

## SYLLABUS 2017/2018

Level of study	Master's Course		
Course title in Ukraine	Метаматеріали		
Course title in English	<i>Metamaterials</i>		
Course code		ECTS credits	3
Lecturer(s)	Ph.D. Mykhailo Dergachov Email address: <a href="mailto:dergachov-mp@dsu.dp.ua">dergachov-mp@dsu.dp.ua</a> ;		

Course objectives (learning outcomes)	<p>This course aims at providing an introduction to the basic ideas and major topics in microwave and optical metamaterials.</p> <p>The students will be exposed to the main properties of metal-dielectric, negative-index metamaterials, and photonic crystals.</p> <p>The course also seeks to provide the background knowledge necessary for modelling and applications of metamaterials in the transfer and storage information systems.</p>
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### Prerequisites:

Knowledge	Physical and mathematical knowledge on the Bachelor level.
Skills	Physical and mathematical skills on the Bachelor level.
Courses completed	General physics, Solid-state physics, Electrodynamics.

### Learning effects:

	Learning effects of the course	Relation of the learning effects to the specialization
Knowledge	<p><b>W01</b> A student has a basic knowledge about the origin of electromagnetic phenomena in artificially structured materials with nano-scale inhomogeneities.</p> <p><b>W02</b> A student learns basics information on classification of metamaterials and methods of their fabrication.</p> <p><b>W03</b> A student knows various approaches to the describing and forecasting of properties of metamaterials.</p> <p><b>W04</b> A student acquires knowledge about modern trends in constructing and applying metamaterials.</p>	W01 – W10

	Learning effects of the course	Relation of the learning effects to the specialization
Skills	<p><b>U01</b> A student can explain the most important electromagnetic phenomena in metamaterials, in particular, in negative-index metamaterials, using by Maxwell's equations.</p> <p><b>U02</b> A student is able to describe the behavior of the permittivity and the permeability of the simplest composites. A student can explore the mixing rules for estimating the values of macroscopic effective parameters.</p> <p><b>U03</b> A student is able to make a comparison between the existing metamaterial fabrication methods and can choose the most effective of them.</p> <p><b>U04</b> A student can forecast an electromagnetic response of metamaterial over a microwave and/or optical range and determine the branch of their effective application on the base of properties of its compounds and their structural arrangement.</p>	U01 – U07

Social skills	Learning effects of the course	Relation of the learning effects to the specialization
	<b>K01.</b> A student has the creativity and the ability to conceptual thinking. <b>K02</b> A student is able to present and justify the personal point of view. <b>K03</b> A student is able to use the information technologies for the communication with the scientific community. <b>K04</b> A student is aimed to expand personal knowledge and skills. <b>K05</b> A student has the legal erudition. <b>K06</b> A student concerned about the environmental safety of physical experiment.	K01 – K06

### Course organization:

Form of classes	Lecture (W)	Group-exercises							
		A (large group)	K (small group)	L (Lab)	S (Seminar)	P (Project)	E (Exam)		
Contact hours	38								
Semester	2								
Language	English, Ukrainian								

### Teaching methods:

Classes will be performed in tutorial system on a weekly basis using multimedia presentation and internet in a form of the lectures open for discussion and questions.  
 In-class exercises are designed to probe knowledge developed through this process, with emphasis on how well students have understood the underlying physical and mathematical ideas.  
 The students will prepare one individual presentation.

### Assessment methods:

	E – learning	Didactic games	Classes in schools	Field classes	Laboratory tasks	Individual project	Group project	Discussion participation	Student's presentation	assignment (essay)	Oral exam	Written exam	Other
W01						x		x				x	
W02						x		x				x	
W03						x		x				x	
W04						x		x	x			x	
U01							x	x				x	
U02							x	x				x	
U03							x	x				x	

U04							x	x				x	
K01						x		x	x			x	
K02							x	x				x	
K03							x	x	x			x	
K04						x	x	x				x	
K05												x	
K06												x	

