GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Spectroscopic research methods, PG_00067892		
Field of study	Technical Physics		
Date of commencement of studies	February 2026	Academic year of realisation of subject	2026/2027
Education level	second-cycle studies	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	2	ECTS credits	2.0
Learning profile	general academic profile	Assessment form	assessment
Conducting unit	Department of Solid State Physics -> Faculty of Applied Physics and Mathematics -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	dr hab. Tomasz Wąsowicz	
	Teachers	dr hab. Tomasz Wąsowicz	

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	30.0	0.0	0.0	0.0	0.0	30
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	30	3.0	17.0	50

Subject objectives

The aim of the course is to discuss the basic theoretical and practical issues of spectroscopy and presentation of the various types of spectroscopic setups, methods and ways to interpret spectra.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_W02] has enhanced, theoretically-founded, detailed knowledge of selected field of physics, and sufficient knowledge of related fields of science or technology	The student has detailed knowledge of physical models describing the structure and properties of radiation–matter interaction and is able to relate them to engineering and technological issues.	[SW1] Assessment of factual knowledge [SW3] Assessment of knowledge contained in written work and projects
[K7_U07] has enhanced skill of preparing speeches in Polish and English, including presentation of own research results	The student prepares and delivers coherent, logically structured oral presentations in Polish and English, tailored to the audience, using appropriate specialist vocabulary and presenting the results of their own research or analyses.	[SU5] Assessment of ability to present the results of task [SU1] Assessment of task fulfilment
[K7_W06] has enhanced knowledge of the experimental methods and techniques applied in physics	The student knows and understands selected advanced experimental techniques used in collisional spectroscopy and can explain their principles of operation and areas of application.	[SW1] Assessment of factual knowledge

Subject contents	Course content – lecture Lecture: **Concept of the atom** **Introduction to spectroscopic measurement** **Quantum-mechanical model of atom** **Fine structure** **Hyperfine structure** **Isotope shift of spectral lines** **Stark effect** **Zeeman effect** **Transition probabilities of radiative processes** **Types of chemical bonding** **Molecular optical spectroscopy in the UV-VIS range** **Fundamentals of vibrational spectroscopy** **Fundamentals of rotational spectra formation** **Vibrationalrotational spectroscopy** **Electronic structure of energy levels** **Explaining the principle of photodynamic therapy based on the Jablonski diagram** **Photon-induced dissociation** **X-ray absorption spectroscopy** **Scattering spectroscopy** **Mass spectrometry** **Molecular beams** Laboratory: 1. Study of a trochoidal electron monochromator; 2. Mass spectrometry using quadrupole mass analyser; 3. Electron impact fluorescence spectra of N2 molecule; 4. Measurement and analysis of emission and absorption spectra of molecules.

Prerequisites and co-requisites	A course in atomic and molecular physics and quantum mechanics.	
Assessment methods and criteria		

Subject passing criteria	Passing threshold	Percentage of the final grade
Performance of laboratory exercises and laboratory reports preparation	100.0%	40.0%
Solving tasks and problems as part of homework	50.0%	10.0%
Final test from the theory	50.0%	50.0%

Recommended reading	Basic literature	[1] J.M.Hollas, Modern Spectroscopy, John Wiley & Sons, Ltd. [2] J.Sadlej, Molecular Spectroscopy, WNT, Warszawa (in Polish) [3] D.L.Pavia i in., Introduction to Spectroscopy, Brooks/Cole [4] Z.Kęcki, "Basics of molecular spectroscopy", PWN, Warszawa (in Polish) [5] P.Willmott, An Introduction to Synchrotron Radiation: Techniques and Applications, John Wiley & Sons, Ltd.
	Supplementary literature	[6] H. Haken, H. Ch. Wolf., "Molecular physics and elements of quantum chemistry", Springer [7] C.D.Wagner i in. Handbook of photoelectron spectroscopy, Perkin-Elmer Corporation [8] G.Bunker, Introduction to XAFS, Cambridge Univ. Press [9] A.Gołębiewski, Elements of quantum mechanics and chemistry, PWN (in Polish)
	eResources addresses	

Example issues/ example questions/ tasks being completed	1. What is a spectroscopy? Describe the types of spectroscopy due to the kind of radiation used. 2. What is a spectrum? Specify and describe the main parameters that characterize the spectral line shape. 3. List and describe the main causes of spectral lines broadening. 4. Define: transmittance, absorbance and absorption coefficient. 5. Describe term symbol which characterize atomic states under Russell-Saunders coupling (Spin-Orbit coupling) condition. 8. Write the selection rules for rotational transitions and define the rotational energy levels in a rigid rotor approximation. 9. How on the basis of rotation spectrum the molecule bond length can be determined (in a rigid rotor approximation)? 10. Write the selection rules for vibrational transitions and define the vibrational energy levels in an harmonic oscillator approximation. 11. Write the selection rules for vibrational transitions and define the vibrational energy levels for real oscillator (anharmonic oscillator). 12. How on the basis of vibration spectrum, bond energy of molecule can be determined? 13. Describe the shape of the vibration-rotation spectrum. 14. Raman spectroscopy: describe the origin and the idea of the phenomenon (e.g. on the basis of Placek polarizability theory) and shape of Raman spectrum. 15. Specify what the complementarity of Raman and IR spectroscopies means. 16. What is the origin of color of the transition metals complexes? 17. Explain the main cause of the line broadening observed in UV-Vis spectrum. 18. What is the auxochrome and how it can change the UV-Vis spectrum? 19. Explain hyperchromic and hypochromic effect, bathochromic and hypsochromic shift. 20. Photoelectron spectroscopy (PES, ESCA): describe the main idea of the technique and present the phenomena which accompanying the effect of the core electron photoexcitation (secondary effects, multi-electron effects). 21. Why photoelectron spectroscopy is a surface sensitive technique? 22. X-ray absorption spectroscopy (XAS): describe the origin of the phenomenon. 23. What kind of information can provide us X-ray absorption spectrum analysis close to absorption edge (XANES, X-ray absorption near edge structure)? 24. Explain the origin of the absorption coefficient fine structure observed in the extended energy range of X-ray absorption spectrum (EXAFS).

	25. Why EXAFS (Extended X-ray Absorption Fine Structure) analysis is considered as a probe of local structure at the atomic level?
Practical activites within the subject	Not applicable

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