

COURSE OFFERED

Name of the course	Polish	Metody eksperymentalne we współczesnej fizyce
	English	Experimental methods in modern physics

1 LOCATION OF THE COURSE WITHIN THE EDUCATION SYSTEM

1.1. Section ¹	Section of Exact and Natural Sciences
1.2. Discipline ²	Physical Sciences
1.3. Type of education	Full-time
1.4. Level of education	Doctoral School (PQF Level 8)
1.5. Person preparing the course description	dr hab. Dariusz Banaś, prof. UJK
1.6. Contact	Dariusz Banaś

2 GENERAL CHARACTERISTICS OF THE COURSE

2.1. Type of course ³	Specialised subject in the discipline (elective)
2.2. Language of the course	English

3 DETAILED CHARACTERISTICS OF THE COURSE

3.1. Type of classes ⁴	Lectures, seminar	
3.2. Number of hours ⁵	30 h including 15 h of lectures and 15 h of seminars/laboratories	
3.3. Location of classes	Classroom at Jan Kochanowski University in Kielce	
3.4. Type of assessment	Graded pass based on oral assessment, class activity, and individual presentation.	
3.5. Didactic methods	Lectures: Expository teaching, multimedia presentations, problem-based teaching. Seminars/Laboratory Classes: Demonstration method, practical exercises, guided discussion, student presentations.	
3.6. Literature	basic	1. Leo, W.R., Techniques for Nuclear and Particle Physics Experiments: A How-to Approach, 2nd ed., Springer, 1994. DOI: https://doi.org/10.1007/978-3-642-57920-2 2. Grupen, C., Shwartz, B., Particle Detectors, 2nd ed., Cambridge University Press, 2008 (reissued as Open Access in 2023). DOI: https://doi.org/10.1017/9781009401531 3. Vickerman, J.C., Gilmore, I.S. (Eds.), Surface Analysis: The Principal Techniques, 2nd ed., Wiley, 2009. DOI: https://doi.org/10.1002/9780470721582 4. Oura, K., Lifshits, V.G., Saranin, A.A., Zotov, A.V., Katayama, M., Surface Science: An Introduction, Springer, 2003. DOI: https://doi.org/10.1007/978-3-662-05179-5

¹ Sections: Humanities; Social Sciences; Exact and Natural Sciences; Medical and Health Sciences; Arts.

² Discipline as specified in the curriculum of the Doctoral School.

³ General subjects; general subjects in the discipline; specialised subjects in the discipline.

⁴ Classes, lecture or seminar.

⁵ Consistent with the curriculum of the Doctoral School of Jan Kochanowski University in Kielce.

	supplementary	1. Behnke, O., Kröninger, K., Schott, G., Schörner-Sadenius, T. (Eds.), Data Analysis in High Energy Physics: A Practical Guide to Statistical Methods, Wiley-VCH, 2013. DOI: https://doi.org/10.1002/9783527653416 2. Shirkov, G.D., Zschornack, G., Electron Impact Ion Sources for Charged Heavy Ions, Vieweg+Teubner Verlag, 1996. DOI: https://doi.org/10.1007/978-3-663-09896-6 3. CERN NA61/SHINE Collaboration, NA61/SHINE Experiment – Official Website and Scientific Documentation. Website: https://shine.web.cern.ch/ 4. Selected scientific papers and technical reports on modern experimental techniques, particle physics experiments, surface characterization methods, and Electron Beam Ion Sources (EBIS), provided by the lecturers.
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4 OBJECTIVES SYLLABUS CONTENT AND INTENDED LEARNING OUTCOMES

4.1. Course objectives (lecture)

C01 To introduce modern experimental methods used in high-energy physics, with particular emphasis on particle detection techniques and experimental data acquisition and analysis.

C02 To familiarize students with major international experimental collaborations, their scientific objectives, and selected ongoing and planned experiments in particle physics.

C03 To introduce experimental techniques used in low-energy atomic and surface physics, including XPS, SIMS, LEED/RHEED, and AFM/STM.

C04 To familiarize students with the principles and applications of highly charged ion sources, particularly Electron Beam Ion Sources (EBIS), including the EBIS facility at Jan Kochanowski University in Kielce.

