Національний технічний університет України
«КИЇВСЬКИЙ ПОЛІТЕХНІЧНИЙ ІНСТИТУТ
імені ІГОРЯ СІКОРСЬКОГО»

| Emblem of the<br>of the department (if any) | Department of Computer Science |
|---|---|

# METHODS AND ORGANIZATION OF RESEARCH

## Work program of the academic discipline (Silabus)

| Details of the discipline | |
|---|---|
| **Level of higher education** | *First (bachelor's) degree* |
| **Field of expertise** | *12 Information technologies* |
| **Specialty.** | *123 Computer engineering* |
| **Educational program** | *Computer systems and networks* |
| **Status of the discipline** | *Selective* |
| **Form of study** | *full-time (daytime)* |
| **Year of study, semester** | *3rd year, 7th semester* |
| **Scope of the discipline** | *4 credits, 120 hours* |
| **Semester control / control measures** | *Credit for the ICR* |
| **Class schedule** | *//rozklad.kpi.ua* |
| **Language of instruction** | *Ukrainian* |
| **Information about course leader / teachers** | *D., Associate Professor Selivanov V.L., v.selivanov2013@gmail.com, Assistant Kiryanov A. hunter953214@gmail.com/* |
| **Placement of the course** | Website of the Department of OT FIOT of NTU "KPI" |

## Program of the discipline

### 1. Description of the discipline, its purpose, subject matter and learning outcomes

***The purpose of studying the discipline is to develop students' abilities:***

The purpose of the discipline is:

- Study of research methods used at the empirical and theoretical levels of scientific research.

- Study of mathematical modeling methods.
- Learning the methods of direct analogy.
- Learning the method of electromechanical analogy.
- Study of the method of mathematical modeling with the help of operational blocks.
- Study of methods of displaying and converting information in computer systems.
- Study of selection methods.
- Learning the methods of equivalent transformations.

- Study of quasi-analytical methods.
- Study of approximate methods...
- Learning the basics of planning theory and experiment strategy.

This course is of particular importance because it lays the foundation for independent scientific work, starting with the performance of various laboratory works in the disciplines of general engineering training, planning and execution of scientific research through the study of the basics of planning and strategy of the experiment by future specialists.

### *The main tasks in the study of the discipline*

According to the requirements of the educational and professional program, students studying the course "Methods and Organization of Scientific Research" must demonstrate the following learning outcomes and acquire the following set of knowledge:

**--Know:**

1.Methods of solving differential equations (from the course "Mathematical Analysis").
2. Iteration methods (from the course "Discrete Mathematics").
3. Methods of encoding and decoding unipolar and bipolar information (from the course "Methods and Organization of Scientific Research").
4.Modeling methods, approximation methods, method of solving the governing equation, methods of equivalent and identical transformations, bitwise equilibration method, zero offset methods with subsequent correction, forced polling methods and least squares method (from the course "Methods and organization of scientific research").
5.Methods of construction of operating units of indirect action, methods of construction of analog-to-digital and digital-to-analog converters (from the course "Methods and organization of scientific research").
6.Methods of calculating electrical circuits (from the course "Theory of Electrical Circuits").

**--Skill**:

1.Create models of direct analogy.
2 Create mathematical models based on operational blocks.
3.Derive the defining differential equations for various time functions.
4.Model the internal structure of various operational blocks using MATLAB and MATCAD languages, change the parameters of these blocks.
5. Obtain the equation of variance.
6.Build factor plans.
7.Calculate the coefficients of the regression equation.
8 Perform statistical tests of the results of the experiment.

**-Have skills (experience)**:

1. Programming in MATLAB and MATCAD, modifying the operating system, connecting additional functions.
2. Experience in independent research work.
3. Optimal planning and execution of experimental studies.
4 Using methods of displaying and converting information in the development of software or hardware

## 2. Previous requisites and disciplines (place in the structural and logical scheme of study in the relevant educational program)

The study of the discipline "Methods and Organization of Scientific Research" allows students to develop the competencies necessary to solve practical problems of professional activities related to the analysis and use of modern information technologies and modern computer systems related to the creation and use of mainly analog and hybrid computing devices and systems.

The discipline "Methods and Organization of Scientific Research" is based on the study of the following credit modules: "Mathematical Analysis, Analytical Geometry, Algorithms and Methods *of* Computation, Discrete Mathematics, Probability Theory and Mathematical Statistics, Physics, Theory of Electrical Circuits, and Computer Electronics.

For successful study of the course "Methods and organization of scientific research" you need knowledge of the methods of modeling circuits using application programs such as MATLAB, MATSAD, etc.

## 3. Content of the discipline

List of main topics included in the program of study of the discipline "Methodology and organization of scientific research"

**Section 1**

**Methods of scientific research (SR), general characteristics of SR, levels of SR, classification of SR.**

***Topic 1.1 Scientific research and stages of scientific research.***

Scientific research. The purpose of scientific research. The main stages of scientific research. Levels of scientific research (empirical and theoretical.

***Topic 1.2. Methods of scientific research used at the empirical level, theoretical level and universal methods of research.***

Methods of scientific research used at the empirical level (observation, equation, measurement and experiment). Methods of scientific research used at the theoretical level (idealization, formalization, axiomatic method, scientific assumptions, hypothesis and scientific theory). Research methods used at both the empirical and theoretical levels (abstraction, analysis and synthesis, induction and deduction, modeling).

***Topic 1.3. Methods of modeling.***

Modeling. The concept of the original and the model. Physical modeling, a priori modeling, simulation modeling, mathematical modeling. Mathematical modeling based on analogies between phenomena of different physical nature, dual models.

