Syllabus
Course Program

Mixed Problems for Thin-Walled Structures

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
1

Language of instruction
English

Lecturers and course developers

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More about the lecturer on the department's website

General information

Summary

The basics of the general theory and methods of calculating mixed problems for thin-walled structures are given, as well as methods of calculating the technological processes of shell forming.
The application of the theory of elasticity and plasticity of inverse problems for plates and shells is considered. Mathematical models of the loss of stability of the forming processes of thin-walled structural elements are considered. In practical classes, students gain experience in using modern software complexes for calculating problems for plates

Course objectives and goals

The purpose of teaching the educational discipline "Mixed problems for thin-walled structures" is the formation of students' abilities:
- identify cases of the need to use certain methods and algorithms of inverse problems of the mechanics of a deformed solid body;
- set a mathematical problem (write out a system of equations with initial and boundary conditions), which will be adequate for solving the actual problem;
- assign an effective method and algorithm, or choose an existing program that will allow solving the set mixed task on a PC;

- perform calculations, analyze their results and make a decision about the sufficient quality of the obtained results or about the need to make changes in the formulation of the boundary value problem or the method and algorithm of its solution;
- prepare the results of calculations in the form of a report, using the relevant standards, recommendations and requirements of the customer interested in solving the current problem

Format of classes

Lectures, practical classes, consultations, self-study. Final control in the form of a credit.

Competencies

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.
PC4. Ability to develop and research mathematical and computer models, conduct computational experiments and solve formalised problems using specialised software.
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 discipline is 120 hours. (4 ECTS credits): lectures – 32 hours, laboratory work – 16 hours, independent work – 72 hours.

Course prerequisites

To study the course, students need basic knowledge of
- theoretical mechanics;
- linear theory of elasticity;
- theories of oscillations
- skills in using software tools for solving mathematical problems.

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

The educational process includes: lectures using computer and information tools; practical classes, independent work. When teaching the lecture course, methods of problem-based learning are applied by applying such forms of learning as thematic and problem-based lectures. The purpose of such lectures is to develop students' logical and independent understanding of material.

Practical classes of meaningful modules are planned for each topic, include preparation for practical classes according to the specified plan; execution of control tasks; review of scientific publications on the selected issue. The following forms and methods of teaching are used: explanation, discussion, debate, writing theses, creating presentations, forming individual components of scientific works.

Students' independent work includes: preparation for practical classes, study of recommended scientific literature, writing reports, preparation for modular tests and assessment. Tasks of students' independent work are considered completed if they: are submitted within the specified time and are fully completed (reveal the topic of the task); do not have logical and calculation errors.

Program of the course

Topics of the lectures

Topic 1. Inverse one-dimensional problems of elastic deformation of thin plates.
Construction of geometric ratios under various types of constraints for modulating the processes of shape formation

Topic 2. Inverse one-dimensional problems of elastic deformation of thin plates.
Construction of geometric ratios under various types of constraints for modulating the processes of shape formation

Topic 3. Inverse one-dimensional problems of elastic-plastic deformation of thin shells.
Construction of physical relationships using the theory of plastic flow with isotropic and kinematic hardening.

Topic 4. Use of the theory of hollow shells for setting inverse problems of shape formation. Creation of criteria for the loss of stability of elastic-plastic deformation.

Topic 5. Study of unloading processes during forming of thin-walled elements.

Topic 6. Setting of tasks for the design of stamps and punches to achieve the desired shape of thin-walled shell structures taking into account elastic unloading.

Topic 7. Research of forming processes based on statements of contact problems of elastic-plastic deformation of plates and shells.

Topic 8. Research of technological processes of high-temperature forming during creep

Topics of the workshops

Topics of the laboratory classes

Work 1. Solution inverse problems of cylindrical bending of plates .

Work 2. Inverse problems for axisymmetric bending of round plates

Work 3. Solving the problems of elastic deformation of plates by a rigid stamp

Work 4. One-dimensional problems of elastic deformation of cylindrical shells under movement restrictions.

Work 5. Inverse problems of elastic deformation of cylindrical shells.

Work 6. Numerical solution of inverse problems of elastic-plastic bending of plates

Work 7. Numerical solution of inverse problems of elastic-plastic bending of cylindrical shells

Work 8. Numerical solution of inverse problems of shaping of hollow shells.

Self-study

Preparation for practical classes. Completion of mandatory homework

Course materials and recommended reading

Basic literature

1. Bertram A. . Elasticity and Plasticity of Large Deformations. — Springer, 2012. — 345 c.
2. Hashiguchi K., Yamakawa Y. . Introduction to Finite Strain Theory for Continuum Elasto-Plasticity. — Wiley, 2012. — 417 c.
3. Haupt P. . Continuum Mechanics and Theory of Materials. — Springer, 2002. — 643 c.

Lubliner J. . Plasticity Theory. — Macmillan Publishing, 1990. — 528 p.

Additional literature

1 S. Timoshenko, S. Woinuwsky-Krieger. Theory Plates and Shells. New-York, 1987.-635 p.– 10202p.

2. Zeidler E. Basic Equations of Nonlinear Elasticity Theory / Nonlinear Functional Analysis and its Applications. IV: Applications to Mathematical Physics, 1988. Springer Verlag New York, Inc. P. 158 – 232.

Assessment and grading

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

To assess a student's performance, a point accumulation system is used. Maximum number of points for:

- independent work 5 points,
- control work 10 points,
- modular test 15 points.
- mandatory homework 20 points.

As an alternative to the cumulative point system, it is possible to take a written exam

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