Syllabus
Course Program

Probabilistic and Statistical Models

Specialty
121 – Software Engineering
122 – Computer Science

Institute
Institute of Computer Science and Information Technology

Educational program
Software Engineering
Computer Science and Intelligent Systems

Department
Software Engineering and Management Intelligent Technologies (321)

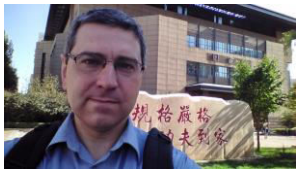
Level of education
Bachelor's level

Course type
Special (professional), Elective

Semester
4

Language of instruction
English, Ukrainian

Lecturers and course developers



Stanislav Pohorielov

stanislav.pohorielov@khpi.edu.ua
Doctor of Science in Physic and Mathematics, Professor, Professor of Software Engineering and Management Intelligent Technologies Department

Google Scholar: https://scholar.google.com/citations?hl=en&user=UE0HQSUAAAAJ
ORCID: https://orcid.org/0000-0002-0189-8655
Scopus: https://www.scopus.com/authid/detail.uri?authorId=9270293800
Web of Science: https://www.webofscience.com/wos/author/record/AAA-7891-2019
More about the lecturer on the department's website

General information

Summary

During the study of the discipline the main attention will be paid to the essence of statistical models of modern financial, socio-economic processes, conditions of application of estimation methods of their parameters and research, scientific interpretation of analysis results and practical application of created models.

Course objectives and goals

Study of the basic theoretical and practical provisions of construction of mathematical and statistical models of complex processes and practical use of analysis results for maintenance of scientific conclusions and hypotheses.

Format of classes

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

Competencies

121 - Software Engineering
К01. Ability to abstract thinking, analysis and synthesis.

К02. Ability to apply knowledge in practical situations.
К05. Ability to learn and master modern knowledge.
К06. Ability to search, process and analyze information from various sources.
К07. Ability to work in a team.
К14. Ability to participate in the design of software, including modeling (formal description) of its structure, behavior and processes of functioning.
К19. Knowledge of data information models, ability to create software for storing, extracting and processing data.
К20. Ability to apply fundamental and interdisciplinary knowledge to successfully solve software engineering problems.
К26. Ability to think algorithmically and logically.

122 - Computer Science and Intelligent Systems

GC1. Ability to abstract thinking, analysis and synthesis.
GC2. Ability to apply knowledge in practical situations.
GC3. Knowledge and understanding of the subject area and understanding of professional activities.
GC6. Ability to learn and master modern knowledge.
GC7. Ability to search, process and analyze information from various sources.
GC8. Ability to generate new ideas (creativity).
GC9. Ability to work in a team.
GC11. Ability to make informed decisions.
PC1. Ability to mathematically formulate and study continuous and discrete mathematical models, justify the choice of methods and approaches for solving theoretical and applied problems in the field of computer science, analysis and interpretation.
PC2. Ability to identify statistical regularities of non-deterministic phenomena, apply methods of computational intelligence, in particular statistical, neural network and fuzzy data processing, machine learning and genetic programming methods, etc.
PC4. Ability to use modern methods of mathematical modeling of objects, processes and phenomena, to develop models and algorithms for numerical solution of mathematical modeling problems, to take into account the errors of approximate numerical solution of professional problems.
PC7. Ability to apply the theoretical and practical foundations of modeling methodology and technology to study the characteristics and behavior of complex objects and systems, to conduct computational experiments with processing and analysis of results.
PC15. Ability to analyze and functional modeling of business processes, construction and practical application of functional models of organizational, economic, production and technical systems, methods of risk assessment of their design.

Learning outcomes

121 - Software Engineering

PLO05. To know and apply relevant mathematical concepts, methods of domain, system and object-oriented analysis and mathematical modeling for software development.
PLO14. Apply in practice software tools for domain analysis, design, testing, visualization, measurement and documentation of software.

122 - Computer Science and Intelligent Systems

PLO1. To apply knowledge of the basic forms and laws of abstract and logical thinking, the basics of the methodology of scientific knowledge, forms and methods of extracting, analyzing, processing and synthesizing information in the subject area of computer science.
PLO3. To use knowledge of the laws of random phenomena, their properties and operations on them, models of random processes and modern software environments to solve problems of statistical data processing and build predictive models.
PLO8. To use the methodology of system analysis of objects, processes and systems for the tasks of analysis, forecasting, management and design of dynamic processes in macroeconomic, technical, technological and financial objects.
PLO19. To create intelligent management systems using methods of mathematical modeling and analysis of complex systems, methods of modeling and analysis of business processes, information technology management of business systems.

Student workload

The total volume of the course is 120 hours (4 ECTS credits): lectures - 16 hours, laboratory classes - 32 hours, self-study - 72 hours.

Course prerequisites

Higher mathematics, Probability theory and mathematical statistics, Mathematical models and systems analysis, Mathematical modeling and systems analysis

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

Teaching and learning methods:
interactive lectures with presentations, discussions, laboratory classes, teamwork, case method, student feedback, problem-based learning.
Forms of assessment:
written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), express surveys (CAS), online tests (CAS), final/semester control in the form of a semester exam, according to the schedule of the educational process (FAS).