***Topic 1.4. Models of direct analogy.***

Electromechanical analogies for translational and rotational motions (nodal and contour), electrodiffusion, electrothermal, and electrohydrodynamic analogies.

***Topic 1.5. Mathematical modeling based on operational blocks.***

Operational blocks. Definition. Forms of submission and receipt of information in operational blocks (digital and analog). Digital operating blocks (definitions and examples). Analog operating units (definitions and examples). Hybrid operating units (definitions and examples). Mathematical modeling based on operational blocks {methods of increasing and decreasing the order of the derivative (definition and example of the method of decreasing the order of the derivative)}.

**Section 2**

**Methods of display and transformation used in computer systems.**

***Topic 2.1. Methods of selection***.

The method of conventional ("manual") selection. The method of forced polling of the real axis. Analog-to-digital converter (ADC) of sequential counting. The method of forced polling of the time axis. Method of forced polling of the complex plane. Bitwise balancing method. Bit-wise equilibration ADC. Register of successive approximations. Method of minimization (minimization descent). The method of implicit functions (automatic selection). The method of artificial reversibility.

***Topic 2.2. Methods of equivalent transformations.***

The method of identical transformations. The method of equivalent transition to another coordinate system. Coordinate systems on the plane (Cartesian and Ordinary).Coordinate systems in space (Cartesian, cylindrical, spherical, oblique or affine, barycentric, dipolar, conical, toroidal, projective, cylindrical parabolic, ellipsoidal, etc.) Zero shift method with subsequent correction. The need to convert unipolar information into bipolar information in computer systems. Application of the zero shift method with subsequent correction in the organization of various codes {direct, inverse (inverse or complementary to ones), complementary (complementary to twos} and shifted}. Methods of equivalent transformations of a differential equation containing derivatives of one variable. Reducing a differential equation of the nth order to a system of differential equations of the first order, i.e. to various forms of the universal form UE1. Obtaining the normal form of PDE1 and the canonical form of PDE1. Other forms of the universal form UV1. Methods of equivalent transformations of a differential equation containing derivatives of two variables. Reducing a differential equation of the n-th order to a system of differential equations of the first order, that is, to various forms of the universal form PDE2. Obtaining the normal form NF2 and the canonical form KF2}. Other forms of the universal form UV2. Methods of equivalent transformations of a differential equation containing the derivatives of several (**N**) variables and obtaining the normal form of **NFN** and the canonical form of **KFN** based on the Lening-Bettin method

***Topic 2.3. Quasi-analytical methods.***

The method of solving the defining equation. Definition. Time functions that can be obtained principally accurately as a solution to a linear homogeneous differential equation, Obtaining other time functions that cannot be obtained principally accurately as a solution to a linear homogeneous differential equation, but which can be obtained with a given error value. The method of restoring the determining linear homogeneous differential equation. A method for recovering the determining linear inhomogeneous differential equation with a constant perturbation. The method of further investigation of the governing equation.

***Topic 2.4. Approximate methods.***

Interpolation and approximation of functions. Definition. Criteria for the accuracy of approximation of functions used to assess the accuracy (absolute error, cutoff error, relative error, reduced error, error reduced to half a scale). Criterion of approximation accuracy of functions used to select the best of several approximating functions (least squares criterion). Methods of increasing the accuracy of approximation. Piecewise constant (stepwise), piecewise linear, and piecewise quadratic (parabolic approximation) approximations. Polynomial approximation. Performing piecewise linear approximation. Analytical form of writing a broken line. Geometric interpretation of the analytical form of the broken line.

## Chapter 3
## Planning and strategy of the experiment.

***Topic 3.1: Fundamentals of the theory of experiment planning. Basic concepts and definitions of the theory of experiment planning.***

General information and objectives of the experiment. Optimal planning and organization of the experiment. Development of the theory of experiment planning. Multivariate experiments. Basic concepts and definitions of the theory of experiment planning. Factors, levels of factors, absolute and coded values of factors, factor space, star points, star shoulder, lines and surfaces of equal level. Optimization parameter. Response function. Approximating polynomial. Choosing an approximating function Approximating nonlinear polynomial (Taylor series) with quadratic terms. Factorial experiments (plans). Planning matrix. Full factorial experiment FFE. Fractional (partial) factorial experiment FFE. Compositional plans of the CP.

***Topic 3.2. Factorial experiments (plans).***

Planning of multivariate experiments. The required number of combinations of factor levels. The required number of repetitions of each combination and the total number of experiments (sample size). PFE planning matrix for two factors. The properties of the PFE matrix: symmetry of the plan relative to the center of the experiment, normalization of the plan relative to the center of the experiment, orthogonality of the plan and rotatability of the plan. Formation of the PFE MF for three factors, taking into account the preservation of all four MF properties and for each of the two DFE MFs (semi-replicates). Formation of the PFE MP for each subsequent number of factors on the basis of two DFE MPs (semi-replicas) for the previous number of factors, taking into account the preservation of all four properties of the MP and for each of these two DFE MPs (semi-replicas). Formation of composite plans for two, three or more factors. Rotational composite plan RPC and central orthogonal composite plan COCP. Calculation of the absolute value of the star arm for the RCP and for the CCD. Dependence of the required number of factor levels and the type of plans (DFE, PFE, RCP and CFC) on the form of the regression equation and the number of coefficients of the regression equation.

***Topic 3.3. Obtaining approximating polynomials (obtaining a regression equation).***

Obtaining a regression equation from an approximating polynomial. Linear form of the regression equation for two and three factors. Non-linear form of the regression equation for two and three factors (linear with products) {number of factor levels - two}. Non-linear form of the regression equation for two and three factors (linear with products and quadratic terms) {number of factor levels - five}.

