

FACULTY OF ELECTRICAL  
ENGINEERING**SUBJECT CARD**

Name in Polish: **Elektroniczna aparatura elektrometryczna**  
 Name in English: **Electronic Instruments in Electrometric Measurements**  
 Main field of study (if applicable): **Electrical Engineering**  
 Specialization (if applicable): **Industrial Electrical Engineering**  
 Level and form of studies: **2nd level, full-time**  
 Kind of subject: **optional**  
 Subject code: **ELR043309**  
 Group of courses: **NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU):	30		15		
Number of hours of total student workload (CNPS):	60		30		
Form of crediting:	examination		crediting with grade		
For group of courses mark (X) final course:					
Number of ECTS points:	2		1		
including number of ECTS points for practical (P) classes :			1		
including number of ECTS points for direct teacher-student contact (BK) classes:	1.40		0.70		

**PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES**

1. Has a basic knowledge of mathematics, electrical engineering and solid state physics.
2. Knows basic electrical materials and methods of research.
3. Has ordered knowledge of the basic theory of electrical circuits and components.
4. Has a basic knowledge of electrical measurements and units of quantities.
5. Can correctly and effectively apply the knowledge from the analysis of differential calculus, integral calculus of functions of one variable to the qualitative and quantitative analysis of mathematical problems related technical discipline of study.
6. Able to plan and safely perform electrical measurements, develop performance measurements, to estimate the uncertainty of the measured values.
7. Can perform measurements of selected electrical properties of insulating materials and to draw conclusions from the study.
8. Can analytically predict the effect of simple electronic analog and digital circuits on the basis of their structure and properties of the elements.
9. Has a sense of responsibility for their own work and the willingness to comply with the rules work in a team and to take responsibility for collaborative tasks.

**SUBJECT OBJECTIVES**

- C1. Acquiring knowledge of the specify of electrometry and used the electronic converters and specialized electronic measuring equipment.  
 C2. Rational use of knowledge to use electronic apparatus to the electrometric tests.  
 C3. Deepening the ability to work as a team towards a common goal.

**SUBJECT EDUCATIONAL EFFECTS***relating to knowledge:*

- PEK\_W01 Has a basic knowledge of the specific electrometry.  
 PEK\_W02 Knows the basic methods and the basic electronic measuring systems used for signal processing in electrometry.  
 PEK\_W03 Knows the structure, properties, principles and scope of basic electronic measuring equipment in electrometry.

*relating to skills:*

- PEK\_U01 Can theoretically and experimentally determined properties of selected electrometric converters.  
 PEK\_U02 Can predict the effects of use electrometric converters with the selected electrometric circuit.  
 PEK\_U03 Can apply selected electronic converters for electrometric testing, develop and interpret the results.

*relating to social competences:*

- PEK\_K01 Can work with a team in the implementation of complex engineering tasks.

## PROGRAMME CONTENT

Form of classes - lecture		Number of hours:
Lec 1	Form of the course, the principles of assessment, organizational information. The nature and scope of the course. Signals, noises and distortions in the electrometry. The overall structure of the electrometric instruments.	2
Lec 2	Basic current and voltage converters in electrometric apparatus, structure and nominal properties, errors and uncertainties. The use of the active shield.	2
Lec 3	Electrometric charge converter. The working principle, application, limitations and inaccuracies, problems in the application and study the properties of the converter.	2
Lec 4	One-parameter instruments in electrometry, characteristics and application. Electrometer - multifunctional electronic electrometric apparatus. Examples of complex studies, rules and equipment used in them. Research potential return.	2
Lec 5	Insulator leakage research. Resistivity materials studies. Simple systems of megohm meters.	2
Lec 6	Electrification of technical objects; causes, effects, methods of study.	2
Lec 7	Resistors with very large values used in electrometry, types and main characteristics, sets standards. Resistance imitator and the rules for its use. Properties of capacitors used in electrometry, capacitive imitator.	2
Lec 8	Properties of operational amplifiers used in electrometric apparatus. Interpretation of the data directory and the principles of correct application and compensation of some imperfections.	2
Lec 9	General characteristics of noise and its impact on the work of the electrometric circuits. The frequency characteristics of the noises. Example of the noise of electrometric and precision operational amplifiers.	2
Lec 10	Noise in resistors with very large values. Quantitative analysis of the impact of different types of noise at electrometric converter.	2
Lec 11	Properties and effects of used auxiliary components in electrometric circuits: cables, insulators, shields, switches.	2
Lec 12	Modifications to equipment, improving performance. Modifications analog laboratory gigaohmmeter; conditions of work, changing polarity. Picoammeter with microprocessor.	2
Lec 13	Logarithmic converters. The instrument measures the ratio of small currents or very high resistances.	2
Lec 14	Examples of apparatus with charge converter: reference source of small currents.	2
Lec 15	Digital integration gigaohmmeter.	2
Total hours:		<b>30</b>

