COURSE DESCRIPTION CARD

<table>
<tr><td colspan="10">Faculty of Electrical Engineering</td></tr>
<tr><td>Field of study</td><td colspan="6">Electrical and Electronics Engineering</td><td colspan="2">Degree level and programme type</td><td>Master’s degree</td></tr>
<tr><td>Specialization/ diploma path</td><td colspan="6">-</td><td colspan="2">Study profile</td><td>-</td></tr>
<tr><td rowspan="2">Course name</td><td colspan="6" rowspan="2">Numerical Design and Analysis of Metamaterials</td><td colspan="2">Course code</td><td>IS-FEE-20014S</td></tr>
<tr><td colspan="2">Course type</td><td>elective</td></tr>
<tr><td rowspan="2">Forms and number of hours of tuition</td><td>L</td><td>C</td><td>LC</td><td>P</td><td>SW</td><td>FW</td><td>S</td><td colspan="2">Semester</td><td>summer</td></tr>
<tr><td></td><td></td><td></td><td></td><td>30</td><td></td><td></td><td colspan="2">No. of ECTS credits</td><td>3</td></tr>
<tr><td>Entry requirements</td><td colspan="9"></td></tr>
<tr><td>Course objectives</td><td colspan="9">To introduce students to the basics of metamaterial terminology and characterization techniques. To receive an ability of designing functional structures using the transformation optics method. To apply the scattering matrix method for extraction of composite effective parameters. To acquaint students with computations of physical fields using numerical-analysis software. To teach students how to synthesize metamaterial structure utilizing layered composites.</td></tr>
<tr><td>Course content</td><td colspan="9">Terminology, definitions, classification of electromagnetic composites. Characterization of some thermal, DC electric and magnetic as well as microwave metamaterials. Analytic and iterative design techniques of structures and systems requiring complex materials. Introduction to numerical-analysis software and 3D CAD modeling in computational electromagnetics. Homogenization techniques: effective properties identification of composite materials using simulation software. Physical field computations and analysis.Self-working on some problems in design of metamaterials with specified properties/characteristics</td></tr>
<tr><td>Teaching methods</td><td colspan="9">specialization workshop</td></tr>
<tr><td>Assessment method</td><td colspan="9">verification of preparation for classes, written reports, project completion, discussion</td></tr>
<tr><td>Symbol of learning outcome</td><td colspan="7">Learning outcomes
After completion of this course student</td><td colspan="2">Reference to the learning outcomes for the field of study</td></tr>
<tr><td>LO1</td><td colspan="7">uses proper definitions and concepts related to metamaterials, numerical models and field analysis</td><td colspan="2"></td></tr>
<tr><td>LO2</td><td colspan="7">describes the structure, parameters and properties of composite material with relation to specified applications</td><td colspan="2"></td></tr>
<tr><td>LO3</td><td colspan="7">design metamaterial structures using introduced methods</td><td colspan="2"></td></tr>
<tr><td>LO4</td><td colspan="7">creates and computes numerical models of some metamaterials</td><td colspan="2"></td></tr>
<tr><td>LO5</td><td colspan="7">discusses critically the construction of numerical model and computation results</td><td colspan="2"></td></tr>
<tr><td>Symbol of learning</td><td colspan="7">Methods of assessing the learning outcomes</td><td colspan="2">Type of tuition during which the outcome is</td></tr>
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outcome		assessed
LO1	personal assessment, short tests	
LO2	written reports, evaluating the student's solution of specified project	
LO3	written reports, work assessment during classes	
LO4	evaluating the student's solutions of specified problems, written reports	
LO5	evaluating the student's solution of specified project, personal assessment	

Student workload (in hours)		No. of hours
Calculation	preparation for workshop	**5**
	working on reports	**10**
	working on projects	**30**
	workshop attendance	**30**
	TOTAL:	**75**

Quantitative indicators	HOURS	No. of ECTS credits
Student workload – activities that require direct teacher participation	**30**	**1**
Student workload – practical activities	**75**	**3**

Basic references	1. F. Capolino. Metamaterials Handbook - Two Volume Slipcase Set 1st Edition. CRC Press, Boca Raton, 2009. 2. J.-P. Huang. Theoretical Thermotics: Transformation Thermotics and Extended Theories for Thermal Metamaterials. Springer Nature, 2020. 3. B. Banerjee. An introduction to metamaterials and waves in composites. CRC Press Taylor & Francis Group, Boca Raton, 2011. 4. R. Moore. Electromagnetic composites handbook. McGraw-Hill Education, 2016.
Supplementary references	1. T. Han, et al. Full control and manipulation of heat signatures: cloaking, camouflage and thermal metamaterials. Advanced Materials 26, 2014. 2. T. Han, C.-W. Qiu. Transformation laplacian metamaterials: recent advances in manipulating thermal and DC fields. Journal of Optics 18, 2016. 3. T. J. Cui, D. Smith, R. Liu. Metamaterials: Theory, Design, and Applications. Springer Science & Business Media, 2009. 4. R. Pal. Electromagnetic, mechanical, and transport properties of composite materials. CRC Press, 2014.

Organisational unit conducting the course	**Department of Electrotechnics, Power Electronics and Power Engineering**	**Date of issuing the programme**
Author of the programme	Adam Steckiewicz, PhD Eng	**25.02.2020**

L – lecture, C – classes, LC – laboratory classes, P – project, SW – specialization workshop, FW - field work, S – seminar