***Topic 3.4. Calculating the coefficients of the regression equation.***

Using the least squares method to obtain a system of linear algebraic equations (a system of **K** equations with **K** unknown coefficients of the regression equation). Obtaining a function that is used to further obtain the required system, which allows you to calculate the values of the coefficients of the regression equation. Calculation of coefficients for the linear form of the regression equation (the number of factors is one). Calculation of coefficients for the linear form of the regression equation (the number of factors is two). Calculation of coefficients for the nonlinear form of the regression equation (number of factors is one). Converting any nonlinear form of the regression equation to the identical linear form when calculating the coefficients of the regression equation. Multiple linear regression.

***Topic 3.5. Statistical verification of the results.***

Necessary and sufficient conditions for the ability to calculate the parameters of a mathematical statistical model. Homogeneity of variance. The first statistical test of the adequacy of the sample size. Checking the homogeneity of variance by the Cochran criterion. The second statistical check of the obtained experimental data. Verification of the significance of the coefficients of the regression equation (null hypothesis) by the Student's criterion. Third statistical verification of the obtained experimental data. Checking the adequacy of the obtained model to the original by Fisher's criterion.

## 4 Training materials and resources

**Basic**


1. Theory of experiment planning (20402040) Selivanov V.L. Electronic lecture notes. Porev V.M. Electronic synopsis of practices. KPI WiKi, 2016.

2.L.A.Nazarenko Planning and processing of the results of the experiment. Lecture notes. Kharkiv. A.M. Beketov Kharkiv National University of Oil and Gas, 2018

3.Y.S.Hryshchuk Fundamentals of Scientific Research Textbook. Kharkiv: NTU "KhPI", 2008.

4. Bakhrushin V.S. Mathematical modeling, Textbook. Lviv, 2010 - 68 p.

5.Krushelnytska O.V. Methodology and organization of scientific research. Study guide. K. Kondor, 2003.

6.Fundamentals of scientific research. Textbook.Martsyn V.S., Mishchenko N.G., Danilenko O.A., Lviv, Ramus-Polygraph, 2002-120 p.

## Educational content

### 5 Methods of mastering the discipline (educational component)

**5.1 Lecture classes:**

**Section 1: Methods of scientific research (SR), general characteristics of SR, levels of SR, classification of SR.**

***Lecture 1.***

***Topic 1.1. Scientific research and stages of scientific research...***

Scientific research. The purpose of scientific research. The main stages of scientific research. Levels of scientific research (empirical and theoretical).

***Lecture 2.***

***Topic 1.2. Methods of scientific research used at the empirical level, theoretical level and universal methods of research.***

Methods of scientific research used at the empirical level (observation, comparison, measurement and experiment). Methods of scientific research used at the theoretical level (idealization, formalization, axiomatic method, scientific assumptions, hypothesis and scientific theory). Research methods used at both the empirical and theoretical levels (abstraction, analysis and synthesis, induction and deduction, modeling).

***Lecture 3.***

***Topic 1.3. Methods of modeling.***

Modeling. The concept of the original and the model. Physical modeling, a priori modeling, simulation modeling, mathematical modeling. Mathematical modeling based on analogies between phenomena of different physical nature, dual models.

***Lecture 4.***

***Topic 1.4. Models of direct analogy.***

Electromechanical analogies for translational and rotational motions (nodal and contour), electrotrodiffusion, electrothermal, and electrohydrodynamic analogies.

***Lecture 5.***

***Topic 1.5. Mathematical modeling based on operational blocks.***

Operational blocks. Definition. Forms of submission and receipt of information in operational blocks (digital and analog). Digital operating blocks (definitions and examples). Analog operating units (definitions and examples). Hybrid operating units (definitions and examples). Mathematical modeling based on operational blocks {methods of increasing and decreasing the order of the derivative (definition and example of the method of decreasing the order of the derivative)}.

**Section 2. Methods of display and transformation used in computer systems.**

***Lecture 6.***

***Topic 2.1. Methods of selection.***

The method of conventional ("manual") selection. The method of forced polling of the real axis. Analog-to-digital converter (ADC) of sequential counting. The method of forced polling of the time axis. Method of forced polling of the complex plane. Bitwise balancing method. Bit-wise equilibration ADC. Register of successive approximations. Method of minimization (minimization descent). The method of implicit functions (automatic selection). The method of artificial reversibility.

***Lecture 7***.

***Topic 2.2. Methods of equivalent transformations.***

The method of identical transformations. The method of equivalent transition to another coordinate system. Coordinate systems on the plane (Cartesian and Ordinary). Coordinate systems in space (Cartesian, cylindrical, spherical, oblique or affine, barycentric, dipolar, conical, toroidal, projective, cylindrical parabolic, ellipsoidal, etc.) The method of zero shift (displacement) followed by correction. The need to convert unipolar information into bipolar information in computer systems. Application of the zero shift method with subsequent correction in the organization of various codes {direct, inverse (inverse or complementary to ones), complementary (complementary to twos} and shifted}.

***Lecture 8***

Methods of equivalent transformations of a differential equation containing derivatives of one variable. Reducing a differential equation of the nth order to a system of differential equations of the first order, that is, to various forms of the universal form UV1. Obtaining the normal form of PDE1 and the canonical form of PDE1. Other forms of the universal form UV1.