Form of classes - laboratory		Number of hours:
Lab 1	Introduction. Rules of the user safety and work. Rules of pass the laboratory.	1
Lab 2	Current converters i/u, biomedical converter. Structure, optimization, tests of properties.	2
Lab 3	Current converters i/u, biomedical converter. Structure, optimization, tests of properties.	2
Lab 4	Charge converter q/u and i/u Structure, optimization and application, tests of properties.	2
Lab 5	Electronic megohmmeter. Assess the usefulness in tests of leakage resistance, resistivity, the time variation of current and resistance.	2
Lab 6	Instrumental voltage amplifier. Testing the properties and limitations.	2
Lab 7	Picoammeter and source of small currents. Properties and areas of application: electrometric study of linear and non-linear devices at control voltage or current.	2
Lab 8	Summary of the laboratory.	2
Total hours:		<b>15</b>

## TEACHING TOOLS USED

N1. Traditional informative lecture, using slides and/or transparencies.
N2. Own work - to prepare for the laboratory exercises.
N3. Laboratory conducted in the traditional manner, in student exercises groups.
N4. Consultation.
N5. Own work - self-study and preparation for the exam.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT		
Evaluation <i>F – forming (during semester) P – concluding (at semester end)</i>	Educational effect number	Way of evaluating educational effect achievement
F1(W)	PEK_W01 PEK_W02 PEK_W03	Examination in writing and/or direct
P(W)	P=F1	
F1(L)	PEK_U01 PEK_U02	Review and evaluation of preparation to laboratory exercises
F2(L)	PEK_U01 PEK_U02 PEK_U03 PEK_K01	Activity in the laboratory
F3(L)	PEK_U01 PEK_U02 PEK_U03 PEK_K01	Review and evaluation of reports from research
P(L)	$P = 0,2 \cdot F1 + 0,2 \cdot F2 + 0,6 \cdot F3$	

PRIMARY AND SECONDARY LITERATURE
<b>PRIMARY LITERATURE:</b> [1] Nawrocki Z., Wzmacniacze operacyjne i przetworniki pomiarowe, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2008 [2] Kłos Z., Pomiary elektrometryczne, WKŁ, Warszawa 2008 [3] Madej P., Instrukcje Laboratoryjne i Materiały pomocnicze, strona internetowa K3/W5 PWr [4] Gajewski A.S., Elektryczność statyczna: poznanie, pomiar, zapobieganie, eliminowanie, Instytut Wydawniczy Związków Zawodowych, Warszawa 1987 <b>SECONDARY LITERATURE:</b> [1] Keithley Instruments, Inc., Low Level Measurements: Precision DC Current, Voltage and Resistance Measurements, Keithley Instruments, 5th Edition, Ohio, USA 1998 [2] Madej P., Artykuły z zakresu tematyki przedmiotu w Zeszytach Naukowych Instytutu Maszyn, Napędów i Pomiarów Elektrycznych, Wrocław 2000-2014 [3] Kulka Z., Nadachowski M., Zastosowania wzmacniaczy operacyjnych, WNT, Warszawa 1986 [4] Kulka Z., Libura A., Nadachowski M., Przetworniki analogowo-cyfrowe i cyfrowo-analogowe, WKŁ, Warszawa 1987 [5] Kłos Z., Problematyka wzorcowania aparatury elektrometrycznej, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2004
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MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT  
**ELR043309 - Electronic Instruments in Electrometric Measurements**  
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **Electrical Engineering**  
AND SPECIALIZATION **Industrial Electrical Engineering**

Subject educational effect	Correlation between subject educational effect and educational effects defined for main field of study and specialization (if applicable)	Subject objectives	Programme content	Teaching tool number
PEK_W01	S2ETP_W11	C.1	Lec1 Lec2 Lec3 Lec4 Lec5 Lec6 Lec7 Lec8 Lec9 Lec10 Lec11 Lec12 Lec13 Lec14 Lec15	N.1 N.4 N.5
PEK_W02	S2ETP_W11	C.1	Lec1 Lec2 Lec3 Lec4 Lec5 Lec6 Lec11 Lec12 Lec13 Lec14 Lec15	N.1 N.4 N.5
PEK_W03	S2ETP_W11	C.1	Lec1 Lec2 Lec3 Lec4 Lec5 Lec6 Lec9 Lec10 Lec11 Lec12 Lec13 Lec14 Lec15	N.1 N.4 N.5
PEK_U01	S2ETP_U09	C.2	Lab2 Lab3 Lab4 Lab5 Lab6 Lab7	N.2 N.3 N.4 N.5
PEK_U02	S2ETP_U09	C.2	Lab2 Lab3 Lab4 Lab5 Lab6 Lab7	N.2 N.3 N.4 N.5
PEK_U03	S2ETP_U09	C.2	Lab2 Lab3 Lab4 Lab5 Lab6 Lab7	N.2 N.3 N.4 N.5
PEK_K01	K2ETK_K02	C.3	Lab1 Lab2 Lab3 Lab4 Lab5 Lab6 Lab7 Lab8	N.2 N.3 N.4 N.5