<table>
<tr><td>Kod przedmiotu</td><td></td></tr>
<tr><td>Rodzaj i oznaczenie</td><td>Elective Course</td></tr>
<tr><td>ECTS</td><td>1</td></tr>
<tr><td>Nazwa</td><td>Homogenization Theory</td></tr>
<tr><td>Nazwa w języku polskim</td><td>Teoria homogenizacji</td></tr>
<tr><td>Language of instruction</td><td>English</td></tr>
<tr><td>Course level</td><td>8 PRK</td></tr>
<tr><td>Course coordinator</td><td>Prof. dr hab. inż. Marcin Kamiński</td></tr>
<tr><td>Course instructors</td><td>Prof. dr hab. inż. Marcin Kamiński</td></tr>
<tr><td>Delivery methods and course duration</td><td>
<table>
<tr><th></th><th>Lecture</th><th>Tutorials</th><th>Laboratory</th><th>Project</th><th>Seminar</th><th>Other</th><th>Total of teaching hours during semester</th></tr>
<tr><td>Contact hours</td><td>0</td><td>0</td><td>0</td><td>15</td><td>0</td><td>0</td><td>15</td></tr>
<tr><td>E-learning</td><td></td><td>No</td><td>No</td><td>No</td><td>No</td><td>No</td><td></td></tr>
<tr><td>Assessment criteria (weightage)</td><td></td><td></td><td></td><td>1,00</td><td></td><td>0,00</td><td>1,00</td></tr>
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<tr><td>Course objective</td><td>The following course objectives are applicable:
1. presentation of the averaging method of mechanical and physical properties of composite materials;
2. description of the effective modules method for linear elasticity and heat conduction;
3. presentation of deformation energy approach in determination of effective tensor components;
4. an overview of the homogenization techniques for composites with hyperelastic and inelastic components;
5. presentation of multiscale approaches in homogenization;
6. an overview of probabilistic techniques relevant to the homogenization problem.</td></tr>
<tr><td>Learning outcomes</td><td>PhD student after this course is able to
1. determine the averaged physical and mechanical properties of fiber and particle-reinforced composites in deterministic and stochastic case W4
2. identify representative volume elements for various composites W4
3. present analytical relations describing effective elasticity tensor and also effective heat conductivity for fiber and particle reinforced composites W4
4. describe numerical procedure of determination of effective elastic properties using the cell problem for deterministic and random composites U4
5. propose an algorithm of homogenization for composites with inelastic components U4
6. carry out the Finite Element Method study relevant to the chosen homogenization problem U4, K1
7. describe a problem of interface defects and interphases in composites as well as their impact on effective characteristics U4
8. propose a method of determination of the sensitivity coefficients and probabilistic characteristics for effective elasticity tensor U4</td></tr>
<tr><td>Assessment methods</td><td>Learning outcomes would be verified during preparation (U4, K1) and presentation of the project results (W4, U4). Final grade: project - 75%, final presentation - 25%.</td></tr>
<tr><td>Prerequisites</td><td>The candidate should have basic information from mathematics and computer science to use any symbolic computing program for a development of mathematical operations and numerical visualization as well as to remember learning outcomes from the course CC 3 of this school.</td></tr>
<tr><td>Course content with delivery methods</td><td>Project will include the following issues:
1. definition of the effective material and physical characteristics of composites;
2. representative volume element – definition and criteria of determination;
3. analytical lower and upper bounds on effective material characteristics;
4. homogenization of some composite using the Finite Element Method with deformation energy and also the effective modules method;
5. homogenization of some composite accounting for interface defects;
6. determination of probabilistic characteristics of composite materials with material or geometrical uncertainties in their constituents;</td></tr>
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	7. effective material characteristics for composites with hyperelastic or inelastic components; 8. application and significance of sensitivity analysis in homogenization problem. This course is supported by the e-learning realized via email submission of the presentations and computer applications to the program MAPLE as well as usage of the Author's webpage connected with on-line discussion of the projects.
Basic reference materials	[1] J. German, Podstawy mechaniki kompozytów włóknistych. Wyd. PK, Kraków, 2001. [2] R.M. Christensen, Mechanics of Composite Materials. Wiley, New York, 1979. [3] M. Kamiński, Computational Mechanics of Composite Materials. Springer, London, 2005.
Other reference materials	[1] E. Sanchez-Palencia, Non-homogeneous media and vibration theory. Springer, Berlin, 1980. [2] G.W. Milton, The Theory of Composites. Cambridge University Press, Cambridge, 2009.
Average student workload outside classroom	10 h
Comments	Not applicable
Last update	06.05.2023