***Lecture 9***

Methods of equivalent transformations of a differential equation containing derivatives of two variables. Reducing a differential equation of the nth order to a system of differential equations of the first order, that is, to various forms of the universal form UV2. Obtaining the normal form NF2 and the canonical form KF2}. Other forms of the universal form UV2. Methods of equivalent transformations of a differential equation containing the derivatives of several (**N)** variables and obtaining the normal form of **NFN** and the canonical form of **KFN** based on the Lening-Bettin method

**.** ***Lecture 10***

***Topic 2.3. Quasi-analytical methods.***

The method of solving the defining equation. Definition. Time functions that can be obtained fundamentally accurately as a solution to a linear homogeneous differential equation, Obtaining other time functions that cannot be obtained fundamentally accurately as a solution to a linear homogeneous differential equation, but which can be obtained with a given error value. Methods for restoring the determining linear homogeneous differential equation. Method of restoring the determining linear inhomogeneous differential equation with a constant perturbation. Method for studying the governing equation.

***Lecture 11***

***Topic 2.4. Approximate methods.***

Interpolation and approximation of functions. Definition. Criteria for the accuracy of approximation of functions used to assess the accuracy (absolute error, cutoff error, relative error, reduced error, error reduced to half a scale). Criterion for the accuracy of approximation functions used to select the best of several approximating functions (least squares criterion). Methods for improving the accuracy of approximation. Piecewise constant (stepwise), piecewise linear, and piecewise quadratic (parabolic approximation) approximations. Approximation by polynomial. Performing piecewise linear approximation. Analytical form of writing a broken line. Geometric interpretation of the analytical form of the broken line.

**Chapter 3. Planning and strategy of the experiment.**

***Lecture 12***

***Topic 3.1: Fundamentals of the theory of experiment planning. Basic concepts and definitions of the theory***

***planning the experiment.***

General information and objectives of the experiment. Optimal planning and organization of the experiment.
Title. Development of the theory of experiment planning. Multivariate experiments. Basic concepts and definitions.
the importance of the theory of experiment planning. Factors, levels of factors, absolute and coded values factor space, star points, star shoulder, lines and surfaces of equal level. Para-.
optimization meter. Response function. An approximating polynomial.

***Lecture 13***

Selection of an approximating function An approximating nonlinear polynomial (Taylor series) with quadratic terms. Factorial experiments (plans). Planning matrix. Full factorial experiment FFE. Fractional (partial) factorial experiment FFE. Compositional plans of the CP.

***Lecture 14***

***Topic 3.2. Factorial experiments (plans).***

Planning of multivariate experiments. The required number of combinations of factor levels.
the number of repetitions of each combination and the total number of experiments (sample size).

Planning matrices for MPs. PFE planning matrix for two factors. The properties of the PFE MP are as follows

metricity of the plan relative to the center of the experiment, normalization of the plan relative to the center of the experiment,

plan orthogonality and plan rotation. Formation of the MP PFE for three factors from the urge
The study was conducted by preserving all four properties of the MPs and for each of the two DFE MPs (semi-replicas).
Formation of MP PFE for each subsequent number of factors on the basis of two MP DFE (semi-rep count) for the previous number of factors, taking into account the preservation of all four properties of the MP
and for each of these two DFE MPs (semi-replicas).

***Lecture 15***

Formation of composite plans for two, three and more factors. Rotational composite plan RPC and central orthogonal composite plan COCP. Calculation of the absolute value of the star shoulder for the RCP and for the CSCP. Dependence of the required number of factor levels and the type of plans (DFE, PFE, RCP and CFC) on the form of the regression equation and the number of coefficients of the regression equation.

***Lecture 16***

***Topic 3.H Obtaining approximating polynomials (obtaining a regression equation).*** Modeling

Obtaining a regression equation from an approximating polynomial. Linear form of the regression equation for two and three factors. Non-linear form (linear with products) of the regression equation for two and three factors {number of factor levels - two}. Non-linear form (linear with products and quadratic terms) of the regression equation for two and three factors {number of factor levels - five}.

***Lecture 17***

***Topic 3.4 Calculating the coefficients of a regression equation.***

Use the least squares method to obtain a system of linear algebraic equations (a system of **K** equations with **K** unknown coefficients of the regression equation). Obtaining a function that is used to further obtain the required system, which allows you to calculate the values of the coefficients of the regression equation. Calculation of coefficients for the linear form of the regression equation (number of factors is one). Calculation of coefficients for the linear form of the regression equation (the number of factors is two). Calculation of coefficients for the nonlinear form of the regression equation (the number of factors is one). Converting any nonlinear form of the regression equation to the identical linear form when calculating the coefficients of the regression equation. Multiple linear regression.

***Lecture 18***

***Topic 3.5. Statistical checks of the obtained results.*** Functional

Necessary and sufficient conditions for the possibility of calculating the parameters of a mathematical statistical model. Homogeneity of variance. The first statistical test of the adequacy of the sample size. Checking the homogeneity of variance by the Cochrane criterion. The second statistical check of the obtained experimental data. Checking the significance of the coefficients of the regression equation (null hypothesis) by the Student's criterion. Third statistical verification of the obtained experimental data. Checking the adequacy of the obtained model to the original by Fisher's criterion.

## Practical classes

The purpose of the laboratory cycle is to provide students with the necessary practical skills related to the optimal planning and conduct of experiments that allow them to obtain (with a high degree of probability) a statistical mathematical model of an object whose internal structure is unknown with minimal time.

Laboratory work includes:

1. Tasks for laboratory work.
2. Task options.
3. The procedure for performing the work.
4. Table of contents of the report.
5. Control questions.
6. Theoretical information.

Laboratory work No. 1

Basic principles of organizing an experiment with arbitrary values of factors.

