Syllabus
Course Program

Fundamentals of scientific research

Specialty
123 Computer engineeringя

Institute
Educational and Scientific Institute of Computer Science and Information Technology

Educational program
Modern programming, mobile devices and computer games

Department
Department of Computer Engineering and Programming (326)

Level of education
Master's level

Course type
Special (professional)

Semester
2

Language of instruction
English

Lecturers and course developers

Nina Kuchuk

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Doctor of Technical Sciences, Professor

The author of more than 200 scientific and scientific-methodological works, 27 of which are indexed in the Scopus scientometric database (*h*-index – 10), and 6 in the Web of science scientometric database.
More about the lecturer on the department's website

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Doctor of Technical Sciences, Professor

The author of more than 200 scientific and scientific-methodological works. Active member of the Academy of Applied Radioelectronics Sciences (Kharkov). Full member of the Academy of Engineering Sciences of Ukraine (Kyiv). Member of the "Association of Alumni of NTU "KhPI" (Kharkov). Member of the All-Ukrainian public organization "Association of Mechanical Engineering Technologists of Ukraine" (Kyiv). Member of the Scientific Council of NTU "KhPI". Member of the editorial board of 2 scientific specialized publications of Ukraine. Member of the organizing committee of four International Scientific and Technical Conferences: "Problems of Informatics and Modeling", "Informatics, Management and Artificial Intelligence", "Heavy Mechanical Engineering. Problems and prospects of development", "Conferences of masters and postgraduate students of NTU "KhPI". Member of the permanent specialized academic councils of NTU "KhPI" for the defense of doctoral theses: D 64.050.07, specialty 05.13.07 - automation of control processes, D 64.050.15 specialty 05.22.09 - electric transport.
More about the lecturer on the department's website

General information

Summary

Discipline " Fundamentals of Scientific Research " develops knowledge and skills that are necessary for the organization and conduct of scientific research, first of all when completing the final qualifying master's thesis, and later when developing IT projects in the subject field of computer engineering..

Course objectives and goals

The purpose of the discipline is: mastering the basic knowledge of methods and means of organizing scientific research in the subject field of information technologies, students acquiring knowledge about the methodology and organization of scientific research, and about mathematical methods of building models of research objects, planning active experiments and processing experimental data of passive experiments , preparation of scientific and technical documentation, acquisition of practical skills in the organization and conduct of scientific research with the help of modern information technologies in the subject field of computer engineering.

Format of classes

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

Competencies

ZK3. Ability to conduct research at an appropriate level.
ZK5 Ability to generate new ideas (creativity).
SK11 The ability to choose effective methods of solving complex computer engineering problems, critically evaluate the obtained results and argue the decisions made.

Learning outcomes

PH1 Apply general approaches to cognition, methods of mathematics, natural and engineering sciences to solving complex problems of computer engineering.
PH8. Apply knowledge of technical characteristics, design features, purpose and rules of operation of software and technical means of computer systems and networks to solve complex problems of computer engineering and related problems.
PH13. It is clear and unambiguous to convey one's own knowledge, conclusions and arguments on issues of information technologies and related interdisciplinary issues to specialists and non-specialists, in particular to persons who are studying.

Student workload

The total volume of the discipline is 150 hours. (5 ECTS credits): lectures – 32 hours, practical classes – 32 hours, independent work – 86 hours.

Course prerequisites

To successfully pass the course, you need to know: probability theory, mathematical statistics, decision-making tools and algorithms, the basics of mathematical and computer modeling, mathematical packages Excel , MATLAB, Statistic, etc.

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

Lectures are conducted interactively using multimedia technologies. Lectures use: narration, explanation, demonstration, discussion.
In practical classes, students perform individual tasks for calculating model parameters and statistical characteristics of research objects. For this, they use personal computers and mathematical packages: Excel, Matlab, Statistic, etc.
According to the sources of knowledge, the following teaching methods are used: verbal - narration, explanation, instruction; visual - demonstration, illustration; laboratory work, exercises, tests. According

to the nature of the logic of knowledge, the following methods are used: analytical, synthetic, analytical-synthetic, inductive, deductive.
According to the level of independent mental activity, methods are used: problem-based, partially research-based, research.
Educational materials are available to students in the Google Disk cloud environment.

