, Biomedical Engineering		
Date of commencement of studies	February 2027	Academic year of realisation of subject	2026/2027
Education level	second-cycle studies	Subject group	Optional subject group Specialty subject group 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	1	ECTS credits	3.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Department of Physics of Electronic Phenomena -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	dr Małgorzata Franz	
	Teachers	dr Małgorzata Franz dr hab. Jan Franz	

Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	15.0	0.0	0.0	0.0	45
	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	45	4.0	26.0	75

Subject objectives	The aim of the course is to familiarize the student with selected issues of molecular physics.

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[K7_K01] is ready to create and develop models of proper behaviour in the work and life environment; undertake initiatives; critically evaluate actions of their own, teams and organisations they are part of; lead a group and take responsibility for its actions; responsibly perform professional roles taking into account changing social needs, including: - developing the achievements of the profession, - observing and developing rules of professional ethics and acting to comply to these rules	is able to prepare a presentation on molecular physics in relation to modern trends in biomedical engineering	[SK4] Assessment of communication skills, including language correctness
	[K7_U02] can perform tasks related to the field of study as well as formulate and solve problems applying recent knowledge of physics and other areas of science	is able to use the acquired knowledge in solving problems related to molecular physics	[SU3] Assessment of ability to use knowledge gained from the subject
	[K7_W02] knows and understands, to an increased extent, selected laws of physics and physical phenomena, as well as methods and theories explaining the complex relationships between them, constituting advanced general knowledge in the field of technical sciences related to the field of study	knows and understands the basics of molecular physics	[SW1] Assessment of factual knowledge

Subject contents	Course content – lecture LECTURE: 1. Introduction to the lecture: black body radiation, photoelectric effect, Compton effect, Bohr model of hydrogen atom, de Broglie hypothesis, basic concepts of quantum mechanics. 2. Fundamentals of quantum mechanics: matter waves, wave-particle duality, wave function, Schrödinger equation, stationary Schrödinger equation, Heisenberg uncertainty principle, free particle motion, particle in a potential cavity, tunnelling phenomenon, harmonic oscillator. 3. Electrical properties of molecules: dipole moment, polarizability, Langevin function, electric polarization vector, Lorentz field, Clausius-Mossotti formula, Debye formula. 4. Magnetic properties of molecules: magnetic moment, types of magnetic dipoles, magnetic susceptibility, magnetization vector, permanent and induced magnetic moments, Curie's law. 5. Structure of molecules: valence bond theory, basic molecular orbital theory, homonuclear diatomic molecules, heteronuclear diatomic molecules, polyatomic molecules. 6. Symmetry of molecules: elements of symmetry, group theory, applications of symmetry. 7. Spatial structure of the molecule: cartesian and internal coordinates of the molecule, structural parameters of the molecule, experimental methods for determining the spatial structure of molecules, optimization of the geometry of the molecule. 8. Molecular solid: types of crystal bonds, van der Waals interactions. 9. Basics of molecular spectroscopy: molecules internal energy, quantization of energy, energy distribution in thermal equilibrium, Lambert-Beer law, probability of absorption and emission of radiation, Einstein coefficients, types of spectroscopy. 10. Rotation energy of molecules: rotation energy of molecules, rotational spectrum, study of the structure of molecules based on the rotational spectrum. 11. Energy of vibrating molecule: harmonic oscillator, molecular vibrational energy, frequency of vibration and molecular structure. 12. Interaction of radiation with vibrating molecules: vibrational spectrum, scattering of radiation, Raman spectrum. 13. Vibrational-rotational spectra: rotational Raman spectroscopy, vibrational Raman spectroscopy. 14. Molecular electronic transitions: electronic spectra, deactivation of excited states. EXERCISES: Part I is carried out in the form of calculation exercises, in which tasks thematically related to the lecture are solved. 1. Fundamentals of atomic physics and quantum optics. 2. Quantum mechanical description of particle motion. 3. Electrical properties of molecules. 4. Magnetic properties of molecules.

5. Structure of molecules.

6. Symmetry of molecules.

7. Interactions between molecules.

8. Fundamentals of molecular spectroscopy.

9. Rotation of molecules.

10. Vibrational motion of molecules.

Part II takes the form of a seminar during which students give presentations on selected topics in molecular physics.

Prerequisites and co-requisites

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
problems solving	50.0%	20.0%
presentation	50.0%	20.0%
passing the lecture	50.0%	60.0%

Recommended reading

Basic literature	Z. Kęcki, "Podstawy spektroskopii molekularnej", Wydawnictwo Naukowe PWN, Warszawa 2013 G. Ślósarek, Biofizyka molekularna, Wydawnictwo Naukowe PWN Warszawa 2011. H. Haken, H. Ch. Wolf, Fizyka molekularna z elementami chemii kwantowej, Wydawnictwo Naukowe PWN Warszawa 1998.
Supplementary literature	P. W. Atkins, R. S. Friedman, "Molecular quantum mechanics", Oxford University Press, 1997.
eResources addresses	

Example issues/ example questions/ tasks being completed

Sample question for completing the lecture: Represent and describe the forms of internal energy of molecules.

An example of a presentation topic to be prepared as part of the second part of the exercises: Biosensors and their application in medical diagnostics.

An example of a task solved during Part I of the exercises: Determine the value and orientation of the electric dipole moment of the amide group, using the partial charges and atomic positions shown in the drawing.

Practical activites within the subject

Not applicable

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