#### Assessment criteria:

Grades	<p>The grading scale will be as follows:</p> <p>90 – 100 % - <b>A</b> including <b>A- excellent</b> (eq. in Ukraine: відмінно (very good))</p> <p>82–89 % : <b>B</b> including <b>B – very good</b> (eq. in Ukraine: добре ( good))</p> <p>74–81 %: <b>C</b> including <b>C – good</b> (eq. in Ukraine: добре ( good))</p> <p>64–73 %: <b>D</b> including <b>D – satisfactory</b> (eq. in Ukraine: задовільно (satisfactory))</p> <p>60–63 %: <b>E</b> including <b>E – acceptable</b> (eq. in Ukraine: задовільно (satisfactory))</p> <p>&lt; 59 %: <b>F failed</b> (eq. in Ukraine: незадовільно (unsatisfactory))</p>
Criteria	<p><b>A.</b> A student knows all terms and concepts mentioned in W1-W4, U1- U4 and K1-K4. A student can work without any assistances, his/her knowledge's are creative and easily applied to decision of specific problem.</p> <p><b>B.</b> A student knows all terms and concepts mentioned in W1-W4, U1- U4 and K1-K4, yet needs a little help when decision of specific problem.</p> <p><b>C.</b> A student knows all terms and concepts mentioned in W1-W4, U1- U4 and K1-K4, however needs a help when decision of specific problem.</p> <p><b>D.</b> A student knows the most of terms and concepts mentioned in W1-W4, U1- U4 and K1-K4 and has difficulty in decision of specific problem.</p> <p><b>E.</b> A student knows only several terms and concepts mentioned in W1-W4, U1- U4 and K1-K4 and can solve only a simple problem.</p> <p><b>F.</b> A student does not know most of terms and concepts mentioned in W1-W4, he/she did not reach the satisfactory level of knowledge this course.</p>

#### Course content (topic list):

Topics	<p><b>W1.</b> Determination and Classification of Metamaterials</p> <p><b>W2.</b> General Properties of the Permittivity and Permeability in Homogeneous Media</p> <p><b>W3.</b> Effective Medium Modelling. The Mixing Rules</p> <p><b>W4.</b> Metal-Dielectric Composites</p> <p><b>W5.</b> Electric Metamaterials</p> <p><b>W6.</b> Magnetic Metamaterials</p> <p><b>W7.</b> Negative-index Metamaterials</p> <p><b>W8.</b> Reverse Phenomena in Negative-index Media</p> <p><b>W9.</b> General Recipe of Construction of Negative-index Metamaterials</p> <p><b>W10.</b> Metamaterial Elements and Components</p> <p><b>W11.</b> Plasmonic Component for Nano- and Meta-Photonics</p> <p><b>W12.</b> Photonic Band Gap Structures</p> <p><b>W13.</b> Fabrication and Characterization of Metamaterials</p> <p><b>W14.</b> Recent Advances of Nonlinear Effects in Metamaterials</p> <p><b>W15.</b> Second Harmonic Generation and Parametric Amplification</p> <p><b>W16.</b> Super Resolution with Meta-Lenses</p> <p><b>W17.</b> Transformation Optics and Electromagnetic Cloak of Invisibility</p> <p><b>W18.</b> Optical Cloaking</p>
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**Literature:**

Compulsory reading	W. Cai, V. Shalaev "Optical Metamaterials. Fundamentals and Applications", Springer Edition, Berlin, 2010 "Metamaterials and Plasmonics: ", Ed. by S. Zouhdi, A. Sihvola, A. P. Vinogradov, Springer, Dordrecht 2009
Recommended reading	Proceedings of the International Congress on Advanced Electromagnetic Materials in Microwaves and Optics organized by Virtual Institute for Artificial Electromagnetic Materials and Metamaterials ( <a href="http://www.metamorphose-vi.org">www.metamorphose-vi.org</a> ) Lecture notes will be also provided.

**Estimation of the total working time of students:**

Contact hours	Lectures	38
	Seminars	
	Other (consultation, meetings)	4
Students' work hours (without the lecturer)	Reading books and preparation for the lectures	20
	Preparation for quizzes and exercises	
	Preparation of an individual presentation	10
	Preparation to the exam	20
Total works' hours		90
ECTS credits 1 ECTS = 25 h		3