FACULTY OF ELECTRICAL ENGINEERING

SUBJECT CARD

Name in Polish:	**Ogniwa fotowoltaiczne**
Name in English:	**Photovoltaic Cells**
Main field of study (if applicable):	**Electrical Engineering**
Specialization (if applicable):	**Renewable Energy Sources**
Level and form of studies:	**2nd level, full-time**
Kind of subject:	**obligatory**
Subject code:	**ELR041315**
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):	90		30		
Form of crediting:	crediting with grade		crediting with grade		
For group of courses mark (X) final course:					
Number of ECTS points:	3		1		
including number of ECTS points for practical (P) classes :			1		
including number of ECTS points for direct teacher-student contact (BK) classes:	2.10		0.70		

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. The student should have basic knowledge of physics.
2. The student should be capable of implementing correctly and effectively the laws of physics to the qualitative analysis to problems related to the studied engineering discipline.
3. The student should understand the need for studying the selected discipline of study. The student should understand the need for improvements of professional, personal and social skills

SUBJECT OBJECTIVES

C1. knowledge of the photovoltaic effect and physical models of the PV cells;
C2. learning of the photovoltaic cells and modules technology, their characteristics and parameters.
C3. understand the methods of energy storage and energy conversion from photovoltaic systems.
C4. understanding methods testing, calibration and the proper selection of indicators of photovoltaic system elements and the legal code concerning photovoltaics;

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge:

PEK_W01	the student has a working knowledge about solar radiation and application of semiconductor materials for conversion of radiation into electricity and they has a working knowledge about photovoltaic solar cells, connecting solar cells into photovoltaic panels as well as arranging the panels into photovoltaic systems;
PEK_W02	the student is capable to investigate and test photovoltaic cells and panels and is famillar with the legal conditions in Poland;

relating to skills:

PEK_U01	Able to analyze the resulting performance and signals received from the PV cells and photovoltaic systems.
PEK_U02	Can choose the elements of the photovoltaic power plant
PEK_U03	able to apply the theory to have met the qualitative and quantitative evaluation of the physical sizes of engineering.

relating to social competences:

PEK_K01	ability to think and act creatively and resourcefully. and understanding the needs of continuous monitoring of the photovoltaic knowledge

PROGRAMME CONTENT		
Form of classes - lecture		**Number of hours:**
Lec 1	Introduction of the subject, requirements and grading policy. Energy sources, the state's energy resources and their impact on the environment.	2
Lec 2	Basic concepts and units of energy. Solar radiation and the Earth's atmosphere.	2
Lec 3	Photovoltaic cells.	2
Lec 4	Description of the photovoltaic effect, current-voltage characteristics (I-V), Schottky barrier PV cells, MIS structure, the photovoltaic effect in semiconductors with a variable width of the barrier potential.	2
Lec 5	Technology and parameters of photovoltaic cells. Preparation, cleaning and crystallization of silicon.	2
Lec 6	Crystalline cells. Polycrystalline thin-film cells. cadmium tellurium cells. Cells based on amorphous silicon.	2
Lec 7	Parameters and characteristics of the photovoltaic modules.	2
Lec 8	Influence of various factors on the efficiency of photovoltaic conversion. Photovoltaic modules construction .	2
Lec 9	Stand-alone photovoltaic systems and PV systems integrated with grid.	2
Lec 10	Integrated systems with buildings and keep up with the sun systems.	2
Lec 11	Accumulation of electricity from photovoltaic modules, Hubs radiation. Standardization in photovoltaic energy.	2
Lec 12	Manufacturers of photovoltaic cells and modules. Testing and calibration of photovoltaic cells or modules.	2
Lec 13	Indicators of proper selection of photovoltaic system elements. Strategy of development photovoltaic technology.	2
Lec 14	Final test,	2
Lec 15	discussion of results of the final test	2
	Total hours:	**30**

Form of classes - laboratory		**Number of hours:**
Lab 1	Getting acquainted with laboratory, requirements and method of assessment. Presentation of the Rules of Procedure Health and Safety Laboratory.	2
Lab 2	Study I-V characteristics of crystalline and polycrystalline silicon PV cells	2
Lab 3	Study of the effect of lighting conditions and temperature on the I-V characteristics of PV cells.	2
Lab 4	Getting familiar with the construction and operation of photovoltaic power system.	2
Lab 5	Getting acquainted with the construction and operation of small-power hybrid (PV and wind).	2
Lab 6	Analysis of the signals from the photovoltaic power system in conjunction with weather data.	2
Lab 7	Computer simulation of photovoltaic power plant operation	2
Lab 8	Crediting with grade	1
	Total hours:	**15**

TEACHING TOOLS USED
N1. Traditional lectures supplemented by audio-visual demonstrations. Multi-medial presentation.
N2. Final test
N3. Traditional laboratory exercises in student groups.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT		
Evaluation *F – forming (during semester)* *P – concluding (at semester end)*	**Educational effect number**	**Way of evaluating educational effect achievement**
F1(W)	PEK_W01 PEK_W02	Final test
P(W)	P=F1	
F1(L)	PEK_U01 PEK_U02 PEK_U03 PEK_K01	Evaluation with preparations for the laboratory
F2(L)	PEK_U01 PEK_U02 PEK_U03 PEK_K01	Activity on the laboratory classes
P(L)	P=0,5F1+0,5F2	

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] E. Klugman-Radziemska – Fotowoltaika w teorii i praktyce , Wydawnictwo BTC , Legionowo 2008.
[2] M.T. Sarniak, Podstawy fotowoltaiki , Oficyna Wydawnicza Politechniki Warszawskiej, 2008.

SECONDARY LITERATURE:

[1] E. Klagmann, E. Klugman-Radziemska – Ogniwa i moduły fotowoltaiczne oraz inne niekonwencjonalne źródła energii, Fundacja Ekonomistów Środowiska i Zasobów Naturalnych, Białystok, 2005
[2] Z. Pluta – Słoneczne instalacje energetyczne, Oficyna Wydawnicza Politechniki Warszawskiej, 2008.

SUBJECT SUPERVISOR

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MATRIX OF CORRELATION BETWEEN EDUCATIONAL EFFECTS FOR SUBJECT
ELR041315 - Photovoltaic Cells
AND EDUCATIONAL EFFECTS FOR MAIN FIELD OF STUDY **Electrical Engineering**
AND SPECIALIZATION **Renewable Energy Sources**

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	S2OZE_W06	C.1 C.2	Lec1 Lec2 Lec3 Lec4 Lec5 Lec6 Lec7 Lec8 Lec9 Lec10 Lec14 Lec15	N.1 N.2
PEK_W02	S2OZE_W06	C.1 C.2	Lec11 Lec12 Lec13 Lec14 Lec15	N.1 N.2
PEK_U01	S2OZE_U04	C.1 C.2 C.3 C.4	Lab1 Lab2 Lab3	N.3
PEK_U02	S2OZE_U04	C.1 C.2 C.3 C.4	Lab4 Lab6	N.3
PEK_U03	S2OZE_U04	C.1 C.2 C.3 C.4	Lab2 Lab3 Lab4 Lab5 Lab6 Lab7	N.3
PEK_K01	K2ETK_K06 K2ETK_K07	C.1 C.2 C.3 C.4	Lec1 Lec2 Lec3 Lec4 Lec5 Lec6 Lec7 Lec8 Lec9 Lec10 Lec11 Lec12 Lec13 Lec14 Lec15 Lab1 Lab2 Lab3 Lab4 Lab5 Lab6 Lab7 Lab8	N.1 N.2 N.3