Syllabus
Course Program

Elastic-Plastic Deformation of Plates and Shells

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

Gennadiy Lvov
Gennadiy.Lvov@khpi.edu.ua
professor, doctor of technical sciences
Scopus: Scopus Author ID: 6506190655
ORCID: http://orcid.org/0000-0003-0297-9227
ResearcherID: U-8774-2017

More about the lecturer on the department's website

General information

Summary

"Elastic-plastic deformation of plates and shells" is one of the important disciplines in the preparation of a master's degree in applied mathematics. The applied value of these subjects is due to the fact that most of the disasters that occur are associated with insufficient strength of structures, when their individual elements stop under under the action of the load to perform their functions and lose their strength. Knowledge of such phenomena and the ability to resist them is mandatory for specialists who conduct applied research in various fields of the mechanics of a solid deformed body.

Course objectives and goals

The purpose of the discipline "Elastic-plastic deformation of pastes and shells" is to equip students with the ability to solve complex specialized problems and practical problems of applied mathematics in professional activities or in the learning process, which involves the application of mathematical theories, methods, algorithms, information technologies and specialized software - assign an effective method and algorithm, or choose an existing program that will allow solving the set mixed task on a PC.

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

Introduction

The subject of the theory of plates and shells. Basic definitions and limitations. Kirchhoff's hypotheses in the theory of bending plates and shells.
Topic 1. Basic equations of plate theory.
1.1. Movements and deformations in plates
1.2. Efforts and moments
1.3. Static equations..
1.4. Boundary conditions in the theory of plate bending
Topic 2. Basics of shell theory
2.1. Some information on the theory of surfaces
2. 2. Geometric equations of the theory of shells
2. 3. Integral characteristics of the stressed state of shells.
Topic 3. Theory of plastic deformation
3.1. Plasticity surface. Modeling of strengthening processes.
3.2. Thermodynamic dependences of irreversible deformation.
3. 3. Associated flow law.
Topic 4. Types of physical dependencies
4.1. Theory of small elastic-plastic deformations
4.2. Theory of flow with isotropic strengthening
4. 3. Variants of translational strengthening
Topic 5. Construction of complete systems of equations
5.1. Differential equations of the theory of shells.
5.2. Boundary conditions.
5.2. Solving problems of plastic deformation in displacement
Тема 6.Наближені методи розв'язання задач пластичності
6.1. Метод змінних параметрів пружності
6.2. Метод додаткових навантажень
6.3. Метод часових кроків нввантаження .
6.4. Застосування варіаційних принципів.
Тема 7.Рішення деяких задач по теорії пластичної течії
7.1. Сумісний розтяг та кручення тонкостінних труб
7.2. Технологічні задачі обробки матеріалів тиском
Тема 8. Граничний стан
8.1. Статична та кінематичні теореми граничного стану
8.2. Рівняння граничного стану круглих та кільцевих пластин

Topics of the workshops

Topics of the laboratory classes

Topic 1. Problems of elastic-plastic bending of plates
Topic 2. Problems of cylindrical bending of folded plates
Topic 3. Problems of elastic-plastic bending of cylindrical shells
Topic 4. Problems of the momentless theory of shells of rotation
Topic 5. Numerical solution of problems of elastic-plastic deformation of rectangular plates
Topic 6. Numerical solution of problems of elastic-plastic deformation of flat shells
Topic 7. Problems of determining residual stresses in plates after plastic deformation.

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 с.

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