



## Subject card

Subject name and code	Optical Measurement Techniques, PG_00048097						
Field of study	Electronics and Telecommunications						
Date of commencement of studies	October 2021		Academic year of realisation of subject		2024/2025		
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		3.0		
Learning profile	general academic profile		Assessment form		exam		
Conducting unit	Department of Metrology and Optoelectronics -> Faculty of Electronics, Telecommunications and Informatics						
Name and surname of lecturer (lecturers)	Subject supervisor		dr inż. Maciej Wróbel				
	Teachers		dr inż. Maciej Wróbel				
Lesson types and methods of instruction	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	15.0	0.0	15.0	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		42.0	75
Subject objectives	Provision of knowledge and abilities in the field of key optical measurement methods used in the industry and science.						
Learning outcomes	Course outcome		Subject outcome		Method of verification		
	[K6_U06] can analyse the operation of components, circuits and systems related to the field of study, measure their parameters and examine technical specifications		Analyzes the operation of spectrometers, interferometers and other optoelectronic measurement systems. Knows their measurement applications and the physical basis of their operation.		[SU1] Assessment of task fulfilment		
	[K6_W31] Knows the definitions of measurement error and uncertainty, measurement methods, including digital methods of time, frequency and phase measurements, transducer properties and knows digital signal processing systems.		Student is able to propose appropriate components and structures of spectral, interferometric and other optoelectronic measurement systems. Determines the sources of noise and interference in optoelectronic measurements		[SW1] Assessment of factual knowledge		

Subject contents	<p><b>1. Basic properties of light, interactions of light with matter.</b> Electromagnetic wave, wavelength, optical spectrum ranges Intensity, photometric and radiometric units, Polarization, Jones vector, Stokes vector, Poincare sphere Refraction and reflection of light, Diffraction, Near and far field, Diffraction limit, Diffraction orders Absorption, Absorbance, Lambert-Beer law.</p> <p><b>2. Light scattering and measurements of scattering parameters.</b> Light scattering, physical basics, Mie scattering description parameters Measurements of scattering and absorption parameters Integration spheres, construction, applications, Method of measuring radiometric parameters using spheres, Method of measuring scattering parameters using the IAD method, application in biomedicine.</p> <p><b>3. Synchronous detection in optical measurement methods.</b> The problem of noise in optical measurements Synchronous (phase-sensitive) detection theory Lock-in amplifier circuit Measuring applications</p> <p><b>4. Microscopy.</b> Basics of microscopy, image formation, resolution, PSF, contrast Contrast improvement methods, bright field, dark field, Polarizing microscopy, phase contrast, confocal microscopy</p> <p><b>5. Spectrometry, Fluorescence.</b> Basics of spectral measurement methods, Jabłoński diagram, fluorescence, phosphorescence, absorption spectroscopy, fluorescence microscopy, emission and excitation spectra, spectrofluorimeter, confocal laser fluorescence microscopy, fluorescence lifetime, applications of measurement methods.</p> <p><b>6. Raman spectroscopy and IR spectroscopy.</b> Raman spectroscopy, configuration of measurement systems, basics of operation. IR spectroscopy, configuration of measurement systems, basics of operation. Raman microspectroscopy, optical probes, applications of measurement methods, analysis of measurement data.</p> <p><b>7. Interferometry.</b> Amplitude and wavefront division interferometers, interferometer designs, Advanced interferometric methods: FTIR, FT-Raman, Low-coherence interference, Optical coherence tomography (OCT) - in the time domain (TD-OCT) and spectrum (SD-OCT).</p>		
Prerequisites and co-requisites	No requirements		
Assessment methods and criteria	Subject passing criteria	Passing threshold	Percentage of the final grade
	Exam	50.0%	40.0%
	Laboratory	50.0%	60.0%
Recommended reading	Basic literature	<ol style="list-style-type: none"> <li>1. P.K. Rastogi, Optical Measurement Techniques and Applications, Artech Book House, 1998</li> <li>2. F Ratajczyk, Dwójtomność i polaryzacja optyczna, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2000</li> <li>3. M. Pluta, Mikrointerferometria w świetle spolaryzowanym, WNT Warszawa 1991</li> <li>4. M. Born, E. Wolf, Principles of Optics, np. 6th Edition, Pergamon Press, Oxford 1993</li> </ol>	
	Supplementary literature	No requirements	
	eResources addresses	Adresy na platformie eNauczanie:	

Example issues/ example questions/ tasks being completed	<ol style="list-style-type: none"> <li>1. Describe the phenomenon of dispersion and its use in spectroscopy. Physical basis, patterns, diagram of elements using this phenomenon.</li> <li>2. Describe the parameters describing scattering and how they are measured, diagram of the measurement system, algorithms, applications. Describe the principle of operation, construction, measurement method and measurement applications of integration spheres.</li> <li>3. Present the method of describing the state of polarization, explain the method of describing partially polarized light based on the Poincaré sphere.</li> <li>4. Describe the principle of operation of the synchronous detection method, the purpose of its use, the method of operation and the circuit diagram, formulas.</li> <li>5. Introduce different methods for obtaining better contrast in microscopy. Describe the structure of a phase contrast microscope.</li> <li>6. Describe the principle of operation of a confocal microscope. Scheme, idea and applications, also as a system in combination with other measurement methods.</li> <li>7. Describe, based on Jabłoński diagrams, the phenomena of absorption, fluorescence, phosphorescence and scattering of elastic light.</li> <li>8. Describe the principle of operation, physical basis, measurement systems, and basic laws describing the UV-VIS absorption spectroscopy method.</li> <li>9. Describe the principle of operation, physical basis, measurement systems, and basic laws describing the IR spectroscopy method, and why use ATR.</li> <li>10. Describe the principle of operation, physical basis, measurement systems, fluorescence spectroscopy.</li> <li>11. What is the relationship between the absorption and emission spectra of fluorophores? What is the difference between excitation and emission spectra, describe a spectrofluorimeter.</li> <li>12. Describe the principle of operation, physical basis, measurement system and basic laws describing the Raman spectroscopy method, pay attention to the practical implementation of measurements, what should you pay attention to when selecting the elements of such a measurement system?</li> <li>13. Describe the difference and similarities between IR spectroscopy and Raman spectroscopy.</li> <li>14. Describe the different ways of constructing probes in Raman spectroscopy and their applications.</li> <li>15. Describe the difference in the method of measuring Raman spectra (IR spectra) in a classic (dispersive) spectrometer and an interference spectrometer (FT-Raman) / (FTIR).</li> <li>16. Describe the differences between an amplitude division interferometer and a wavefront division interferometer.</li> <li>17. Describe how optical low coherence tomography (OCT) works, the principle of operation, measurement systems, differences between the source sweep system (SS-OCT, Swept Source OCT) and the spectral domain system (SD-OCT, Spectral-Domain OCT), OCT measurement applications.</li> </ol>
Work placement	Not applicable