FACULTY OF ELECTRICAL ENGINEERING

SUBJECT CARD

Name in Polish:	**Modelowanie obwodowo-polowe maszyn i urządzeń elektrycznych**
Name in English:	**Field-circuit modelling of electrical machines and apparatus**
Main field of study (if applicable):	**Electrical Engineering**
Specialization (if applicable):	**Industrial Electrical Engineering**
Level and form of studies:	**2nd level, part-time**
Kind of subject:	**optional**
Subject code:	**ELR053166**
Group of courses:	**NO**

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU):	22		11		
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 ordinary differential equations and differential equations with partial derivatives.
2. Has a basic knowledge of classical electrodynamics (electrostatics, electric current, magnetostatics, electromagnetic induction, electromagnetic waves).
3. He knows the fundamental laws and properties of the electromagnetic field.
4. Is able to correctly and effectively apply the knowledge of differential and integral calculus of several variables for qualitative and quantitative analysis of mathematical problems related to engineering discipline of study.
5. Is able to apply the learned theory of the electromagnetic field for the qualitative and quantitative assessment of the physical quantities of an engineering.
6. Is able to work together in a group and present the results of this cooperation.

SUBJECT OBJECTIVES

C1. Presentation for students the physical description of electromagnetic phenomena which constitute the principle of operation of electrical machines and apparatus.

C2. Raising students' awareness due to the relationship between induced electromagnetic fields in machines and apparatus and characteristics of their operations.

C3. Acquaint students with the universal method of fields calculation (finite element method) as a tool for calculating the induction parameters, forces and power losses.

C4. Acquaint students with the field-circuit method for analysis and design of electrical machines and apparatus.

C5. Acquaint with work as a team on the calculation project.

SUBJECT LEARNING OUTCOMES

relating to knowledge:	
PEU_W01	Know the basic laws of electrodynamics described by Maxwell's equations.
PEU_W02	Is able to describe the construction of a field model and a field-circuit model of electrical machines and apparatus.
PEU_W03	Is able to explain the methods for calculating the induction parameters of windings, electromagnetic forces and power losses.
relating to skills:	
PEU_U01	Is able to use commercial applications to field and field-circuit electromagnetic calculation.
PEU_U02	Is able to design two-dimensional field and field-circuit models of electrical machines and apparatus and is able to assess the results of numerical calculations of electromagnetic field distribution.
PEU_U03	Is able to calculate the inductance of windings, electrodynamic forces and torques, and the power losses in construction elements.
relating to social competences:	
PEU_K01	He knows the rules of group work and managing a small team taking responsibility for the results of his work.

PROGRAMME CONTENT		
Form of classes - lecture		**Number of hours:**
Lec 1	A general description of the course. Historical outline. Indication and discussion of literature. Presentation of requirements and way to complete the course.	2
Lec 2	Fundamental laws of electrodynamics. Maxwell's equations, constitutive relations. Electromagnetic properties of materials used in electrical machines and apparatus. Hard and soft magnetic materials.	2
Lec 3	Differential and integral equations. Scalar and vector potentials.	2
Lec 4	Energy and power. Energetic relations. Poynting's theorem. Eddy current power losses.	2
Lec 5	Fundamentals of numerical finite element method. Construction of field calculation model, mesh generation.	2
Lec 6	Field and field-circuit models. Coupling the field-circuit model with the equation of motion. Dynamic calculations.	2
Lec 7	Calculations for the steady state. Harmonics fields. Complex magnetic vector potential.	2
Lec 8	The calculation of transients. Solution "transient".	2
Lec 9	Calculation of self and mutual multi-phase winding inductance using power and magnetic coupling methods.	2
Lec 10	Power losses in windings, magnetic cores and in construction elements.	2
Lec 11	Electrodynamic forces and electromagnetic torque.	2
	Total hours:	**22**

Form of classes - laboratory		**Number of hours:**
Lab 1	Instruction manual of computer software for field calculation.	2
Lab 2	Development of the two-dimensional, flat-parallel field model of the electromagnetic device (e.g. electromagnet contactor).	2
Lab 3	Calculations of the flat-parallel magnetic field in the electromagnetic device. Analysis of the field distribution.	2
Lab 4	Development of the two-dimensional, axisymmetric field model of the electromagnetic device (e.g. electromagnetic valve).	2
Lab 5	Calculations of axisymmetric magnetic field in the electromagnetic device. Analysis of the field distribution and calculation of the electrodynamics force.	2
Lab 6	Presentation to assessment of reports of performed classes.	1
	Total hours:	**11**

TEACHING TOOLS USED
N1. Lecture with audio-visual technology, multimedia presentations.
N2. Computing laboratory conducted on individual workstations.

EVALUATION OF SUBJECT LEARNING OUTCOMES ACHIEVEMENT		
Evaluation *F – forming (during semester)* *P – concluding (at semester end)*	**Educational effect number**	**Way of evaluating educational effect achievement**
F1(W)	PEU_W01 PEU_W02 PEU_W03	Examination
P(W)	P=F1	
F1(L)	PEU_U01 PEU_U02 PEU_U03 PEU_K01	Reports on performed calculations
P(L)	P=F1	

PRIMARY AND SECONDARY LITERATURE

PRIMARY LITERATURE:

[1] Turowski J., Obliczenia elektromagnetyczne elementów maszyn i urządzeń elektrycznych, WNT, Warszawa 1982
[2] Turowski J., Elektrodynamika techniczna, WNT, Warszawa 1993
[3] Demenko A., Symulacja dynamicznych stanów pracy maszyn elektrycznych w ujęciu polowym, Wydawnictwo Politechniki Poznańskiej, 1997

SECONDARY LITERATURE:

[1] Sadiku M. N. O., Numerical Techniques in Electromagnetics, CRC PRESS LLC, 2001
[2] Bianchi N., Electrical machine analysis using finite elements, CRC Taylor&Francis, Boca Raton, 2005

SUBJECT SUPERVISOR
Paweł Zalas, pawel.zalas@pwr.edu.pl