Syllabus
Course Program

Rheology of Modern Materials

Specialty
113 – Applied Mathematics

Institute
Institute of Computer Modeling, Applied Physics and Mathematics

Educational program
Computer and mathematical modeling

Department
Mathematical Modeling and Intelligent Computing in Engineering (161)

Level of education
Master's level (1 year 4 months)

Course type
Special (professional), Elective

Semester
2

Language of instruction
English

Lecturers and course developers

Victor Fedorov

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PhD, Associate Professor of the Department " Mathematical modeling and intelligent computing in engineering "

Author of more than 40 scientific and methodical publications.
Courses: "Computational methods", "Nonlinear models of a deformed body", "Rheology of Modern Materials"
Google Scholar: https://scholar.google.com/citations?user=xozYUyIAAAAJ&hl=uk
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More about the lecturer on the department's website

General information

Summary

Rheology is a science that studies the mechanical behavior of materials. In a narrow sense, the behavior of structural materials related to processes over time is understood. Such properties are usually exhibited by polymers and polymer composites, which make up a significant part of modern machines and devices. Therefore, the study of the rheological properties of these materials and structures is an important component of the design of modern technology.

Course objectives and goals

The goal of studying the discipline is to acquire the ability to build physical relationships of viscoelastic materials and to study the stress-deformation state (SDS) of viscoelastic structural elements.
Objectives: assimilation of knowledge from the mathematical apparatus of integral equations, theoretical foundations of the mechanics of viscoelastic materials of anisotropic and heterogeneous materials and structural elements, formulation of their mathematical models and the ability to apply them to research the SDS of viscoelastic structural elements.

Format of classes

Lectures, laboratory classes, independent work, consultations, calculation work. Final control in the form of credit.

Competencies

GC3. Ability to master modern knowledge, formulate and solve problems.
PC1. Ability to solve tasks and problems that can be formalised, require updating and integrating knowledge, in particular in conditions of incomplete information.
PC2. Ability to conduct scientific research aimed to develop new and adapt existing mathematical and computer models to study various processes, phenomena and systems, conduct appropriate experiments and analyse the results.
PC9. The ability to mathematically formalise the formulation of scientific and practical problems, to choose a mathematical analytical or numerical method of its solution, which ensures the required accuracy and reliability of the result.
PC10. Ability to develop mathematical methods and algorithms for computer modelling of nonlinear physical phenomena and processes in innovative technological systems.

Learning outcomes

LO4. Build mathematical models of complex systems and choose methods of their research, implement the built models in software and check their adequacy using computer technologies.
LO14. To have the knowledge to mathematically formalise the formulation of scientific and practical problems, to choose a mathematical analytical or numerical method of its solution, which ensures the required accuracy and reliability of the result.
LO16. Be able to develop mathematical methods and algorithms for computer modelling of nonlinear physical phenomena and processes in innovative technological systems.

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures - 32 hours, laboratory classes - 16 hours, self-study - 72 hours.

Course prerequisites

The student may have knowledge of the theory of elasticity and the theory of shells.

Features of the course, teaching and learning methods, and technologies

Presentation of theoretical material in lectures is supplemented by laboratory classes, in which students solve practical problems with computing tools available to them. The results are drawn up in the form of reports, which should contain the conditions of the problem, its mathematical model, the sequence of calculations and the results in numerical and (or) graphic form. All actions must be accompanied by short comments. Appropriate work is graded after a short survey on this topic.

Program of the course

Topics of the lectures

Topic 1. Mechanical properties and features of deformation of polymers and polymer composites
Polymeric materials and methods of their production. Relaxation phenomena in polymers. Characteristic features of the behavior of crystalline polymers during deformation. Strength and destruction of polymers.
Topic 2. Mathematical models of viscoelastic material
Concept of viscoelasticity. The defining equations of the theory of viscoelasticity. Cores of creep and relaxation. Analytical presentation of kernels in hereditary viscoelasticity operators.
Topic 3. Methods of solving problems of the theory of viscoelasticity
Quasi-static problems of the theory of linear viscoelasticity. The method of quasi-constant operators. Application of power series of the Volterra operator. Methods of integral transformations.

Topic 4. The problem of homogenization of composite materials
Basic concepts of the theory of composite materials. Elastic characteristics of composites. The problem of homogenization of composite materials. Methods of homogenization of composites
Topic 5. Homogenization of viscoelastic transversely isotropic composite
Basic assumptions and initial relations. Longitudinal stretching. Transverse stretching. Longitudinal shift. Transverse shear.

Topics of the laboratory classes

Topic 1. Calculations of viscoelasticity parameters according to various mathematical models
Topic 2. Solving problems of viscoelasticity of structural elements
Topic 3. Homogenization of elastic properties of composites
Topic 4. Homogenization of a viscoelastic transversely isotropic composite

Self-study

Elaboration of lecture material.
Preparation for laboratory classes.
Independent study of topics and issues that are not taught in lectures.
Execution of individual calculation works.

Course materials and recommended reading

1. Christensen, R. M. Theory of Viscoelasticity. NY: Dover, Meneola. 1982. – 238 p.
2. Cho, K. S. Viscoelasticity of Polymers. Theory and Numerical Algorithms. NY: Springer Dordrecht. 2016. – 612 p.
3. Bland D. R., The Theory of Linear Viscoelasticity, Oxford, 1960. – 242 p.
4. Jones R. M. Mechanics Of Composite Materials. – Boca Raton: CRC Press, 2018. – 538 p.
5. Christensen R. M. Mechanics of Composite Materials. New York: John Wiley and Sons, Inc., 1979. – 278 p.
6. Aboudi J., Arnold S.M. , Bednarcyk B.A. Micromechanics of Composite Materials: A Generalized Multiscale Analysis Approach. Oxford: Butterworth-Heinemann, 2012. – 1006 p.

Tasks and methodical instructions for solving them will be sent when studying the relevant topics

Assessment and grading

Criteria for assessment of student performance, and the final score structure

Currently, the successful completion of nine tasks is assessed at 10 points.
The results of theoretical knowledge training are valued at 10 points, for a total of 100 points.

Grading scale

Total points	National	ECTS
90–100	Excellent	A
82–89	Good	B
75–81	Good	C
64–74	Satisfactory	D
60–63	Satisfactory	E
35–59	Unsatisfactory (requires additional learning)	FX
1–34	Unsatisfactory (requires repetition of the course)	F

Norms of academic integrity and course policy

The student must adhere to the Code of Ethics of Academic Relations and Integrity of NTU "KhPI": to demonstrate discipline, good manners, kindness, honesty, and responsibility. Conflict situations should be openly discussed in academic groups with a lecturer, and if it is impossible to resolve the conflict, they should be brought to the attention of the Institute's management.
Regulatory and legal documents related to the implementation of the principles of academic integrity at NTU "KhPI" are available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by	Date August 30, 2023	Head of the department Oleksiy VODKA
	Date August 30, 2023	Guarantor of the educational and professional program (1 year 4 months) Oleksiy LARIN