**Syllabus**
Course Program

# Analytical geometry

Specialty
113 - Applied mathematics

Institute
Institute of Computer Modelling, Applied Physics and Mathematics

Educational program
Computer and mathematical modelling

Department
Applied mathematics (170)

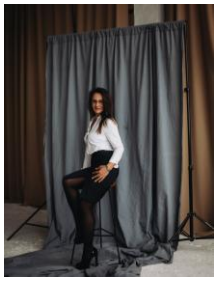
Level of education
Bachelor's degree

Course type
Special (professional),

Semester
1

Language of instruction
English

## Lecturers and course developers




**Halyna Timchenko**

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PhD in Engineering, Associate Professor, Professor of the Department of Applied Mathematics at NTU "KhPI". He has 23 years of experience. He is the author of more than 84 scientific and educational works.

More about the lecturer on the department's website



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He has 25 years of experience. Author of more than 50 scientific and educational works.

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

## Summary

The course in analytical geometry provides the knowledge necessary for theoretical and practical training of engineers in this speciality in the acquisition of mathematical methods for solving systems of linear algebraic equations, the basics of linear algebra, vector algebra, analytical geometry in the plane and in space.

## Course objectives and goals

Teaching future specialists the basics of linear algebra and analytical geometry (matrices, systems of linear algebraic equations, vector algebra, lines and planes, second-order curve theory), developing students' ability to independently deepen and expand mathematical knowledge and apply it to solving applied problems.

## Format of classes

Lectures, practical classes, independent work, consultations. Individual calculation task. The final control is an exam.

## Competencies

GC6. Ability to think abstractly, analyse and synthesise.
PC1. Ability to use and adapt mathematical theories, methods and techniques to prove mathematical statements and theorems.
PC3. Ability to choose and apply mathematical methods for solving applied problems, modelling, analysis, design, management, forecasting, decision-making..

## Learning outcomes

PO02. To know the basic principles and methods of mathematical, complex and functional analysis, linear algebra and number theory, analytical geometry, theory of differential equations, including partial differential equations, probability theory, mathematical statistics and random processes, numerical methods

## Student workload

The total volume of the discipline is 120 hours (4 ECTS credits): lectures - 32 hours, practical classes - 16 hours, independent work - 72 hours.

## Course prerequisites

To successfully complete the course, you need to have knowledge and practical skills in school algebra and geometry.

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

Learning materials are available to students through OneNote.

# Program of the course

## Topics of the lectures

Topic 1: Determinants and systems of linear algebraic equations (SLAE)
Determinants of the 2nd and 3rd order and their properties. Kramer's formulas for 3x3 SLAR.
Determinants of the nth order and their properties. Kramer's formulas for the nxn SAR.
Topic 2. Matrices and operations on them
Matrices, types of matrices. Linear operations on matrices and their properties. Matrix multiplication operation and its properties. The inverse matrix. Matrix equations.

Matrix rank, methods of its calculation. Elementary matrix transformations The concept of linear dependence of matrix rows and columns. The base minor theorem.

Topic 3. General study of a system of linear algebraic equations (SLAE)
Arbitrary SLARs. Extended matrix of the system. The condition of compatibility of SLARs (Kronecker-Capelli theorem). Gauss method. Compatibility of homogeneous PDEs. Fundamental system of solutions of homogeneous PDEs.
Topic 4. Vector algebra
Vectors, basic definitions. Linear operations on vectors. Linear dependence and independence of vectors. The concept of the basis and coordinate system. Cartesian rectangular coordinate system. Coordinates, modulus, orthogonal and directional cosines of a vector. Decomposition of a vector by a basis. Scalar, vector and mixed products of vectors, their properties and geometric interpretation.
Topic 5. Plane and line in space
The plane as a surface of the 1st order. The general equation of a plane. The angle between the planes. Conditions of parallelism and perpendicularity of planes. Normal equation of a plane. Distance from a point to a plane. General equations of a line in space. Canonical equations of a line. Transition from general equations of a line to canonical equations. Parametric equations of a line. Angle between lines, relative position of lines. Distance from a point to a line. The relative position of a plane and a line in space. Determining the point of intersection of a line and a plane. The angle between a line and a plane. The distance between intersecting lines.
Topic 6. A line on a plane
A line is a line of 1st order. The general equation of a line. Equation of a line with an angular coefficient. Canonical and parametric equations. Normal and directional vectors. The angle between lines. Conditions of parallelism and perpendicularity. Normal equation of a line. Distance from a point to a line.
Topic 7. Curves of 2nd order in the plane
Transforming coordinates on the plane. Circle, ellipse, hyperbola, parabola - definitions, derivation, properties: foci, eccentricity, directrix, asymptotes. The focal-directrix property. Investigation of the general equation of the 2nd order curve. Invariants of curves. Classification of 2nd order curves.

