Subject (course) name: **Electrical Metrology**		
Programme: **Electrical Engineering** Specialty:		Subject code: **11K** Title graduate: **Engineer**
Type of course: **obligatory**	Course level: **First-cycle studies**	Year: **II** Semester: **III** Semester: **autumn**
Form of classes: **Lectures, Classes, Labs, Seminar, Project**	Number of hours per week: **2L, 0C, 2Lab, 0, 0**	Credit points: **5 ECTS**

GUIDE TO SUBJECT

SUBJECT OBJECTIVES

C1. General knowledge in of the theory of measurement.

C2. Knowledge of the principles use of analog and digital measurement tools of electrical values.

C3. Practical knowledge of realization of the electrical measurements

SUBJECT REQUIREMENTS

1. Knowledge of mathematics in the field of differential equations and integrals.
2. Knowledge of physics in terms of size and physical phenomena used in the construction and operation of sensors and measuring transducers.
3. Knowledge of circuit theory in the field of fundamental rights.
4. Ability to work independently on a given topic related to the subject of the course.
5. Ability to prepare a report of the measurements.
6. Ability to use literature and online resources.
7. Skills to work independently and in a group.

LERNING OUTCOMES

EK 1 - The student has theoretical knowledge of the theory of electrical measurements.
EK 2 - The student is able to choose instruments and measurement methods for a given measurement task.
EK 3 - The student is able to independently perform measurements and prepare a documentation of the measurements.
EK4 - The student is able to analyse knowledge in the literature, catalogs and other sources and do independent work on a given topic related to the subject classes and present the resulting knowledge.
EK 5 - The student is able to prepare a report on the measurement.

SUBJECT CONTENT

Form of classes - lectures

Topic	Hours
W 1 – Basic terms. Introduction on electrical metrology	**2**
W 2 – Units of measure, systems of units	**2**
W 3, 4 – Measurement tools	**4**
W 5 – Circuits and measuring systems	**2**
W 6 – Measurement methods, types, division	**2**

W 7 – Calculus of uncertainty. Systematic errors	**2**
W 8 – Uncertainties accidental. Distributions, confidence intervals	**2**
W 9 – Errors of indirect measurements	**2**
W 10 - Processing characteristics	**2**
W 11, 12 – Analog devices	**4**
W 13 – Static and dynamic properties of analog devices	**2**
W 14 - Dividers, measuring transformers, additional resistors	**2**
W 15 – Final exam.	**2**
Total	**30**

Form of classes – laboratory

Topic	Hours
L 1 – Introduction to the lab.	**2**
L 2 – Verification of the measuring devices	**2**
L 3 – Expanding the range of analog measuring devices.	**2**
L 4 – Power measurements of DC and AC current	**2**
L 5 – Measurements of the energy in the AC circuit	**2**
L 6 – Technical method of resistance measurement	**2**
L 7 – Statistical analysis of the measurements	**2**
L 8 – Test	**2**
L 9 – Resistance measurement by use of Wheatstone's bridge	**2**
L 10 – Resistance measurement by use of Thomson's bridge	**2**
L 11 – Measurements of active power in three-phase systems	**2**
L 12 – Measurements of reactive power in three-phase systems	**2**
L 13 – Systems of instrument transformers	**2**
L 14 – Magnetic measurements	**2**
L 15 – Test.	**2**
Suma	**30**

STUDY METHODS

1. Lectures with use of multimedia presentations.
2. Solving problems in classes.
3. Lab – experiments in sections (two or three students).
4. Discussion during the course and individual consultations.

EDUCATIONAL TOOLS

1. Audiovisual equipment
2. Lab instructions
3. Lab equipment.
4. Computer lab
5. Standards for sensors, transducers and measurement systems

METHODS OF ASSESMENT (F – Forming, P – Summary)

F1. Validation of the results of measurements in the laboratory and timely preparation of reports on the subsequent laboratory.
P1. Lecture - written exam.
P2. Laboratory classes - the average of the ratings for laboratory exercises 50% and 50% of the final test.

STUDENT WORKLOAD

Form of activity	Averaged workload (hours)		
	[h]	∑ [h]	ECTS
Participation in class activities lectures	30	60	2
labs	30		
Preparation for tutorials (reading literature)	10	60	3
Preparation for labs	20		
Preparation of lab reports	20		
Preparation for tests	10		
Preparation for exam	10		

Total		**120**	**5**

A. BASIC READING

1. Morris A.S.: Principles of Measurements and Instrumentation.. Prentice Hall Inc. New York, London, 1998

2. Guide to the Expression of Uncertainty in Measurement. ISO, 1995

3. Dally J. W., Riley W. F., McConnell K. G.: Instrumentation for Engineering Measurement. John Wiley & Sons Inc., New York, 1999

4. S. C. Bhargava, Electrical Measurement Instruments and Measurements, CRC Press Inc., 2013.

5. A.V.Bakshi U.A.Bakshi, Electrical Measurements, Technical Publications, 2008

B. FURTHER READING

1. McGhee J., Henderson I., Korczyński M. J., Kulesza W.: Scientific Metrology, ISBN 83-904299-9-3, Printed by LODART, Łódź, first edition 1996, second edition 1998.

