



COURSE CARD

1. Basic information

Course name in English:	Modern measurement techniques	
Course name in Polish:	Nowoczesne metody pomiarowe	
Number of hours:	15	
Type of course:	Elective course	
Form of course:	mixed forms (combination of lecture, seminar and laboratory)	
Code of course:	NFQ100468L/ W11NAF-SD0164L	
Course leader:	Prof. Grzegorz Sęk	
Faculty of the course leader:	W11 Faculty of Fundamental Problems of Technology	
Email address of the course leader:	grzegorz.sek@pwr.edu.pl	
Scientific discipline(s) assigned to the course (doctoral students representing the marked disciplines can participate in the course):	Architecture and urban planning	<input type="checkbox"/>
	Automation, electronic, and electrical engineering	<input checked="" type="checkbox"/>
	Information and communication technology	<input type="checkbox"/>
	Biomedical engineering	<input checked="" type="checkbox"/>
	Chemical engineering	<input checked="" type="checkbox"/>
	Civil engineering and transport	<input type="checkbox"/>
	Mechanical engineering	<input checked="" type="checkbox"/>
	Environmental engineering, mining, and energy	<input checked="" type="checkbox"/>
	Mathematics	<input type="checkbox"/>
	Chemical sciences	<input checked="" type="checkbox"/>
	Physical sciences	<input checked="" type="checkbox"/>
	Management and quality studies	<input type="checkbox"/>

2. Objectives

3. Content

Detailed information about the course content, including topics and form of classes.

No.	Topic	Number of hours	Form of classes
1	Introductory lecture	1	lecture
2	Preview of selected modern measurement techniques	2	lecture
3	Scanning electron microscopy imaging with focused ion beam processing	2	laboratory
4	Microwaves for materials and devices diagnostics	2	laboratory
5	Pulsed lasers to probe ultrafast processes	2	laboratory
6	Nowadays transmission electron microscopy	2	laboratory



7	Nanometrology	2	laboratory
8	Capabilities of customized Fourier transform spectroscopy	2	laboratory

4. Prerequisites

List of prerequisites relating to knowledge, skills and other competences for course participants.

Fundamentals of physics, chemistry and material science

5. Learning outcomes

List of learning outcomes at level 8 of the Polish Qualifications Framework assigned to the course (mark the learning outcomes in the last column).

Symbol	Learning outcome	
	<i>KNOWLEDGE. Doctoral student knows and understands:</i>	
SzD_W3	the main trends in the development of the scientific or artistic disciplines covered in the curricula;	<input checked="" type="checkbox"/>
SzD_W4	research methodology;	<input checked="" type="checkbox"/>
SzD_W5	the rules for the dissemination of scientific results, including in open access mode;	<input type="checkbox"/>
SzD_W6	the fundamental dilemmas of modern civilization;	<input checked="" type="checkbox"/>
SzD_W7	the legal and ethical conditions of scientific activity;	<input type="checkbox"/>
SzD_W8	the economic and other relevant conditions of scientific activity;	<input type="checkbox"/>
SzD_W9	basic principles of knowledge transfer to the economic and social spheres and commercialisation of results of scientific activity and know-how related to these results.	<input type="checkbox"/>
	<i>SKILLS. Doctoral student is able to:</i>	
SzD_U2	use knowledge from different fields of science or art to creatively identify, formulate and innovatively solve complex problems or perform research tasks, in particular: - define the purpose and subject of scientific research, formulate a research hypothesis, - develop research methods, techniques and tools, and use them creatively, - draw conclusions on the basis of scientific research; critically analyse and evaluate the results of scientific research, expertise and other creative work and their contribution to knowledge development; transfer the results of scientific activities to the economic and social spheres;	<input checked="" type="checkbox"/>
SzD_U3	communicate on specialised topics to the extent that they enable an active participation in the international scientific community;	<input checked="" type="checkbox"/>
SzD_U4	disseminate research results, including in popular forms;	<input type="checkbox"/>
SzD_U5	initiate debates and participate in a scientific discourse;	<input type="checkbox"/>
SzD_U6	be able to speak a foreign language at B2 level of the Common European Framework of Reference for Languages to a level that enables them to participate in the international scientific and professional environment;	<input type="checkbox"/>



SzD_U7	plan and implement an individual or collective research or creative activity, including in an international environment;	<input type="checkbox"/>
SzD_U8	independently plan and act for one's own development and inspire and organize the development of others;	<input type="checkbox"/>
SzD_U9	plan classes or groups of classes and implement them using modern methods and tools.	<input type="checkbox"/>
<i>SOCIAL COMPETENCES. Doctoral student is ready to:</i>		
SzD_K3	fulfilling the social obligations of researchers and creators, initiate public interest activities, thinking and acting in an entrepreneurial way;	<input type="checkbox"/>
SzD_K4	maintaining and developing the ethos of research and creative environments, including: - carrying out scientific activities in an independent manner, - respecting the principle of public ownership of research results, taking into account the principles of intellectual property protection.	<input type="checkbox"/>

6. Evaluation

Short description of the method(s) used to evaluate the learning outcomes assigned to the course, e.g., exam, test, report, presentation, etc.

Written report summarizing the outcomes of the laboratory exercises

7. Teaching methods

Short description of the teaching methods used during the course, e.g., multimedia presentation, discussion, literature studies, developing written documents, own work, etc.

multimedia presentation, discussion, literature studies, developing written documents, participation in laboratory experiments, own work

8. Literature

List of primary and secondary literature used to prepare the course and including additional knowledge for participants, e.g., books, textbooks, research papers, standards, web pages, etc.

Supplementary literature: 1) P. W. Hawkes, J. C. H. Spence, Springer Handbook of Microscopy; 2) W.C. Sanders, Atomic Force Microscopy: Fundamental Concepts and Laboratory Investigations; 3) N.V. Tkachenko, Optical Spectroscopy. Methods and Instrumentation; 4) A. Weiner, Ultrafast optics; 5) A. Migdall, S. Polyakov, J. Fan, J. Bienfang, Single-Photon Generation and Detection. Physics and Applications; 6) A. Oleś, Metody doświadczalne fizyki ciała stałego (in Polish); 7) T. Gotszalk, Systemy mikroskopii bliskich oddziaływań w badaniach mikro- i nanostruktur (in Polish); 8) Scientific articles in the subject of the selected experimental methods and their applications; 9) Internet resources in the subject of the selected experimental methods and their applications

9. Other remarks

Additional remarks, comments, (e.g., language of the course)

Language of the course - English