## Topics of the workshops

Topic 1: Determinants and systems of linear algebraic equations
Calculation of second and third order determinants. Solving the SLAP using Kramer's formulas.
Topic 2. Matrices and operations on them
Actions with matrices. Inversion of matrices. Solving an nxn SLAP using the inverse matrix. Matrix equations. Calculating the rank of a matrix
Topic 3. General research on SLAR
Solving the SLAP by the Gaussian method . Structure of the general solution.
Topic 4. Vector algebra
Linear operations on vectors. Calculating the modulus, orthogonal and cosine of a vector. Decomposition of a vector by a basis. Scalar, vector and mixed products of vectors. Calculation of areas and volumes of geometric figures.
Topic 5. Plane and line in space
General equation of a plane. An equation of a plane containing three given points. The angle between the planes. The relative position of planes in space. Distance from a point to a plane. Equation of a plane in segments on the axes. General equations of a line in space. Canonical and parametric equations of a line. Transition from general equations of a line to canonical equations. The relative position of lines. Distance from a point to a line. The relative position of a plane and a line in space. Determining the point of intersection of a line and a plane.
Topic 6. A line on a plane
The general equation of a line. Equation of a line with an angular coefficient. Canonical and parametric equations. The angle between the lines. Conditions of parallelism and perpendicularity. Distance from a point to a line.
Topic 7. Curves of 2nd order in the plane
Circle, ellipse, hyperbola, parabola. Reducing the general equation of a 2nd order curve to the canonical form.

### Topics of the laboratory classes

Laboratory work is not included in the course.

### Self-study

The course involves completing an individual calculation task on the following topics:
1. Determinants, matrices and systems of linear algebraic equations.
2. Vector algebra.
3. Line and plane in space. A line on the plane.
4. Curves of the 2nd order on the plane.
Students are also recommended additional materials for self-study.

## Course materials and recommended reading

Main literature
1. Timchenko G.M., Odintsova O.V., Kirillova N.O., Mazur O.S. A short course of higher mathematics, part 1. Analytical geometry and elements of linear algebra: a textbook - Kyiv: Condor, 2022. -188c.
2. Solving problems of analytical geometry by the vector method: study guide / S. Dimitrova-Burlaenko, V. M. Burlaenko, N. P. Gyrya; National Technical University "Kharkiv Polytechnic Institute." - 2nd ed: NTU "KhPI", 2020. 50 p.
3. Higher mathematics in examples and problems: in 2 vols. T.1: Analytical geometry and linear algebra. Differential and integral calculus of functions of one variable: textbook / L.V. Kurpa, J.B. Kashuba, G.B. Lushuba. Kurpa, Zh. Kurpa - Kharkiv: NTU "KhPI", 2009. - 532 p.
4. Analytical geometry in theorems and problems / textbook. Second edition. Corrected and supplemented by V.V. Gorodetskyi, S.B. Bodnaruk, Zh.I. Dovhei, V.S. Luchko - Chernivtsi: - Yuriy Fedkovych Chernivtsi National University, 2021. 408 p.

Further reading
1. Methodical instructions for independent work on the topic "Fundamentals of linear algebra and analytical geometry" in the course "Higher Mathematics": for students of technical specialities of correspondence and accelerated forms of education / compiled by G. B. Linnik, I. O. Morachkovska ; National Technical University "Kharkiv Polytechnic Institute." - Kharkiv: NTU "KhPI", 2019. 31 p.
2. Borovyk V., Yakovets V., Vavrykovych L. Analytical geometry. - University Press, 2018 - 291 p.
3. Mathematics in a Technical University: Textbook / I. V. Alekseeva, V. O. Haidei, O. O. Dykhovychnyi, L. B. Fedorova ; edited by O. I. Klesov ; Igor Sikorsky Kyiv Polytechnic Institute. - Kyiv : Igor Sikorsky Kyiv Polytechnic Institute, 2018.

## Assessment and grading

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

100% of the final grade is made up of the results of the examination (30%) and the current assessment (70%).
The exam consists of a written assignment (two questions on theory + solving two problems) and an oral answer.
Current assessment: online tests (10%), quizzes (20%) and an 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": 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

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| Approved by | Date, signature | Head of the department<br>Vyacheslav BURLAENKO |
| | Date, signature | Guarantor of the educational program<br>Gennadiy LVOV |