Syllabus
Course Program

Linear algebra

Specialty
113 - Applied mathematics

Institute
Institute of Computer Modeling, Applied Physics and Mathematics

Educational program
Computer and mathematical modelling

Department
Applied Mathematics (170))

Level of education
Bachelor's degree

Course type
Special (specialised)

Semester
2

Language of instruction
English

Lecturers and course developers

Halyna Timchenko

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Candidate of Technical Sciences, Associate Professor, Professor of the Department of Applied Mathematics, NTU "KhPI"
Work experience – 23 years. She is the author of more than 84 scientific and educational works.

More about the lecturer on the department's website

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Candidate of Technical Sciences, Associate Professor, Associate Professor of the Department of Applied Mathematics, NTU "KhPI"

Work experience – 25 years. She is the author of more than 50 scientific and educational works.

More about the lecturer on the department's website

Yurii Mikhlin

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Doctor of Physical and Mathematical Sciences, Professor, Professor of the Department of Applied Mathematics of NTU "KhPI".

He is the author of more than 300 scientific articles and publications in the proceedings of scientific conferences.

More about the lecturer on the department's website

General information

Summary

The course of linear algebra provides the knowledge necessary for the theoretical and practical training of engineers of this specialty to master mathematical methods for solving problems in the following sections: systems of linear algebraic equations, linear, Euclidean spaces, linear operators, quadratic forms.

Course objectives and goals

Acquaintance and mastery by students of modern mathematical methods necessary for solving theoretical and practical problems, development of skills in constructing mathematical models of various processes and phenomena, their application to the analysis of applied problems.

Format of classes

Lectures, practical classes, independent work, consultations. Individual calculation task. Final control – exam.

Competencies

ЗК6. Ability to abstract thinking, analysis, and synthesis.
ФК1. Ability to use and adapt mathematical theories, methods, and techniques to prove mathematical statements and theorems.
ФК3. Ability to choose and apply mathematical methods to solve applied problems, modeling, analysis, design, management, forecasting, decision-making.

Learning outcomes

РН2. Possess the basic provisions and methods of mathematical, complex and functional analysis, linear algebra and number theory, analytic geometry, theory of differential equations, in particular partial differential equations, probability theory, mathematical statistics and random processes, numerical methods.

Student workload

The total amount of discipline is 120 hours. (4 ECTS credits): lectures – 32 hours, practical classes – 16 hours, individual work – 72 hours.

Course prerequisites

To successfully complete the course, you must have knowledge and practical skills in the following disciplines: mathematical analysis, analytical geometry.

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

Study materials are available to students through OneNote.

Program of the course

Topics of the lectures

Topic 1. Linear space

Axioms. Examples. Basis, measurability. Transform the coordinates of a vector when converting the basis of an n-dimensional linear space.

Topic 2. Subspaces of a linear space

Ways to define a subspace. Sum and intersection of subspaces. Dimension of sum and intersection.

Topic 3. Linear operators in linear space

Linear operator and its matrix. Core and Value Area. Eigenvectors and eigenvalues of a linear operator. Transformation of the matrix of a linear operator when switching to another basis. Invariant subspaces.

Topic 4. Euclidean space and orthogonal design
Euclidean space. Orthonormal basis. Basis orthogonalization. Orthogonal subspace complement. Orthogonal projection into subspace.

Topic 5. Linear operators in Euclidean spaces
Conjugate operator. Self-adjoint operator. Eigenvalues and eigenvectors of a self-adjoint operator. Unitary and orthogonal operators.

Topic 6. Bilinear and quadratic forms
Linear transformations and operations on them. Bilinear forms and their properties.
Quadratic forms and their matrices. Transformation of a matrix of quadratic form with a linear non-degenerate transformation of its variables. Reduction of the quadratic form to the canonical form by the Lagrange method. Sylvester's theorem. Classification of quadratic forms. Reduction of quadratic form to canonical form by orthogonal transformation. Extreme properties of quadratic forms.

Topics of the workshops

Topic 1. Linear spaces and subspaces
Examples of linear spaces. Determination of the basis and dimensionality of a vector system. Vector decomposition by basis. Relationship between coordinates in different bases.

