Subject (course) name: **High Voltage Engineering**		
Programme: **Electrical engineering** Specialty:		Subject code: **3KO**
		Title graduate: **Engineer**
Type of course: **obligatory**	Course level: **First-cycle studies**	Year: **II** Semester: **IV** Semester: **spring**
Form of classes: **Lectures, Labs**	Number of hours per week: **2L, 0, 2Lab, 0, 0**	Credit points: **4 ECTS**

GUIDE TO SUBJECT

SUBJECT OBJECTIVES

C1. General knowledge on high voltage technology.

C2. Particular knowledge of methods of analysis of high voltage circuits.

C3. Practical ability to maintain high voltage devices in a HV lab.

SUBJECT REQUIREMENTS

1. knowledge of electrical engineering
2. knowledge of electrical materials science
3. knowledge of physics
4. ability to work individually and in teams

LEARNING OUTCOMES

EK 1 – Student is able to define basic notions from the scope of electrical engineering, distinguishes basic forms of electrical discharges, diagnostics and measurement methods

EK2 – Student is able to avail of theoretical knowledge and to dispose of it in practice in the HV laboratory. He/she is able to identify the analysis of the circuit and interpret the experimental results

EK3 – Student is able to cooperate with other team members, is engaged in fulfillment of tasks to be carried out in the laboratory. Student is creative and determined in solving practical problems. He/she is able to able to cooperate with other team members, is engaged in fulfillment of tasks in the lab, strides at a proper fullfilment of his/her tasks

SUBJECT CONTENT

Form of classes - lectures

Topic	Hours
W1 – Introduction – the role of high voltage technology in power engineering	**2**
W2 – Phenomena related to high voltage technology in insulation of power engineering devices, electrical discharge in a gas dielectric air ionisation, meta-stable levels	**2**
W3 – Discharge mechanisms in a gas dielectric: Townsend, canal discharge. Paschen's law. The role of spatial charge in the discharge process.	**2**
W4 – Discharge mechanisms in a liquid dielectric, ion, gas, bridge mechanisms, durability dependencies	**2**
W5 – Discharge mechanisms in a solid dielectric, Frohlich criterion, thermal balance for the dielectric in the insulation system	**2**
W6 – The effect of the shape of electrodes on maximum field strength, the role of barriers, complex insulation systems	**2**
W7 – The effect of time of the maximum field strength in the insulation system, stroke coefficient, stroke dependencies for chosen systems, insulation coordination, practical solutions	**2**
W8- The effect of atmospheric conditions on the durability of practical insulations systems: pressure, humidity, temperature, discharge in the artificial rain and for dirty insulators, methods of examination and practical solutions	**2**
W9 – Partial discharges in the solid insulation systems, treeing and o the ageing mechanisms.	**2**
W10 – Sliding discharges in complex insulation systems	**2**
W11 – Methods of control of electric field distribution	**2**
W12 –An overview of high voltage dependencies used in practical calculations., high voltage insulation of power transformers and rotating machines	**2**
W13 –Ageing of insulation systems, ageing experiments, practical methods of interpretation of experimental data	**2**
W14 – Mechanisms of forming the thunderstorm front, atmospheric discharges, thunders, methods of protection of households and plants	**2**
W15 – Recap. The effects of high voltage energy transfer on the environment	**2**
Total	**30**

Form of classes – laboratory

Topic	Hours
L1 – Making up laboratory teams, getting acquainted with the study program and the lab regulations	**2**
L2 – Corona discharge	**2**
L3 – Partial discharges in the air.	**2**
L4 – Sliding discharges on the surface of a solid dielectric.	**2**
L5 – Measurements of maximum voltage in HV systems	**2**
L6 – Extra notice meeting time	**2**
L7 – A colloquium	**2**
L8 – Durability and breakdown of a solid dielectric	**2**
L9 – Voltage distribution in a chain of insulators	**2**
L10 – Examination of a surge arrester	**2**
L11 – The Schering bridge	**2**
L12 –Short-circuit on the surface of a dry and wet insulator	**2**
L13 – Multiple reflection of waves	**2**
L14 – A colloquium	**2**
L15 – Extra notice meeting time, credits, recap	**2**
Total	**30**

STUDY METHODS

1. Lectures using multimedia presentations
2. Discussion during the course and during individual consultations
3. Laboratory – teamwork

