COURSE DESCRIPTION CARD - SYLLABUS

Course name
MICROMECHANICS OF MATERIALS

Course

Proposed by Discipline
Civil Engineering and Transport

Year/Semester
II/3

Type of studies
Doctoral School

Course offered in
English

Form of study
full-time

Requirements
elective

Number of hours

Lecture
4

Tutorials

Projects/seminars

Number of credit points

1

Lecturers

Responsible for the course/lecturer:
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Institute of Mechanics
Otto von Guericke University Magdeburg
Universitaetsplatz 2, 39106 Magdeburg,
Germany

Responsible for the course/lecturer:

Prerequisites

Knowledge: background in Continuum Mechanics; background in Mathematical Analysis; background in Numerical Analysis.

Skills: the ability to lead engineering programing; the ability to solve differential and integral equations; the ability to implement selected numerical schemes.

Social competencies: the ability to work in a team; ability to work in a multi-cultural environment; communication skills (in English).

Course objective

This course will provide fundamental concepts of micromechanics with emphasis on application to composite materials; will introduce unified theories of micromechanics of solids, understanding the microstructure of materials in the context of continuum mechanics, study methods and techniques for predicting of the mechanical behavior of composite materials.

Course-related learning outcomes

Knowledge

A PhD student who graduated from doctoral school knows and understands:
1) the extent that enables revision of existing paradigms - global achievements, covering theoretical basis as well as general and selected specific issues, that are specific to scientific disciplines studied at the doctoral school, [P8S_WG/SzD_W01]
2) fundamental dilemmas of the contemporary civilization. [P8S_WK/SzD_W05]

Skills

A PhD student who graduated from doctoral school can:
1) critically analyze and asses scientific research results, work of experts and other creative activities together with their contribution into knowledge development, [P8S_UW/SzD_U02]
2) transfer the results of scientific activity to the economic and social sphere, [P8S_UW/SzD_U03]
3) take part in scientific discourse, [P8S_UK/SzD_U07]
4) plan and implement individual and team research projects, also in the international community, [P8S_UO/SzD_U09]
5) plan classes and groups of classes and conduct them with the use of up-to-date methods and tools. [P8S_UU/SzD_U011]

Social competences

A PhD student who graduated from doctoral school is ready to:
1) acknowledge the importance of knowledge in solving cognitive and practical problems, [P8S_KK/SzD_K03]
2) think and act in an entrepreneurial manner, [P8S_KO/SzD_K06]
3) maintain and develop the ethos of research and creative communities, including:
- conducting independent scientific activity,
- respecting the principle of public ownership of the results of scientific activities, including the principles of intellectual property protection. [P8S_KR/SzD_K07]

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

PQF code	Methods for verification of learning outcomes	Assessment criteria
W01, W05	individual project	50-65% - 3.0 66-80% - 4.0 81-100% - 5.0
U02, U03, U07, U09, U011	individual project	as above
K03, K06, K07	individual project	as above

Programme content

1. Basic Equations of Continuum Mechanics (Displacement and Deformation, Stresses and Equations of equilibrium, Constitutive laws: linear elastic (isotropic and anisotropic), plasticity, viscoelasticity, Boundary Value Problems for Small-Strain Linear Elasticity).
2. General Theory of Eigenstrain (Definition of eigenstrain, Formal solutions to eigenstrain problem: Fourier series & integrals representations, Green's functions representations).
3. Inhomogeneities and Inclusions (Definitions of Inclusions and Inhomogeneities, Interface Conditions, Eshelby's solution for an ellipsoidal inclusion, Equivalent inclusion method).
4. Effective Properties of Heterogeneous Media (Random and periodic microstructures, Fourier series expansion for periodic structures, Volume and ensemble averages: representative volume element, average stresses and average strains, Mori-Tanaka theorem, Upper and lower bounds: Voigt and Reuss bounds, Hashin-Shtrikman bounds).
5. Effective Medium Theories (Self-consistent methods: generalized self-consistent method, differential self-consistent method, Mori-Tanaka method, Levin’s effective field model, Differential Scheme).
6. Homogenization methods (Probability and random variables, Statistical approaches: Willis's model of closure approximation, method of conditional moments, Asymptotic homogenization: periodic structure, perturbation method, Numerical homogenization, Comparison of different methods).
7. Damage and Failure of Engineering Composites (Introduction to Damage Mechanics, Brittle damage, Ductile damage: void growth, damage models, fracture concept, Interfaces: modeling of imperfect interfaces, effects of imperfect interfaces on effective properties, Fibers: fiber fragmentation (shear lag), mechanics of fiber pull-out (push-in), fiber bridging, Matrix: transverse matrix cracks, radial cracks, Probabilistic damage mechanics: statistical damage concept of Weibull, Probabilistic damage mechanical analysis).

Teaching methods

Lecture: multimedia presentation including illustrations and examples.

Bibliography

Basic

1. T. Mura, Micromechanics of Defects in Solids, 2nd Edition, Kluwer Academic, 1987.

2. R. Christensen, Mechanics of Composite Materials, Krieger, 1991.

Additional

1. S. Nemat-Nasser, M. Hori, Micromechanics: Overall Properties of Heterogeneous Materials, Second Edition, North-Holland Series in Applied Mathematics and Mechanics, 1999.

2. D. Gross, T. Seelig, Fracture Mechanics with an Introduction to Micromechanics, Springer, 2006.

Breakdown of average student's workload

	Hours	ECTS
Total workload	23	1.0
Classes requiring direct contact with the teacher	8	0.5
Student's own work (literature studies, preparation for tutorials, project preparation) [1]	15	0.5

[1] delete or add other activities as appropriate