Topic 2. Subspaces of a linear space
Determination of the basis and dimension of the subspace. Determination of the basis and measurability of the sum and intersection of subspaces.

Topic 3. Linear operators in linear space
Construction of a linear operator matrix. Search for eigenvectors and eigenvalues of a linear operator.

Topic 4. Euclidean space and orthogonal design
Construction of an orthonormative basis of Euclidean space. Orthogonal subspace complement. Orthogonal projection into subspace.

Topic 5. Linear operators in Euclidean spaces
Conjugate and self-conjugate operators. Constructing a matrix of a conjugate operator. Search for eigenvectors and eigenvalues of a self-adjoint operator. Unitary and orthogonal operators.

Topic 6. Linear transformations. Bilinear and quadratic forms
Matrix of quadratic form. Conversion of a quadratic matrix in the transition to a new basis. Reduction of the quadratic form to the canonical form by the methods of Lagrange and Jacobi. Sylvester's criterion. Reduction of quadratic form to canonical form by orthogonal transformation. Simultaneous reduction of a pair of quadratic forms to a canonical form.

Topics of the laboratory classes

Laboratory work within the discipline is not provided.

Self-study

The course involves the performance of an individual calculation task on the following topics: 1. Linear spaces and subspaces.2. Linear operators in linear space.3. Euclidean space and orthogonal design.4. Linear operators in Euclidean spaces.5. Quadratic forms.
Additional self-study materials are also recommended for students..

Course materials and recommended reading

Basic literature

1. Тимченко Г. М., Одинцова О. В., Кириллова Н. О., Мазур О. С. Стислий курс вищої математики, частина 1. Аналітична геометрія та елементи лінійної алгебри: навч. посібник,- Київ: «Кондор», 2022. - 188с.
2. Лінійна алгебра та аналітична геометрія. Частина 2 : навч. посіб. Для студ. спеціальності 113 «Прикладна математика», спеціалізації «Data Science та математичне моделювання» /В.В. Третиник, В.О. Ліскін,В.В. Мальчиков, КПІ ім. ІгоряСікорського. – Київ : КПІ ім. Ігоря Сікорського, 2022. –125 с.
3. Математика в технічному університеті : Підручник / І. В. Алєксєєва, В. О. Гайдей, О. О. Диховичний, Л. Б. Федорова ; за ред. О. І. Клесова ; КПІ ім. Ігоря Сікорського. — Київ : КПІ ім. Ігоря Сікорського, 2018. — Т. 1. — 496 с.

Supplementary literature:
1. Навчальний посібник з лінійної алгебри для студентів механіко-математичного факультету / О. О. Безущак, О. Г. Ганюшкін, Є. А. Кочубінська. – К. : ВПЦ "Київський університет", 2019. – 224 с.
2. Сенчук Ю.Ф. Лінійна алгебра. Теорія лінійних просторів : Навч. посібник для студентів спеціальності «Прикладна математика» – Харків, НТУ «ХПІ», 2001. 200 с.
3. Дзюбак Л.П., Іглін С.П., Ліннік Г.Б., Морачковська І.О. Лінійна алгебра. Збірка завдань та методика розв'язання: навч.-метод. посібник. – Харків, НТУ «ХПІ», 2013. 240 с.

Assessment and grading

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

100% of the final grade consists of the results of the assessment in the form of an exam (30%) and the current assessment (70%).
Exam: written task (two theory questions + solution of two problems) and oral answer.
Current assessment: online test (10%), tests (20%) and individual calculation task (40%).

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": show discipline, good manners, goodwill, honesty, responsibility. Conflict situations should be openly discussed in study groups with the teacher, and if it is impossible to resolve the conflict, they should be brought to the attention of the staff of the Institute's directorate.
Regulatory and legal support for the implementation of the principles of academic integrity of NTU "KhPI" is available on the website: http://blogs.kpi.kharkov.ua/v2/nv/akademichna-dobrochesnist/

Approval

Approved by

Date, signature

Head of the department
Vyacheslav BURLAYENKO

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Guarantor of the educational program
Gennadiy LVOV