Subject (course) name: **Electromagnetic field theory**		
Programme: **Electrical Engineering** Specialty:		Subject code: **25K**
		Title graduate: **Engineer**
Type of course: **obligatory**	Course level: **First-cycle studies**	Year: **III** Semester: **V** Semester: **winter**
Form of classes: **Lectures, Classes, Labs, Seminar, Project**	Number of hours per week: **$2L^E$, 1C, 0, 0, 1P**	Credit points: **5 ECTS**

GUIDE TO SUBJECT

SUBJECT OBJECTIVES

C1. General knowledge of mathematical description of electromagnetic field.

C2. General knowledge of fundamental properties of electrostatic, magnetostatic, electroconductive and electromagnetic fields.

C3. General ability of analyzing simple field problems with use of selected analytical and numerical methods.

SUBJECT REQUIREMENTS

1. General knowledge of physics related to electricity and magnetism.
2. General knowledge of calculus and vector analysis and ability of using them.
3. General ability to independently search in literature.

LERNING OUTCOMES

EK1 – The student knows the differential operators used in electromagnetic field theory and can apply them.

EK2 – The student knows the fundamental laws and phenomena related to electrostatic, electroconductive, magnetostatic and electromagnetic fields.

EK3 – The student can apply the laws of electromagnetism and analytical and numerical methods to solve simple field problems.

EK4 − The student can interpret the results of analytical and numerical computations related to field theory.

SUBJECT CONTENT

Form of classes - lectures

Topic	Hours
L1 – Introduction to field theory.	**2**
L2 – Coulomb forces and electric field intensity.	**2**
L3 – Electric flux and Gauss' law.	**2**
L4 – Work, potential and energy of electrostatic field.	**2**
L5 – Electrostatic field in matter.	**2**
L6 – Solving electrostatic problems.	**2**
L7 – Currents and conductors.	**2**

L8 – Magnetostatic field.	**2**
L9 – Magnetic potentials.	**2**
L10 – Forces and work in magnetic field.	**2**
L11 − Magnetic properties of matter.	**2**
L12 – Inductance and magnetic energy.	**2**
L13 − Electromotive force and induced electric field.	**2**
L14 − Electromagnetic field.	**2**
L15 – Time harmonic magnetic field.	**2**
Total	**30**

Form of classes

Topic	Hours
C1 – Vector analysis, contour and surface integrals.	**1**
C2 – Coulomb forces, electric field intensity.	**1**
C3 – Using Gauss' law.	**1**
C4 – Work, potential and energy of electrostatic field.	**1**
C5 – Electrostatic field in matter.	**1**
C6 – Solving electrostatic problems.	**1**
C7 – Electroconductive field.	**1**
C8 – Test 1 (electrostatic and electroconductive field).	**1**
C9 – Using Biot-Savart law and Ampère's law.	**1**
C10 – Forces and work in magnetic field.	**1**
C11 − Solving magnetostatic problems.	**1**
C12 – Inductance and magnetic energy.	**1**
C13 − Electromotive force and induced electric field.	**1**
C14 − Test 2 (magnetic field and EMF).	**1**
C15 – Time harmonic magnetic field.	**1**
Total	**15**

Form of project

Topic	Hours
P1 – Introduction	**1**
P2 – Types of field problems, equations and boundary/initial conditions, a review of analytical and numerical methods in field theory.	**1**
P3,4,5 – The method of separation of variables	**3**
P6,7,8 – The method of finite differences	**3**
P9,10,11 – The method of finite elements	**3**
P12,13,14 – Using software to solve assigned problems and create solution reports	**3**
P15 – Evaluation of reports.	**1**
Total	**15**

STUDY METHODS

1. Lectures with use of multimedia presentations.
2. Solving problems in classes.
3. Solving problems with use of numerical methods (project).
4. Discussion during the course and individual consultations.

EDUCATIONAL TOOLS

1. Audiovisual equipment, lectures in electronic version.
2. Black board and chalk or white board and markes.
3. Suitable software, computers (optional).

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

F1. Assessment of comprehending material – oral answer.
P1. Lecture – written examination test on theory and solving problems.
P2. Classes – written tests.
P3. Project – assessment of the report on solving the numerical problem assigned to the student.

STUDENT WORKLOAD

Form of activity	Averaged workload (hours)

	[h]	∑ [h]	ECTS
Participation in class activities lectures classes project consultations	30 15 15 5	65	3
Preparation for tutorials (reading literature)	10	60	2
Preparation for class tests	10		
Preparation for classes	10		
Project realization	10		
Preparation for exam	20		
Total		**135**	**5**

BASIC READING

1. Jabłoński P., Engineering Physics – Electromagnetism, electric version in the TUC Main Library.

2. Edminister J.A.: Theory and problems of electromagnetics. Schaum's Outline Series, McGraw-Hill, 1993.

3. Nasar S.A.: 2000 solved problems in electromagnetics. Schaum's Solved Problems Series, McGraw-Hill, 1992.

4. Sibley M., Introduction to electromagnetism, Essential Electronics Series, Butterworth-Heinemann Ltd., 1995.

5. Kraus J.D., Electromagnetics, McGraw-Hill Series in Electrical & Computer Engineering, McGraw-Hill College, 1991.

6. Cheng D.K., Field and Wave Electromagnetics, International Edition, Prentice Hall, 1991.

7. Hayt W.H., Engineering Electromagnetics, Electrical & Electronic Engineering Series, McGraw-Hill Science/Engineering/Math, 2005.