EDUCATIONAL TOOLS

1. Audiovisual equipment, black(white)board, lectures in electronic version
2. Textbooks
3. Laboratory classes

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

F1. assessment of self preparation for laboratory classes – oral answer
F2. assessment of correctness and timeliness of lab reports
P1. assessment of the ability to follow the study highlights – a colloquium (50% of the final credit mark)
P2. laboratory – assessment of the ability to solve problems, draw conclusions and prepare reports – team reports from lab classes (50% of the final credit mark)
P3. Written exam

STUDENT WORKLOAD

Form of activity		Averaged workload (hours)		
		[h]	∑ [h]	ECTS
Participation in class activities	lecture laboratory	30 30	60	3
Preparation for lectures and lab reports		15		
Preparation for lab classes		15	30	1
Total			**90**	**4**

A. BASIC READING

1. E. Kuffel et al. High voltage engineering. Fundamentals. Second Edition, Butterworth-Heinemann 2000
2. M. S. Naidu, V. Kamaraju, High Voltage EngineeringTata McGraw-Hill 2009
3. Dieter Kind, Hermann Kärner. High Voltage Insulation Technology: Textbook for Electrical EngineersGlp International, 1985

B. FURTHER READING

1. Z. Flisowski, Technika wysokich napięć, WNT 1992 (in Polish)
2. A. Schwab, Hochspannungsmesstechnik. Springer 1981.
3. M. Babikow et al., Technika wysokich napięć, WNT 1967 (in Polish)

Learning objectives	In relation to the learning outcomes specified for the field of study	Subject objectives	Study methods	Methods of assessment
EK1	KE1A_W01 KE1A_W04	C1 C2	lecture	P1, P3
EK2	KE1A_U10 KE1A_U12 KE1A_U13	C2, C3	lab	P2
EK3	KE1A_K03 KE1A_K06	C2, C3	lab	P1, P2

II. EVALUATION

Grade	Outcome
EK1	**Student characterizes basic concepts and notions related to high voltage technology, is able to characterize different discharges, diagnostic and measurement methods**
2	Student does not characterize any of the basic concepts and notions related to high voltage technology
3	Student is able to characterize just a few of the basic concepts and notions related to high voltage technology
3.5	Student is able to characterize many of the basic concepts and notions related to high voltage technology.
4	Student distinguishes physical phenomena related to high voltage technology and knows the basics of the measurements and diagnostics methods.
4.5	Student distinguishes physical phenomena related to high voltage technology in detail and knows well the measurements and diagnostics methods.
5	Student can carry out a detailed analysis of most issues related to high voltage technology.
EK2	**Student avails of theoretical knowledge and is able to use it for solving practical problems in the lab. Is able to identify a problem, carry out the analysis of the system and interpret the experimental results.**
2	Student cannot avail of theoretical knowledge obtained during the lecture. Student is not able to formulate a scientific problem properly..
3	Student is able to formulate a scientific problem properly.
3.5	Student is able to formulate a scientific problem properly and indicate a method how to solve it.
4	Student is able to formulate a scientific problem properly and attempts to solve it.
4.5	Student is able to formulate a scientific problem properly and solves it in a correct way with a little help from tutor. Student is able to interpret the research in a correct way.
5	Student is able to formulate a scientific problem properly and solves it in a correct way without any guidance. Student is able to interpret the research in a correct way.
EK3	**Student is able to cooperate with other team members is engaged in fulfilment of tasks in the lab, strides at a proper fulfilment of his/her tasks.**
2	Student cannot cooperate within a team.
3	Student can cooperate within a team as an ordinary team member.
3.5	Student can cooperate within a team as an ordinary team member. He/she is engaged during fulfilment of his/her tasks.
4	Student can cooperate within a team taking different roles, including being a team leader. He/she is engaged during fulfilment of his/her tasks and exhibits initiative..
4.5	Student can cooperate within a team taking different roles, including being a team leader. He/she is engaged during fulfilment of his/her tasks and exhibits high level initiative. He/she is extremely accurate, pedantic and scrupulous.
5	Student can cooperate within a team taking different roles, including being a team leader. He/she is engaged during fulfilment of his/her tasks and exhibits high level initiative. He/she is extremely accurate, pedantic and scrupulous. He is extremely creative when solving the problems.

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