



## Subject card

Subject name and code	Photophysics and introduction to molecular spectroscopy , PG_00061307						
Field of study	Nanotechnology						
Date of commencement of studies	October 2020		Academic year of realisation of subject		2023/2024		
Education level	first-cycle studies		Subject group		Optional 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	4		Language of instruction		Polish		
Semester of study	7		ECTS credits		2.0		
Learning profile	general academic profile		Assessment form		assessment		
Conducting unit	Instytut Nanotechnologii i Inżynierii Materiałowej -> Faculty of Applied Physics and Mathematics						
Name and surname of lecturer (lecturers)	Subject supervisor		dr hab. inż. Agnieszka Witkowska				
	Teachers		dr hab. inż. Agnieszka Witkowska				
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	15.0	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		0.0		0.0	30
Subject objectives	The aim of the course is to present the main issues related to the interaction between electromagnetic radiation and matter, to discuss photophysical processes and the basics of molecular spectroscopy.						
Learning outcomes	Course outcome		Subject outcome		Method of verification		
	K6_U06		Preparing and presenting a seminar, the student acquires the ability to present in a simple and understandable way technological and scientific issues and problems related to the properties and application of nanostructures.		[SU2] Assessment of ability to analyse information [SU5] Assessment of ability to present the results of task		
	K6_K05		Preparing and presenting a seminar, the student acquires the ability to clearly present the effects of her/his work. Participating actively in the discussion after each presentation and participating in the presentations evaluation, she/he is able to communicate, perform self-evaluation and constructively evaluate the effects of other people's work.		[SK4] Assessment of communication skills, including language correctness		
	K6_W07		The student acquires knowledge in the field of optical properties of materials and nanomaterials, learns spectroscopic methods of studying the structural and physico-chemical properties of materials and nanomaterials.		[SW1] Assessment of factual knowledge [SW2] Assessment of knowledge contained in presentation		

Subject contents	<b>Lecture:</b>  1) Introduction. The nature of EM radiation (classical electrodynamics and Maxwell's equations, waveparticle duality ); nature and structure of matter (Waveparticle duality, quantum mechanics, atomic and molecular orbitals, energy states in a molecule); interaction of EM radiation with matter (electric dipole approximation, Einstein coefficients, selection rules for optical transitions).  2) Jabłoński diagram of photophysical processes: radiative transitions (fluorescence and phosphorescence, Kasha's rule, mirror symmetry rule for absorption and emission spectra, Stokes shift, quantum efficiency and lifetime of fluorescence and phosphorescence decay), non-radiative transitions (vibrational relaxation, internal conversion, intersystem crossing). Types of luminescence.  3) Spectroscopy methods: classification of spectroscopy methods; Beer-Lambert law, transmittance, absorbance, absorption coefficient, attenuation length; measurement methods (continuous wave and Fourier Transform methods); absorption and emission spectrometer; spectrum, basic parameters of spectral lines and their physical meaning. Infrared absorption spectroscopy vs. Raman spectroscopy. UV-Vis spectroscopy.  <b>Seminar (sample topics):</b> 1. Photobiology (pigments and natural colorants, bioluminescence) 2. Photomedicine: photodynamic diagnostics and therapy 3. Applied photochemistry (photochemical synthesis methods, photopolymerization, photochemical removal of pollutants, atmospheric photochemistry) 4. Photocatalytic water decomposition by visible light: review of opportunities, progress and challenges 5. Photosensors and color-changing sensors for temperature, pressure, the presence of metals and viruses 6. Color and light in architecture and art 7. Spectroscopic methods and art and cultural heritage 8. Nanophotonics from biochemistry to telecommunications														
Prerequisites and co-requisites	Basic knowledge of electromagnetism, modern physics, atomic and molecular physics and solid state physics.														
Assessment methods and criteria	<table><tr><td>Subject passing criteria</td><td>Passing threshold</td><td>Percentage of the final grade</td></tr><tr><td>Seminar preparation and presentation</td><td>50.0%</td><td>40.0%</td></tr><tr><td>Written test in the lecture part</td><td>51.0%</td><td>60.0%</td></tr><tr><td>Participation in the seminar</td><td>75.0%</td><td>0.0%</td></tr></table>			Subject passing criteria	Passing threshold	Percentage of the final grade	Seminar preparation and presentation	50.0%	40.0%	Written test in the lecture part	51.0%	60.0%	Participation in the seminar	75.0%	0.0%
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Recommended reading	Basic literature	[1] D.L.Andrews, Molecular Photophysics and Spectroscopy, Morgan & Claypool Publ.  [2] J.Sadlej, Spektroskopia molekularna, WNT, Warszawa (in polish)													
	Supplementary literature	[3] H.Haken, H.Ch.Wolf, Molecular Physics and Elements of Quantum Chemistry, Springer  [4] D.L.Pavia i in., Introduction to Spectroscopy, Brooks/Cole													
	eResources addresses	Adresy na platformie eNauczanie: Fotofizyka i podstawy spektroskopii molekularnej 2023 - Moodle ID: 22566 <a href="https://enauzanie.pg.edu.pl/moodle/course/view.php?id=22566">https://enauzanie.pg.edu.pl/moodle/course/view.php?id=22566</a>													

Example issues/ example questions/ tasks being completed	<ol style="list-style-type: none"> <li>1. Using Maxwell's equations, prove that light is an electro-magnetic wave.</li> <li>2. List and describe a few types of molecular orbitals.</li> <li>3. List and briefly discuss mechanisms of light absorption in the molecule.</li> <li>4. Describe term symbol which characterize atomic states under Russell-Saunders coupling condition. Discuss the excited Singlet and Triplet state.</li> <li>5. Explain the phenomena of absorption, spontaneous and stimulated emission. What is the probability of individual processes occurring and what parameter allows to assess this probability.</li> <li>6. Photophysical vs. photochemical processes state the difference between them.</li> <li>7. Present the Jabłoński diagram and use it to discuss the basic photophysical processes.</li> <li>8. Explain Kasha's rule</li> <li>9. Fluorescence: basic rules, laws, quantum yield and the fluorescence decay time.</li> <li>10. Spectroscopy: definition, types of spectroscopy methods.</li> <li>11. Specify and describe physical meaning of the parameters that characterize spectral line shape.</li> <li>12. Define: transmittance, absorbance and absorption coefficient. Describe the relations between them.</li> <li>13. Raman spectroscopy: discuss the origin and the idea of the phenomenon and describe shape of the Raman spectra.</li> <li>14. What is the auxochrome and how it can change the UV-Vis spectrum.</li> </ol>
Work placement	Not applicable