8. Jabłoński P., Piątek Z.: Przykłady i zadania z podstaw teorii pola elektromagnetycznego. Część I. Wyd. Pol. Częstochowskiej, Częstochowa 2008.

9. Piątek Z., Jabłoński P.: Podstawy teorii pola elektromagnetycznego. WNT, Warszawa 2010.

10. Bolkowski S., Stabrowski M., Skoczylas J., Sroka J., Sikora J., Wincenciak S.: Komputerowe metody analizy pola elektromagnetycznego. WNT, Warszawa 1993.

FURTHER READING

1. Moon P., Spencer D.E.: Teoria pola. PWN, Warszawa 1966.

2. Rawa H.: Podstawy elektromagnetyzmu. Oficyna Wyd. Pol. Warszawskiej, Warszawa 1996.

3. Jaszczyk B., Łukaniszyn M., Przytulski A.: Zbiór zadań z teorii pola elektromagnetycznego. Oficyna Wyd. Pol. Opolskiej, Opole 2000.

4. Łobos T., Łukaniszyn M., Jaszczyk B.: Teoria pola dla elektryków. Oficyna Wyd. Pol. Wrocławskiej, Wrocław 2004.

5. Sikora J., Skoczylas J., Sroka J., Wincenciak S.: Zbiór zadań z teorii pola elektromagnetycznego. Oficyna Wyd. Pol. Warszawskiej, Warszawa 2004.

Learning objectives	In relation to the learning outcomes specified for the field of study	Subject objectives	Study methods	Methods of assessment
EK1	KE1A_W02 KE1A_W06	C1	lecture, classes	F1, P1, P2
EK2	KE1A_W06 KE1A_W06	C2	lecture, classes	F1, P1, P2
EK3	KE1A_U05 KE1A_U07 KE1A_U08	C3	lecture, classes, project	F1, P1, P2, P3
EK4	KE1A_U09 KE1A_U11	C3	lecture, classes, project	F1, P1, P2, P3

II. EVALUATION

Grade	Outcome
EK1	**The student knows the differential operators used in electromagnetic field theory and can apply them.**

2 (F)	The student does not know differential operators used in electromagnetic field theory.
3 (E)	The student knows operators of gradient, divergence and rotation in Cartesian coordinates.
3,5 (D)	The student can define the operators of gradient, divergence and rotation.
4 (C)	The student can enumerate and define all the fundamental differential operators used in electromagnetic field theory.
4,5 (B)	The student can enumerate, define and apply all the fundamental differential operators used in electromagnetic field theory.
5 (A)	The student can enumerate, define and apply all the fundamental differential operators used in electromagnetic field theory, he knows the relationships between them.
EK2	**The student knows the fundamental laws and phenomena related to electrostatic, electroconductive, magnetostatic and electromagnetic fields.**
2 (F)	The student cannot give any laws or phenomena related to any of the mentioned field.
3 (E)	The student formulates some of the laws for some of the mentioned fields.
3,5 (D)	The student formulates and writes some of the laws for some of the mentioned fields.
4 (C)	The student formulates and writes the crucial laws for all of the mentioned fields.
4,5 (B)	The student formulates and writes the crucial laws for all of the mentioned fields, he knows the substantial phenomena for the fields.
5 (A)	The student formulates, writes and explains the crucial laws for all of the mentioned fields, he knows and explains the substantial phenomena for the fields.
EK3	**The student can apply the laws of electromagnetism and analytical and numerical methods to solve simple field problems.**
2 (F)	The student cannot give any methods of solving of field problems.
3 (E)	The student can give some methods of solving of field problems.
3,5 (D)	The student can give and describe some methods of solving of field problems.
4 (C)	The student can give and describe some methods of solving of field problems, he can apply one of them to solve a simple field problem.
4,5 (B)	The student can give and describe many methods of solving of field problems, he can apply some of them to solve a simple field problem.
5 (A)	The student can give, describe and apply many methods of solving of field problems.
EK4	**The student can interpret the results of analytical and numerical computations related to field theory.**
2 (F)	The student cannot interpret the results of calculations.
3 (E)	The student can poorly interpret the results of calculations.
3,5 (D)	The student can correctly interpret the results of calculations.
4 (C)	The student can correctly interpret the results of calculations and determine integral parameters.
4,5 (B)	The student can deeply interpret the results of calculations and determine integral parameters.
5 (A)	The student can deeply interpret the results of calculations, determine integral parameters and assess the correctness of the computations.

III. OTHER USEFUL INFORMATION

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