Laboratory work № 2

Conducting a two-factor experiment using a linear regression equation.
Laboratory work № Z
Conducting a three-factor experiment using a linear regression equation Laboratory work № 4
Conducting a three-factor experiment using a linear regression equation with an interaction effect.
Laboratory work № 5
Conducting a three-factor experiment using a linear regression equation with the interaction effect and quadratic terms (composite plan - rotational)
Laboratory work № 6
Conducting a three-factor experiment using a linear regression equation with the interaction effect and quadratic terms (composite plan - central orthogonal).
Laboratory work № 7
A simplex optimization method for performing a two-factor experiment.
Laboratory work No. 8
Influence of the measurement error of the initial value on the accuracy of determining the coefficients of the regression equation.
Laboratory work № 9
Influence of the number of repeated studies at the points of the factor space on the accuracy of determining the coefficients of the regression equation.

| Names of sections, topics | Distribution by semesters and types of classes | | | | | | |
|---|---|---|---|---|---|---|---|
| | *In total* | *Lectures* | *Practical training* | *Seminar classes* | *Laboratory work* | *Computer workshop* | *SRS* |
| | 1 | **2** | 3 | 4 | 5 | 6 | 7 |
| Chapter 1 | **15** | **10** | | | | | **5** |
| **Methods of scientific research (ND), general characteristics of ND, levels of ND, classification of ND.** | 4 | **4** | | | | | |
| Topic 1.1 | 3 | 2 | | | | | 1 |
| ***Scientific research and stages of research works.*** | | | | | | | |
| Topic 1.2 | 3 | 2 | | | | | 1 |
| ***Methods of scientific research, which are used at the empirical level, theoretical level and universal methods of scientific research.*** | | | | | | | |
| Topic 1.3. | 3 | 2 | | | | | 1 |
| ***Modeling methods*** | | | | | | | |
| Topic 1.4. | 3 | 2 | | | | | 1 |
| **Models of direct analogy** | | | | | | | |
| Topic 1.5. | 3 | 2 | | | | | 1 |
| ***Mathematical modeling based on operational blocks.*** | | | | | | | |
| Section 2 | **22** | **12** | | | | | **6** |
| **Mapping and transformation techniques used in computer systems.** | | | | | | | |
| Topic 2.1 | 4 | 2 | | | | | 2 |
| ***Selection methods.*** | | | | | | | |
| Topic 2.2 | 6 | 4 | | | | | 1 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ***Methods of equivalent transformations.*** | | | | | | | |
| Topic 2.3 | 5 | 2 | | | | | 2 |
| ***Quasi-analog methods.*** | | | | | | | |
| Topic 2.4 | 7 | 4 | | | | | 1 |
| ***Approximate methods.*** | | | | | | | |
| Section 3 | **70** | **12** | | | | **18** | **7** |
| **Experiment planning and strategy.** | | | | | | | |
| Topic 3.1 | 6 | 2 | | | | 2 | 1 |
| ***Basics of experiment planning theory.*** ***Basic concepts and definitions of the theor*** ***experiment planning*** | | | | | | | |
| Topic 3.2 | 10 | 2 | | | | 4 | 1 |
| ***Factor experiments (plans).*** | | | | | | | |
| Topic 3.3 | 10 | 3 | | | | 4 | 2 |
| ***Obtaining approximating polynomials (obtaining the regression equation).*** | | | | | | | |
| Topic 3.4 | 8 | 3 | | | | 4 | 2 |
| ***Calculation of regression equation coefficients.*** | | | | | | | |
| Topic 3.5 | 24 | 2 | | | | 4 | 18 |
| ***Statistical tests of the obtained results.*** | | | | | | | |
| ***MKR*** | **4** | **2** | | | | | 2 |
| Preparation for the test | **6** | | | | | | **6** |
| test | **1** | | | | | | **1** |
| **Total in the semester:** | **120** | **36** | **-** | **-** | **18** | | **66** |

**Lecture recordings**

| № | The name of the topic of the lecture and a list of main questions |
|---|---|

| lecture | (a list of didactic tools, references to the literature and tasks on the SRS) |
|---|---|
| 1. | Scientific research and stages of research works.<br>Scientific research. The purpose of scientific research. The main stages of scientific research. Levels of scientific research (empirical and theoretical). [1,4,5]<br>SRS: Analysis of features of the empirical level of scientific research. [1,4] |
| 2. | **Methods of scientific research, which are used at the empirical level, theoretical level and universal methods of scientific research.**<br>Scientific research methods used at the empirical level (observation, comparison, measurement and experiment). Methods of scientific research used at the theoretical level (idealization, formalization, axiomatic method, scientific assumptions, hypothesis and scientific theory). Methods of scientific research that are used at both the empirical and theoretical levels (abstraction, analysis and synthesis, induction and deduction, modeling).[1,4,5]<br>**SRS**: Analysis of features of application of the abstraction method. [1,4] |
| 3. | ***Modeling methods.***<br>Modeling. Concept of original and model. Physical modeling, a priori modeling, simulation and mathematical modeling. Mathematical modeling based on analogies between phenomena of different physical nature, dual models. [1,4,6]<br>**SRS**: Dual electrical models (loop and nodal analogies).[1,4,6] |
| 4. | **Models of direct analogy.**<br>Electromechanical analogy for translational and rotational movements (nodal and contour), electrodiffusion, electrothermal and electrohydrodynamic analogies.[4]<br>**SRS: Direct analogy models based on active nodes. [4,6]** |
| 5. | **Mathematical modeling based on operational blocks.**<br>Operating units. Definition. Forms of submitting and receiving information in operational blocks (digital and analog). Digital operational units (definition and examples). Analog operational units (definition and examples). Hybrid operation blocks (definition and examples). Mathematical modeling based on operational blocks {methods of increasing and decreasing the order of the derivative (definition and example of the method of decreasing the order of the derivative)}.[1,4,6]<br>**SRS**: Mathematical modeling based on operational blocks (method of reducing the order of the derivative). [4,6] |
| 6. | **Selection methods.**<br>**The method of normal ("manual") selection. The method of forced polling of the real axis. Analog-to-digital converter (ADC) of serial numbers. Method of forced survey of the time axis. The method of forced survey of the complex plane. Bit-by-bit balancing method. Bit-level ADC. Register of successive approximations. Method of minimization (minimization descent). Method of implicit functions (automatic selection). The method of artificial reversibility.[1]**<br>**SRS**: Simple iteration method. Gauss-Setzdel iteration method. .[1,4] |
| 7. | **Methods of equivalent transformations.**<br>Method of identical transformations. The method of equivalent transition to another coordinate system. Coordinate systems on the plane (Cartesian and porous). Coordinate |

