



## Syllabus Course Program



# Mathematical Methods of Machine Learning 1

**Specialty**

113 Applied mathematics

**Educational program**

Intelligent Data Analysis

**Level of education**

Master's level

**Semester**

1

**Institute**

Educational and Scientific Institute of Computer Science and Information Technology

**Department**

Computer Mathematics and Data Analysis

**Course type**

Special (professional), Mandatory

**Language of instruction**

English

## Lecturers and course developers

**Oleksii Haluza**

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Doctor of Science (Physics&Mathematics), Full Professor, Professor of Computer Mathematics and Data Analysis Department.

Work experience – more than 20 years. The author of many scientific, educational, and methodological works. Leading lecturer in the courses: «Algorithmization and Programming», «Optimization Methods», «Machine Learning», etc.

[More about the lecturer on the department's website](#)

## General information

### Summary

Problems, theoretical approaches and methods of solving the main types of supervised learning problems are considered.

### Course objectives and goals

The discipline is aimed at acquiring the necessary competencies in the field of machine learning.

### Format of classes

Lectures, laboratory classes, consultations, self-study. Final control in the form of an exam.

### Competencies

GC 3. Ability for continuous learning, acquiring new knowledge and skills, including in areas other than professional ones.

GC 4. Ability to identify, pose, and solve problems in professional activities.

GC 7. Ability to work with information, find and use information from various sources necessary for solving professional tasks.

SC 1. Ability to formulate a mathematical problem, relying on the language of the subject area, verifying the correctness of the formulation, including under conditions of uncertainty.  
SC 2. Ability to choose, develop, and investigate mathematical, analytical, or numerical methods for solving practical problems that ensure the required accuracy and reliability of the result.  
SC 5. Ability to conduct mathematical and computer modeling and computational experiments, collect, visualize, analyze, and process obtained data, solve formalized problems using specialized software tools.  
SC 7. Ability to search, study, and analyze scientific and technical information, domestic and foreign experience related to the application of mathematical methods for the study of processes and systems.  
SC 10. Ability to choose, develop, investigate, and apply mathematical models and methods for intelligent data analysis under conditions of uncertainty.  
SC 12. Ability to develop and operate specialized software tools for intelligent data analysis of texts, signals, and images.

### **Learning outcomes**

LO 1. Demonstrate knowledge and understanding of the fundamental and applied mathematics concepts, principles, and theories and apply them in practice.  
LO 2. Be able to formalize problems formulated in the language of a specific subject area, choose a rational method for solving them, solve problems using analytical or numerical methods, assess the accuracy and reliability of the results, and interpret them.  
LO 5. Be able to develop algorithms that are efficient in terms of accuracy, stability, speed, and resource consumption for numerical investigation of mathematical models and data analysis, decision-making.  
LO 7. Apply modern programming technologies and software development, implement numerical and symbolic algorithms.  
LO 12. Know and understand modern methods for solving mathematical problems of statistical and intelligent data analysis, forecasting, etc.  
LO 14. Be able to apply existing and develop new algorithms and software tools for statistical and intelligent analysis of uncertain data.  
LO 15. Be able to apply existing and develop new algorithms and software tools for data processing, text, signals, and images.

### **Student workload**

The total volume of the course is 150 hours (5 ECTS credits): lectures – 32 hours, laboratory classes – 32 hours, self-study – 86 hours.

### **Course prerequisites**

Bachelor's level training.

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

When teaching this discipline, such teaching and learning methods as gamification and peer-to-peer are used. LMS (learning management systems) systems are used in the learning process.

## **Program of the course**

### **Topics of the lectures**

Topic 1. Basic concepts and examples of applied problems  
Topic 2. Linear classifier and stochastic gradient  
Topic 3. Metric methods of classification and regression  
Topic 4. Support vectors machine  
Topic 5. Multivariate linear regression  
Topic 6. Non-linear regression  
Topic 7. Model selection criteria and feature selection methods  
Topic 8. Logical methods of classification  
Topic 9. Linear ensembles  
Topic 10. Advanced ensemble methods

Topic 11. Restoration of distribution density

Topic 12. Bayesian theory of classification

### Topics of the workshops

Workshops are not provided within the discipline.

### Topics of the laboratory classes

Topic 1. Linear classification

Topic 2. Metric classification

Topic 3. Support vectors machine

Topic 4. Logical classification

Topic 5. Logistic regression

Topic 6. Linear regression

Topic 7. Non-linear regression

Topic 8. Non-parametric regression

Topic 9. Ensembles of methods

Topic 10. Restoration of distribution density

Topic 11. Bayesian classification

### Self-study

The course involves the completion of individual tasks, the results of which are monitored and assessed by teachers. Students are also recommended additional materials (videos, articles) for self-study.

## Course materials and recommended reading

### Basic literature

1. Кононова К. Ю. Машинне навчання. – Харків: ХНУ ім. В. Н. Каразіна, 2020. – 301 с.

[https://moodle.znu.edu.ua/pluginfile.php/593075/mod\\_folder/intro/Базовий%20підручник%20%20%20%20Кононова%20К.%20Ю.%20Машинне%20навчання%20-%20методи%20та%20моделі%29.pdf](https://moodle.znu.edu.ua/pluginfile.php/593075/mod_folder/intro/Базовий%20підручник%20%20%20%20Кононова%20К.%20Ю.%20Машинне%20навчання%20-%20методи%20та%20моделі%29.pdf)

2. R.N. Rao. Machine Learning in Data Science Using Python. – Dreamtech Press, 2022. – 956 p. – ISBN 978-939-154-046-3.

3. P. Chatterjee, M. Yazdani, F. Fernández-Navarro, J. Pérez-Rodríguez. Machine Learning Algorithms and Applications in Engineering. – New York: Taylor & Francis, 2023. – 314 p. – ISBN 978-036-756-912-9.

### Additional literature

4. A. Burkov. Machine Learning Engineering. – True Positive Inc., 2020. – 310 p. – ISBN 978-199-957-957-9.

5. M. Kubat. An Introduction to Machine Learning. - Springer Cham, 2021. – 458 p. – ISBN 978-303-081-935-4.

### Internet resources

6. [https://en.wikipedia.org/wiki/Machine\\_learning](https://en.wikipedia.org/wiki/Machine_learning)

## Assessment and grading

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

Description of the final score structure, course requirements, and necessary steps to earn points, especially paying attention to self-study and individual assignments.

### 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, signature  
31.08.2023



Head of the Department  
Olena AKHIEZER

Date, signature  
31.08.2023



Guarantor of the Educational Program  
Leonid LYUBCHYK