Warsaw University of Technology

COURSE OFFERED IN THE DOCTORAL SCHOOL

Code of the course	4606-ES-000DGHP-0319	Name of the course	Polish	Metamateriały. Wyzwanie dla nowoczesnych technologii i nauk inżynieryjnych
			English	Metamaterials. A challenge for modern technology and engineering sciences

Type of the course	Specialized		
Course coordinator	Prof. Francesco dell'Isola		
Implementing unit	Faculty of Mechanical and Industrial Engineering	Scientific discipline / disciplines*	Mechanical engineering, biomedical engineering, biotechnology, materials engineering

Level of education	Education of doctoral students	Semester	summer		
Language of the course	English				
Type of assessment:	Credit	Number of hours in a semester	15	ECTS credits	1
Minimum number of participants	12	Maximum number of participants	30	Available for students (BSc, MSc)	Yes

Type of classes		Lecture	Auditory classes	Project classes	Laboratory	Seminar
Number of hours	in a week		-	-	-	-
	in a semester	15	-	-	-	-

* does not apply to the Researcher's Workshop-

1. Prerequisites

M. Sc. diploma in physics, mechanical engineering, automotive engineering, aeronautical engineering, mechatronics, materials engineering, civil engineering and transport, automation, electronic and electrical engineering or equivalent.

2. Course objectives

To give to the PhD students the conceptual tools for understanding what is going on in the field and for possibly starting active research in the field. The course will give an outlook on the state of the art but also some hints of possible future researches in computational, experimental and theoretical mechanics of materials and multi physics, including piezoelectromechanical, materials.

3. Course content (separate for each type of classes)

Lecture

1. Basic concepts from Lagrangian Mechanics.
2. Basic ideas in Variational Principles in Physics.
3. The Principle of Virtual Work and its scope.
4. The problem of design of metamaterials.
5. Techniques in 3D printing as a tool for building specimens of metamaterials.
6. Ideas of Digital Image Correlation.
7. Description of some numerical techniques and experimental sets ups.
8. Some hints about future research perspective.

4. Learning outcomes			
	Learning outcomes description	Reference to the learning outcomes of the WUT DS	Learning outcomes verification methods*
Knowledge			
K01	Acquisition of basic knowledge about pantographic metamaterials, their unusual features and possibility of their application	SD W3	Evaluation of activity during classes
K02	Acquisition of basic knowledge about theoretical design of pantographic metamaterials and basics of energy methods	SD W4	Evaluation of activity during classes
Skills			
U01	Skills and competence, based on the acquired knowledge, to efficient use of energy methods in solid mechanics	SD U1	Evaluation of activity during classes
U02	Skills and competence, based on the acquired knowledge, to design simple functional pantographic metamaterial.	SD U2	Evaluation of activity during classes
Social competences			
K01	Graduates can use advanced theoretical mechanical methods knowledge in the issues related to metamaterials	SD K2	Evaluation of activity during classes

*Allowed learning outcomes verification methods: exam; oral exam; written test; oral test; project evaluation; report evaluation; presentation evaluation; active participation during classes; homework; tests

5. Assessment criteria
Short presentation of a subject agreed with the teacher

6. Literature
[1] Dell'Isola, Francesco, and David J. Steigmann, eds. Discrete and continuum models for complex metamaterials. Cambridge University Press, 2020. [2] Dell'Isola, Francesco, et al. "Pantographic metamaterials: an example of mathematically driven design and of its technological challenges." Continuum Mechanics and Thermodynamics 31 (2019): 851-884. [3] Dell'Isola, Francesco, et al. "Advances in pantographic structures: design, manufacturing, models, experiments and image analyses." Continuum Mechanics and Thermodynamics 31 (2019): 1231-1282.

1. PhD student's workload necessary to achieve the learning outcomes**		
No.	Description	Number of hours
1	Hours of scheduled instruction given by the academic teacher in the classroom	15
2	Hours of consultations with the academic teacher, exams, tests, etc.	5
3	Amount of time devoted to the preparation for classes, preparation of presentations, reports, projects, homework	5
4	Amount of time devoted to the preparation for exams, test, assessments	10
	Total number of hours	**35**
	ECTS credits	**1**

** 1 ECTS = 25-30 hours of the PhD students work (2 ECTS = 60 hours; 4 ECTS = 110 hours, etc.)