Program of the course

Topics of the lectures

Topic 1. Introduction. Science and classification of sciences
Introduction. Subject of the course and its tasks. The structure, content of the discipline, its connection with other disciplines and its place in the preparation of the master of this specialty.
Origin and features of science. Science and its main sections. Structure and classification of science. Universal decimal classification. Stages of research work. The main directions of research in the field of information technologies.
Topic 2. Organization of research work in Ukraine.
Management in the field of science. Academic degrees and academic titles. Training of scientific and scientific-pedagogical personnel in Ukraine. Research work of students.
Topic 3. Methodology of scientific research.
The purpose and tasks of science. Objects of scientific research and their classification. Concept of method and methodology of scientific research. Philosophical and general scientific methods of scientific research. General and special methods of scientific research. Hypotheses in scientific research. An experiment in scientific research.
Topic 4. Information provision of scientific research.
Basic terms and concepts. Scientific documents and their classification. Printed information. Scientific and technical patent information. Industry bibliography. Peculiarities of the research process in the conditions of the development of information technologies. Selection of the topic of scientific research. Planning of research work. Completion of reporting documentation..
Topic 5. Modeling in scientific research.
Principles of mathematical modeling. Stages of mathematical modeling. Methods of modeling information and technological processes in various subject areas.
Topic 6. Statistical and probabilistic research methods.
Statistical population. Grouping of observation results. Average values and methods of their calculations. Dispersion, standard deviation and coefficient of variation. The probability of an event. Distribution of a random variable. Prediction of random variable values.
Topic 7. Methods of calculating statistical characteristics and testing hypotheses
Samples and sample functions. Confidence interval. Statistical testing of hypotheses. Testing a hypothesis about the probability of a random event. Testing the hypothesis about the mathematical expectation of a random variable. Testing the hypothesis about the variance of a random variable. Testing the hypothesis that the two samples are drawn from the same population.
Topic 8. Fundamentals of dispersion analysis.
Tasks and fields of application. Univariate variance analysis. Cochrane's theorem. Two-factor variance analysis.
Topic 9. Analysis of the results of observations.
Application of correlation analysis. Statistical characteristics that establish a relationship between numerical values (with a linear relationship x and y). Establishing a relationship between numerical values with a non-linear relationship between x and y (correlation relationship). Multiple correlation coefficient. Analysis of the statistical relationship between ordinal (ordinal) values. Rank correlation coefficient.
Topic 10. Architecture of a floating-point CPU.
Regression analysis. The method of least squares. The method of alignment of empirical series. Determination of indicators in the absence of analytical dependencies. Multiple linear regression model. Nonlinear regression model. Testing the hypothesis about the adequacy of the regression model. Statistical analysis of autoregressive dynamic dependencies.
Topic 11. Experiment planning.
Strategic planning of the experiment. Tactical planning of the experiment. Formation of a simple random sample. Methods of reducing variance.

Topic 12. Planning an experiment in regression analysis.
Basic definitions related to experiment planning. Full factor plans and their fractional replicas. Full factorial experiment 2 2 . Factor plan 2 3 . Small replicas of the full factor plan. Resolution of fractional replica. Main semi-replica. Factorial experiments with repeated observations.
Topic 13. Planning an extreme experiment.
Planning an extreme experiment in the area of growth (decrease) of the function. Planning an experiment near the extremum. Box and Hartley's central composition plans. Box orthogonal plans. Rotatable Box plans.
Topic 14. Latin plans.
Three-factor Latin plans. Factorial classification on orthogonal Greek-Latin squares.
Topic 1 5 . Psychology of scientific creativity .
Scientific thinking. Methods of activation of creative thinking. The influence of external factors on thinking. About the age qualification in science and about "scientific aging". Methods of using literary sources.
Topic 16. Legal foundations in the field of science and scientific and technical activity.
General provisions of the Law of Ukraine on Scientific and Scientific-Technical Activities. Legal status of subjects of scientific and scientific and technical activity. Copyright. The right to discovery and invention.