| | |
|---|---|
| | systems in space (Cartesian, cylindrical, spherical, oblique or affine, barycentric, dipolar, conical, toroidal, projective, cylindrical parabolic, elliptic, etc.). Method of zero shift (displacement) with subsequent correction. The need to convert unipolar information into bipolar information in computer systems. Application of the method of zero shift (offset) with subsequent correction in the organization of various codes {direct, inverse (inverted or one's complement), complementary (two's complement} and shifted}.[1]<br>**SRS**: Application of the method of zero displacement with subsequent correction when organizing the inverse (inverted or complementary to units) code 8421+3 of the binary-decimal numbering system 8421. [1] |
| 8. | **Methods of equivalent transformations.**<br>Methods of equivalent transformations of a differential equation containing derivatives of one variable. The reduction of the differential equation of the nth order to the system of differential equations of the first order, i.e. to different forms of the universal type XB1. Obtaining the normal form of NF1 and the canonical form of KF1. Other forms of the universal type BB1. [1]<br>**SRS**: Obtaining operator form OF1. [1] |
| 9. | **Methods of equivalent transformations.**<br>***Methods of equivalent transformations of a differential equation containing derivatives of two variables. The reduction of the differential equation of the nth order to the system of differential equations of the first order, i.e. to various forms of the universal type XB2. Obtaining the normal form of NF2 and the canonical form of KF2}. Other forms of the universal type BB2. Methods of equivalent transformations of a differential equation containing the derivatives of several (N) variables, and obtaining the normal form of the NFN and the canonical form of the KFN based on the Lenning-Bettin method. [1]***<br>**SRS**: The method of equivalent transformation of systems of linear algebraic equations. [1] |
| 10. | **Quasi-analog methods.**<br>The method of solving the determining equation. Definition Time functions that can be obtained with principle accuracy as a solution of a linear homogeneous differential equation. Obtaining other time functions that cannot be obtained with principle accuracy as a solution of a linear homogeneous differential equation, but which can be obtained with a given error value . The method of restoration of the determining linear homogeneous differential equation. The method of restoring the determining linear inhomogeneous differential equation with a constant perturbation. The method of research of the determining equation. [1,4,5]<br>**SRS**: Using the defining equation to build a low-frequency generator of sinusoidal oscillations. [1,4,5] |
| 11. | **Approximate methods..**<br>Interpolation and approximation of functions. Definition. Criteria for the accuracy of the approximation of the functions used to evaluate the accuracy (absolute error, cut-off error, relative error, reduced error, error reduced to half scale). Criterion of the accuracy of the approximation of functions used to select the best of several approximating functions (least squares criterion). Methods of increasing the accuracy of approximation. Piecewise constant (stepped), piecewise linear and piecewise quadratic (parabola approximation) |

| | |
|---|---|
| | approximations. Polynomial approximation. Execution of piecewise linear approximation. Analytical form of writing a broken line. Geometric interpretation of the analytical form of the broken line record.[1]<br>**SRS**: Least squares test for analytically defined functions. Cri-<br>least squares theorem for functions that are defined discretely. The criterion of naming<br>of squares for functions, one of which is defined analytically, and the second is defined<br>discretely.[1] |
| 12. | **Basics of experiment planning theory. Basic concepts and definitions of theoretical**<br>**the planning of the experiment.**<br>General information and tasks of the experiment. Optimal planning and organization<br>tion of the experiment. Development of the theory of experiment planning. Multifac experiments<br>ryments Basic concepts and definitions of the theory of experiment planning. factors,<br>factor levels, absolute and coded values of factors, factor space, stars<br>points, star shoulder, lines and flat surfaces. Optimization parameter. Function<br>feedback Approximating polynomial. [1-3.5÷12]<br>Three-pole<br>**SRS:** Approximating linear polynomial for five factors.[1-3.5÷12] |
| 13. | **Basics of experiment planning theory. Basic concepts and definitions of theoretical**<br>**the planning of the experiment.**<br>Selection of approximating function Approximating nonlinear polynomial (Taylor series) taking into account quadratic terms. Factor experiments (plans). Planning matrix. Full factorial experiment of PFE. Fractional (partial) factorial experiment DFE. Share measure. Composite plans of KP. [1-3.5÷12]<br>**SRS**: Approximating nonlinear polynomial (linear with products taken into account) for five factors. [1-3.5÷12] |
| 14. | **Factor experiments (plans).**<br>Planning of multivariate experiments. The required number of combinations of equal<br>no factors. The required number of repetitions of each combination and the total number<br>experiments (sample size). Matrices of MP planning. PFE planning matrix<br>for two factors. Properties of MP PFE: symmetry of the plan relative to the center of ex-<br>experiment, normalization of the plan relative to the center of the experiment, orthogonal the plan well, the rotatability of the plan. The formation of MP PFE for three factors from t<br>yum preservation of all four properties of the MP and for each of the two MP DFE (for<br>of each of the half replicas). Formation of MP PFE for each subsequent number of facto- |