Program of the course

Topics of the lectures

Topic 1: Methodological bases of statistical analysis and forecasting
Theoretical foundations of statistical analysis, modeling and forecasting of mass processes.
Topic 2: The essence of modeling. Modeling in scientific activity
Stages of the modeling process. Purpose and object of modeling. Analysis and interpretation of simulation results. Principles of forecasting
Topic 3: Statistical estimation of parameters of mass processes and bases of statistical conclusion
Statistical parameters of distributions of indicators of mass processes and their estimation. Estimation of statistical parameters with a given probability.
Topic 4: Statistical modeling of relationships between indicators and experimental results
Classical correlation-regression analysis.
Topic 5: Nonlinear regression
Reduction of models to linear form, logarithmization, prediction based on nonlinear models.
Topic 6: Analysis of one-dimensional dynamic processes and their forecasting
Models of stationary time series. Adaptive forecasting models. Moving average model (MA).
Topic 7: Box-Jenkins time series analysis: model identification of ARtMA models
Model evaluation, model diagnostics, residual analysis, model comparison, numerical criteria of model adequacy.
Topic 8: Complex analysis and models of dynamic processes
Models of vector autoregression. Evaluation of stationary VAR-models
Topic 9: Comprehensive analysis and models of dynamic processes
modeling of time series when the economic situation changes (structural changes). Economic analysis based on models with changing economic situations.
Topic 10: Panel data models
Features of panel data and their importance in financial and economic activities. Panel data structure: hidden variables and individual effects.
Topic 11: Panel data models (continuance)
Models with random effects. Estimation by the generalized method of least squares.
Topic 12: Statistical models of classification in scientific activity
Classification models in financial and economic activities.
Topic 13: Statistical models of classification in scientific activity
Multidimensional ranking. Classification without training sample. Cluster classification procedures. Hierarchical methods of classification. Classification based on the training sample.
Topic 14: Statistical models of latent variables in research
The concept of latent variables. Methodological principles of construction of models of latent variables.
Topic 15: Statistical models of latent variables in research (continuance)

Models of structural equations with latent variables. Stages of creating models .. Quality indicators, compliance of models.
Topic 16: Statistical models of latent variables in research (continuance)
Examples of modeling psychological, socio-economic, financial and economic integrated indicators as latent.

Topics of the workshops

Workshops are not provided within the discipline.

Topics of the laboratory classes

Topic 1: Probabilistic models of distribution laws. Laws of distribution of discrete quantities. Laws of distribution of continuous quantities.
Topic 2: Data sources for statistical analysis. Sample population as a data source that represents the research object for statistical analysis and modeling
Topic 3: Analysis of variance and its application in scientific research
Topic 4: Modeling of causal relationships: socio-economic processes. Correlation-regression analysis. Checking the adequacy of models.
Topic 5: Modeling of causal relationships: Interpretation of the obtained results
Topic 6: Models with variable variance: ARCH, GARCH, TGARCH and others. Evaluation of models with variable variance.
Topic 7: Models with variable variance: features of their application in the analysis of financial processes.
Topic 8: Special regression models: logit and probit models and binary variable prediction
Topic 9: Special regression models: Classification based on special regression models
Topic 10: Special regression models: Comparative analysis of classification methods in scientific activity.

Self-study

Individual assignments are not provided in the curriculum.
Students are recommended with additional materials (videos, articles) for self-study and processing.

Course materials and recommended reading

Key literature

1. Sheldon M. Ross (2014) Introduction to Probability Models (Eleventh Edition) // Academic press is an Imprint of Elsevier, 767 p.
2. T. M. Liggett. Continuous Time Markov Processes: An Introduction. American Maths Society, Providence, 2010.
3. Vidyadhar G. Kulkarni (2009) Modeling and Analysis of Stochastic Systems (second edition) // CRC Press Taylor & Francis Group, 543 p.
4. R Data Analysis and Visualization, Retrieved from: http://r-analytics.blogspot.com/
5. Bakhrushin V.E. (2011) Data analysis methods: Zaporizhzhja: KPU, 3.Retrieved from: http://www.researchgate.net/publication/235825660_The_Methods_of_ Data_Analysis_(in_Ukrainian)
6. Gayets V.M. Mazaraki A.A (2010) Economical studies (methodology, tools, organisation, aprobation); Kyiv, NTEU]

Additional literature

1. Alberto Leon-Garcia. (2008) Probability, Statistics, and Random Processes for Electrical Engineering (Third Edition) // Pearson Education, Inc., 818 p.
2. Website for econometric modeling society: http://gretl.sourceforge.net/index.html
3. Website of the society for programming and packages of statistical programs and graphics R. Retreved from: http://www.r-project.org/

Assessment and grading

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

100% Final assessment as a result of Final test (30%) and Continuous assessment (70%).
40% Final test
60% Continuous assessment:
Test №1 (10%)
Test №2 (10%)
Laboratory works (40%)
Laboratory work №1 (10%)
Laboratory work №2 (10%)
Laboratory work №3 (10%)
Laboratory work №4 (10%)

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 08.06.2023 Head of the department
Ihor HAMAIUN

08.06.2023 Guarantors of the educational programs
Andrii KOPP
Uliya LITVINOVA