2. Malaric R., Instrumentation and Measurement in Electrical Engineering, BrownWalker Press, 2011

Learning objectives	In relation to the learning outcomes specified for the field of study	Subject objectives	Subject content	Course study methods	Methods of assessment
EK1	KE1A_W08	C1 , C2	Lecture laboratory	**1, 2**	P1
EK2	KE1A_U09	C1 , C2	lecture laboratory	**1,2**	F1, F2
EK3	KE1A_U13	C2	laboratory	**2**	F1, F2
EK4	KE1A_U01	C1 , C2	lecture laboratory	**1,2**	F1, F2
EK5	KE1A_K03 KE1A_U04	C2	laboratory	**12**	P1

II. EVALUATION

Grade	Outcome
EK1	**The student has theoretical knowledge of the theory of electrical measurements.**
2 (F)	The student is not able to describe the basic concepts and laws in electrical measurement
3 (E)	Student is able to describe the basic concepts and laws in force in the theory of electrical measurement
3,5 (D)	Student is able to describe the basic concepts and laws in force in the theory of electrical measurement and can to apply their knowledge at a general level.
4 (C)	Student is able to describe the basic concepts and laws in force in the theory of electrical measurement and can to apply their knowledge at a detailed level.
4,5 (B)	Student is able to describe the basic concepts and laws in force in the theory of electrical measurement and can to apply their knowledge at a detailed level. A student is able to define the conditions of measurement for the task.
5 (A)	Student is able to describe the basic concepts and laws in force in the theory of electrical measurement and can to apply their knowledge at a detailed level. A student is able to define the conditions of measurement for the task and compare with the recommended literature.
EK2	**The student is able to choose instruments and measurement methods for a given measurement task.**
2 (F)	The student is able to choose the instruments and methods of measurement for a given measurement task.
3 (E)	The student is able to choose instruments for a given measurement task.
3,5 (D)	The student is able to choose instruments and methods for a given measurement task.
4 (C)	The student is able to choose instruments and methods for a given measurement task and analyze the choice.
4,5 (B)	The student is able to choose instruments and methods for a given measurement task and analyze the choice. The student has knowledge of available solutions instruments.
5 (A)	Student is able to choose instruments and methods for a given measurement task and analyze the choice. The student has knowledge of available solutions instruments and can make adjustments.
EK3	**The student is able to independently perform measurements and prepare a documentation of the measurements.**

2 (F)	The student is not able to realize measure and prepares report documentation.
3 (E)	The student is able to perform measurements.
3,5 (D)	The student is able to realize measure and prepares report documentation.
4 (C)	The student is able to realize measure and prepares report documentation and analyze the results.
4,5 (B)	The student is able to realize measure and prepares report documentation and analyze the results. The student is able to compare the results with literature data.
5 (A)	The student is able to realize measure and prepares report documentation and analyze the results. The student is able to compare the results with literature data and make their verification.
EK4	**The student is able to analyse knowledge in the literature, catalogs and other sources and do independent work on a given topic related to the subject classes and present the resulting knowledge.**
2 (F)	The students is not able to use the sources of literature and online resources.
3 (E)	The student is able to use online resources.
3,5 (D)	The students is able to use the sources of literature and online resources.
4 (C)	The student can find and use sources of literature and online resources.
4,5 (B)	The students is able to compare the selected issues from literature sources and online resources
5 (A)	The students is able to compare the selected issues from literature sources and online resources
EK5	**The student is able to prepare a report on the measurement.**
2 (F)	The student is not able to prepare a report on the measurement.
3 (E)	The student is able to prepare a report on the measurement.
3,5 (D)	The student is able to prepare a report on the measurements and perform a written presentation of the results.
4 (C)	The student is able to prepare a report on the measurements and perform a written presentation of the results and presents it.
4,5 (B)	The student is able to prepare a report on the measurements and perform a computer presentation of the results.
5 (A)	The student is able to prepare a report on the measurements and perform a computer presentation of the results and present it.

III. OTHER USEFUL INFORMATION

1. All information for students on the schedule are available on the notice board and on the website: https://we.pcz.pl/
2. Information on the consultation shall be provided to students during the first lecture and will be placed on the website https://we.pcz.pl/
3. Terms and conditions of credit courses will be provided to students during the first lecture