| | |
|---|---|
| | based on two MP DFE (half-replicate) for the previous number of factors from the hiding the preservation of all four properties of MP and for each of these two MPs DFE (half replica). [1-3.5÷12]<br>**SRS**: Formation of MP PFE for four factors on the basis of two MP PFE for three factors, taking into account the preservation of all four properties of MP for each noy from two MP DFE. [1-3.5÷12] [1-3.5÷12] |
| 15. | **Factor experiments (plans).**<br>Formation of composite plots for two, three and more factors.<br>The rotatable composite plan of the RCP and the central orthogonal composite TsOKP's strategic plan. Calculations of the absolute value of the magnitude of the star arm for RKP and for TsOKP. Dependence of the required number of factor levels and the type of plans (DFE, PFE, RKP and TSOKP) from the form of the regression equation and from the number of coefficients of the regression equation. [1-3.5÷12]]<br>SRS: Formation of MP PFE for five factors on the basis of two MP PFE for four several fa taking into account the preservation of all four properties of MP for each noy from two MP [1-3.5÷12] |
| 16. | **Obtaining approximating polynomials (obtaining the regression equation).** Obtaining the regression equation from the approximating polynomial. The linear form of the regression equation for two and three factors. The nonlinear form (linear with products taken into account) of the regression equation for two and three factors {the number of factor levels is two}. The non-linear form (linear with products and quadratic terms taken into account, which is also called "quadratic regression") of the regression equation for two and for three factors {the number of factor levels is five}. [1-3.5÷12]<br>**SRS**: Nonlinear form (linear with products and quadratic terms taken into account) of the regression equation for four factors {the number of factor levels is five}.[1-3.5÷12] |
| 17. | **Calculation of regression equation coefficients.**<br>Using the method of least squares to obtain a system of linear algebraic equations (a system of K equations with K unknown coefficients of the regression equation). Obtaining a function that is used to further obtain a non-circular system that allows you to calculate the values of the coefficients of the regression equation. Calculation of coefficients for the linear form of the regression equation (the number of factors is one). Calculation of coefficients for the linear form of the regression equation (the number of factors is two). Calculation of coefficients for the nonlinear form of the regression equation (the number of factors is one). Conversion when calculating the coefficients of the regression equation of any nonlinear form of the regression equation into the identical linear form. Multiple linear regression. [1-3.5÷12]<br>**SRS**: Transformation of the non-linear form (linear taking into account the products and quadratic terms) of the regression equation for three factors into the identical linear form for calculating the coefficients of the regression equation. [1-3.5÷12] |

| | |
|---|---|
| 18. | **Statistical tests of the obtained results.**<br>Necessary and sufficient conditions for the possibility of calculating the parameters of a mathematical statistical model. Homogeneity of dispersion. The first statistical check of the sufficiency of the sample size. Verification of the homogeneity of variance by the Cochren test. The second statistical verification of the obtained experimental data. Checking the significance of the coefficients of the regression equation (null hypothesis) according to the Student's test. The third statistical verification of the obtained experimental data. Checking the adequacy of the obtained original model according to Fisher's criterion. [1-3.5÷12]<br>**SRS**: Checking the homogeneity of variance for two factors by the Romanovs test<br>who Testing homogeneity of variance for two factors by Fisher's test. [1-3]. |

## 6 . Student's independent work (SRS)

In the process of completing individual tasks, students must process the knowledge gained during lectures and independent work, independently study specific topics, deepen their knowledge for further study. Students' independent work consists of the following:

• preparation for lectures by studying the previous lecture material;

• performance of lecture tasks at SRS;

• preparation for laboratory work with the study of the theory of laboratory work with an oral answer to the given questions of the section;

• implementation and registration of the protocol on the previous topic for each laboratory session.

**Questions for self-control:**

1. What is the purpose of scientific research?

2. What are the main stages of scientific research?

3. What are the levels of scientific research?

4. What methods of scientific research are used at the empirical level of scientific research?

5. What requirements must the observation method satisfy in order to be fruitful?

6. What method of the empirical level of scientific research allows you to make an initial schematization of the objects of reality?