Topics of the workshops

Topic 1. Calculations of confidence intervals.
Confidence intervals of such well-known estimates of statistical characteristics as probability, mathematical expectation and variance are calculated. The inverse problem of determining the required number of experiments for given confidence intervals is also considered.
Topic 2. Statistical testing of hypotheses.
Practical calculations of the methodology for formulating and testing the main H0 and alternative H1 hypotheses regarding the parameters of the general population, which are obtained on the basis of a limited sample.
Topic 3. Analysis of the results of observations. Correlation calculations.
Calculations are made of the linear correlation between numerical variables - the Pearson correlation coefficient, and ordinal (ordinal) variables - the Spearman and Kendall correlation coefficient. The statistical significance of the obtained correlation coefficients is also checked.
Topic 4. Calculations of the regression relationship.
Examples of calculating linear and non-linear, univariate and multivariate regressions are considered. To estimate the coefficients of regression models, the method of reducing all types of regressions to one type is shown - multivariate linear by replacing independent variables, which made it possible to form a matrix of the same type and, accordingly, a system of linear equations for determining regression coefficients by the method of least squares.
Topic 5. Experiment planning. Drawing up a plan for a full factorial experiment 2 2 and 2 3 .
Normalization, centering and coding of data is performed; formation of matrices for experiment planning; drawing up a plan for a full 2 2 factorial experiment and calculating regression coefficients; factor plan 2 3 .
Topic 6. Experiment planning. Fractional replicas. Generating relations.
Considered issues of building fractional replicas (FFE) of a full factorial experiment (half-replica, quarter-replica, 1/8-replica, etc.). The main concepts of DFE are defined: resolution; defining contrast and generating relations. Methods of choosing generating ratios and constructing a plan matrix and corresponding equations for unbiased estimation of regression model parameters are shown
Topic 7. Planning an extreme experiment.
The issues of planning an extreme experiment in the area of growth/decrease of the objective function and near the extremum are considered. The practical implementation of the following methods is carried out: the Gauss–Seidel method (the method of coordinate ascent); gradient method (steep ascent method); Box-Wilson method (fastest ascent method); the simplex method and the Nelder-Mead method.
Topic 8. Latin plans. Factorial classification on orthogonal Greek-Latin squares.
The following issues of practical implementation are considered: three- and four-factor Latin squares; Greek-Latin squares; planning of experiments using Latin and Greco-Latin squares; checking the validity of hypotheses H0 or H1 regarding the insignificance or significance of the difference between the levels of factors.

Topics of the laboratory classes

Laboratory work within the discipline is not provided.

Self-study

The student's independent work is reduced to studying the lecture material, preparing for laboratory classes, performing an individual version of the calculation task using methodical recommendations. The topics of the tasks for performing the computational and graphic task correspond to the topics of the master's thesis (the abstract of the master's thesis is being performed). This encourages students to correctly allocate time for completing the master's work, to study the theoretical part of the master's work more deeply and, as a result, to perform the master's work better.
Students are also recommended additional materials (videos, articles, textbooks) for independent study and analysis, preparation for lectures, practical and laboratory classes.

Course materials and recommended reading

1 A. I. Povoroznyuk, V. I. Panchenko, A. E. Filatova. Methodology and organization of scientific research: teaching. manual / – Kh.: "NTMT", 2016. – 215 p.
2 Fundamentals of scientific research: study guide / Marta Malska, Nataliya Pankiv. – Lviv: Ivan Franko LNU Publishing House, 2020. - 226 p. R
3 Strategies for the formation of a creative personality: methods, techniques, forms: collective monograph / author. coll.: V. G. Kremen, V. V. Ilyin, Y. R. Borinstein, M. S. Galchenko, M. V. Lipin, D. V. Pogribna, N. V. Savchuk, O. A. Fedorchuk . - Kyiv: Institute of the Gifted Child of the National Academy of Sciences of Ukraine, 2020. - 320 p.
4. The Fundamentals of Scientific Research: An Introductory Laboratory Manual / Marcy A. Kelly , Pryce L. Haddix (Contributions by) – Wiley-Blackwell – 2015 – 208 P.
5 Tsekhmistrov G.S. Basics of scientific research. Education manual. - Kyiv; "Slovo" Publishing House, 2004. - 240 p.
6 Sheiko V.M., Kushnarenko N.M. Organization and methodology of scientific research activity: Textbook. - 2nd ed., revision. and additional - K.: Znannia-Press, 2002. - 295 p.
7 Kovalchuk V.V., Moiseyev L.M. Basics of scientific research: Study guide. – 2nd edition, revised and supplemented. - K. - VD. "Professional", 2004 - 216 p.
Additional literature
8 Fundamentals of scientific research: Methodical instructions for practical training / A. I. Povoroznyuk, O. A. Povoroznyuk V. I. Panchenko, G. E. Filatova. – Kh.: NTU "KhPI" , 2023. – 87 p.
9 Diploma design in computer engineering: educational method. manual / O. Yu. Zakovorotny, A. I. Povorozniuk., A. O. Podorozhnyak - Kharkiv: NTU "KhPI", 2023. - 56 p.
10 Lists and forms of documents used for attestation of scientific and scientific-pedagogical workers // Byul. VAK of Ukraine.-2010. - #9. - 48 p.
11 Povoroznyuk A. Application of a Multiplicative Model with Linear Partial Descriptions in Self-organization Methods / A. Povoroznyuk O. Povoroznyuk, I. Skarga-Bandurova //CEUR Workshop Proceedings 2711, CEUR-WS.org 2020. - P. 31- 42 http://ceur-ws.org/Vol-2711/paper3.pdf (Scopus)

Assessment and grading

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

The assessment is carried out on a 100-point scale. Points are awarded according to the following ratio: modular controls - 40 points; practical classes - 40 points; exam - 20 points.

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	Head of the department Oleksandr ZAKOVOROTNYI
	Date, signature	Guarantor of the educational program Svitlana GAVRYLENKO