4.2. Syllabus content (30 hours in total)

Lectures – High-Energy Physics (15 hours)

1. Particle Detectors – Principles of operation and applications of modern particle detectors. Tracking systems, calorimeters, and particle identification techniques.
2. Data Acquisition and Analysis – Overview of data acquisition systems, basic methods of experimental data analysis, and interpretation of measurement results.
3. Large-Scale Experimental Collaborations – Organization and scientific objectives of major international collaborations in high-energy physics. Research infrastructure and experimental facilities.
4. The NA61/SHINE Experiment at CERN – Physics programme, experimental setup, detection systems, and selected research results.
5. Current and Future Experiments in High-Energy Physics – Overview of ongoing and planned experiments at CERN and other major international research facilities.

Seminars and Laboratory Classes - Low-Energy Physics (15 hours)

1. Experimental Methods in Surface Physics – Introduction to surface characterization techniques and their applications in modern materials research.
2. Electron and Ion Spectroscopy – Principles and applications of X-ray Photoelectron Spectroscopy (XPS) and Secondary Ion Mass Spectrometry (SIMS).
3. Electron Diffraction Techniques – Surface structure analysis using Low-Energy Electron Diffraction (LEED) and Reflection High-Energy Electron Diffraction (RHEED).
4. Scanning Probe Microscopy – Principles and applications of Atomic Force Microscopy (AFM) and Scanning Tunneling Microscopy (STM).
5. Highly Charged Ion Sources – Principles of operation of Electron Beam Ion Sources (EBIS), production of highly charged ions, and their applications in atomic and surface physics. Presentation of the EBIS facility at Jan Kochanowski University in Kielce.

4.3 Subject learning outcomes

Learning outcome	A doctoral student who has passed the course	Reference to Doctoral School learning outcomes
In the area of KNOWLEDGE		
W01	Has knowledge of modern experimental methods and detection techniques used in high-energy and low-energy physics.	SD_W01
W02	Understands the principles, applications, and recent developments of selected experimental techniques, including particle detectors, surface analysis methods, and highly charged ion sources.	SD_W02
W03	Is familiar with current research directions, major international collaborations, and significant open research questions in modern experimental physics.	SD_W07
In the area of SKILLS		
U01	Can identify research objectives and select appropriate experimental techniques for addressing selected problems in modern physics.	SD_U01
U02	Can apply knowledge of different experimental techniques to discuss and interpret selected research problems and experimental results.	SD_U03
U03	Can discuss experimental methods and present selected research results using appropriate scientific terminology in English.	SD_U07
In the area of SOCIAL COMPETENCE		
K01	Recognizes the importance of scientific knowledge and experimental methods in addressing research problems in modern physics.	SD_K02
K02	Is ready to take initiative in identifying potential applications of modern experimental techniques and research opportunities.	SD_K04

4.4 Methods of assessment of the intended learning outcomes

SUBJECT LEARNING OUTCOMES	METHOD OF ASSESSMENT (+ / -)																				
	Oral / written exam			Test (oral assessment)			Project			Activity in class			Own work			Group work			Other		
	Type of classes			Type of classes			Type of classes			Type of classes			Type of classes			Type of classes			Type of classes		
	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S
W01	+	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
W02	+	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
W03	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
U01	+	-	-	-	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-
U02	+	-	-	-	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-
U03	-	-	-	-	-	+	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-

SUBJECT LEARNING OUTCOMES	METHOD OF ASSESSMENT (+ / -)																				
	Oral / written exam			Test (oral assessment)			Project			Activity in class			Own work			Group work			Other		
	Type of classes			Type of classes			Type of classes			Type of classes			Type of classes			Type of classes			Type of classes		
	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S	L	C	S
K01	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
K02	-	-	-	-	-	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-

L = lecture; C = classes; S = seminar. + = method used; - = method not used.

4.5 Criteria of assessment of the intended learning outcomes

Form of classes	Grade	Criterion of assessment
Lecture (L)	3.0	51–60% of the maximum points in the final oral assessment.
	3.5	61–70% of the maximum points in the final oral assessment.
	4.0	71–80% of the maximum points in the final oral assessment.
	4.5	81–90% of the maximum points in the final oral assessment.
	5.0	91–100% of the maximum points in the final oral assessment.
Seminar /Labora tory (S)	3.0	51–60% of the maximum points based on oral assessment, class activity, and individual presentation.
	3.5	61–70% of the maximum points based on oral assessment, class activity, and individual presentation.
	4.0	71–80% of the maximum points based on oral assessment, class activity, and individual presentation.
	4.5	81–90% of the maximum points based on oral assessment, class activity, and individual presentation.
	5.0	91–100% of the maximum points based on oral assessment, class activity, and individual presentation.

Grade 2.0 (fail): fewer than 51% of the maximum points.

Accepted for implementation

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(date and signature of the lecturer)