7. What requirements must the comparison method satisfy in order to be fruitful?

8. What is measurement as a method of the empirical level of scientific research?

9. The presence of which basic elements implies measurement as a method of the empirical level of scientific research7

10. What is an experiment as a method of empirical level of scientific knowledge?

11. In what cases is an experiment conducted as a method of empirical level scientific research?

12. What methods of scientific research are used at both the empirical and theoretical levels of scientific research?

13. What is abstraction as a method of scientific knowledge?

14. To which objects can the method of abstraction be applied: to real or to abstract ones?

15. What is analysis as a method of scientific knowledge?

16. What is synthesis as a method of scientific knowledge?

17. What is induction as a method of scientific knowledge?

18. What is deduction as a method of scientific knowledge?

19. What is modeling as a method of scientific knowledge?

20. What is a model?

21. What types of modeling do you know?

22. What is the simplest example of physical modeling?

23. What methods of scientific research are used at the theoretical level of scientific research?

24. What is idealization as a method of scientific knowledge?

25. What is the purpose of the method of scientific knowledge, idealization?

26. How is the goal of the idealization method of scientific knowledge achieved?

27. What method of scientific knowledge does idealization use as a basic method of scientific knowledge?

28. What is formalization as a method of scientific knowledge?

29. What are the positive qualities of the formalization method of scientific knowledge?

30. What is the axiomatic method as a method of scientific knowledge?

31. What are the most common methods of system analysis?

32. What are the methods of system analysis used for?

33. What is a scientific hypothesis as a method of scientific knowledge?

34. What is a hypothesis as a method of scientific knowledge?

35. In what case does a hypothesis turn into a scientific theory?

36. In what case does a hypothesis become a false scientific assumption?

37. In what case does a hypothesis remain only a hypothesis?

38. What is a scientific theory, as a method of scientific knowledge?

39. What are the requirements for a new scientific theory?

40. What is scientific theory based on, as a method of scientific knowledge?

41. What is mathematical modeling?

42. What options for mathematical modeling exist?

43. What is mathematical modeling based on analogies between phenomena of different physical nature?

44. What is the name of phenomena (or systems) in mathematical modeling based on analogies between phenomena of the same physical nature?

45. What are dual phenomena (or dual systems)?

46. Give an example of a mechanical dual system with one degree of freedom.

47. Give an example of an electrical dual system.

48. Equations describing the dynamics of sequential movement (displacement) of a body of a mechanical system with one degree of freedom have the form of which differential equation.

49. Equations describing the dynamics of the rotational motion of a body of a mechanical system with one degree of freedom have the form of which differential equation.

50. What does mathematical modeling predict regarding the relationships between the variables and external excitations of the original, on the one hand, and the corresponding variables and external excitations of the model? .

51. What ensures the constancy of the ratios between the variables and external excitations of the original, on the one hand, and the corresponding variables and external excitations of the model? .

52. How should the values of model parameters be calculated?

53. What must be done to ensure the identity of the mathematical descriptions of the original and the model?

54. What is an electromechanical analogy?

55. What is the original in the electromechanical analogy?

56. What is a model in an electromechanical analogy?

57. What is a contour analogy in an electromechanical analogy?

58. What is a nodal analogy in an electromechanical analogy?

59. What is the independent variable of the model in the electromechanical analogy that reflects the independent variable of the original (real time t)?

60. What is mathematical modeling using operational blocks?

61. What is an operating unit?

62. What is a digital operating unit?

63. What is an analog operating unit?

64. What is a hybrid operating unit?

65. What is the method of reducing the order of the derivative in mathematical modeling using operational blocks?

66. What is the method of increasing the order of the derivative in mathematical modeling using operational blocks?

67. Which computer systems (digital, analog or hybrid) do not use the method of increasing the order of the derivative in mathematical modeling using operational blocks?

68. In which computer systems (digital, analog or hybrid) can the method of increasing the order of the derivative be used in mathematical modeling using operational blocks?

69. How are hybrid computer systems used in which the method of reducing the derivative in a row is used in mathematical modeling using operational blocks?

70. How are hybrid computer systems used in which the method of increasing the derivative in a row is used in mathematical modeling using operational blocks?

71. Into which groups can we divide all display and transformation methods used in computer systems.

72. What selection methods do you know?

73. What is the method of "manual" selection?

74. What algorithm is used when applying the method of forced polling of the real axis?

75. In how many stages is the survey of all points of the real axis carried out when using the method of forced survey of the real axis?

76. What part of the real axis is polled at the first stage when using the method of forced polling of the real axis?

77. What substitution is introduced at the second stage when using the method of forced polling of the real axis?

78. Does the method of forced polling of the real axis, in addition to determining the roots of a polynomial, allow you to simultaneously determine the multiplicity of these roots?

79. What algorithm is used when applying the method of forced polling of the time axis?

80. What substitution is introduced at the first stage when using the method of forced polling of the time axis?

81. What substitution is introduced at the second stage when using the method of forced polling of the time axis?

82. What substitution is introduced at the third stage when using the method of forced polling of the time axis?

83. What replacement is introduced at the fourth stage when using the time axis forced polling method?

84. Which selection method is used in analog-to-digital converters of serial numbers?

85. What algorithm is used when applying the method of forced survey of a complex plane?

86. In how many stages is the survey of all points of the complex plane carried out when using the method of forced survey of the complex plane?

87. What part of the complex plane is surveyed at the first stage when using the method of forced survey of the complex plane?

88. What substitution is introduced at the second stage when using the forced survey method of the complex plane?

89. What algorithm is used when applying the bit-by-bit equalization method?

90. Which of the selection methods is used in analog-to-digital converters of bit-by-bit equalization?

91. What selection criteria are used when applying the minimization method?

92. Which of the two selection criteria used when applying the minimization method is easier to implement?

93. How does the Gauss-Seidel iteration method differ from the simple iteration method?

94. Which of the two iterations (simple or Gauss-Seidel) is easier to implement and why?

95. What kind of feedback should be provided when implementing the method of implicit functions (automatic selection)7

96. What is used in modern computer systems when implementing the method of implicit functions (automatic selection) as a fast tracking system?

97. What is a "system with parallel connections" when implementing the method of implicit functions (automatic selection)?

98. What is the number of systems with parallel connections" when implementing the method of implicit functions (automatic selection)?

99. What is a "system with cross connections" when implementing the method of implicit functions (automatic selection)?

100. What is the number of systems with cross connections" when implementing the method of implicit functions (automatic selection)?

101. What is "natural turnover"?

102. What method allows you to perform an inverse mathematical operation without changing the direction of information processing in an operational node (or in an operational element)?

103. How many options are there for obtaining the inverse function for a function of n variables?

104. How many methods of equivalent transformations are studied in this course?

105. What is the essence of the method of identical transformations?

106. Why is the method of equivalent transition to another coordinate system used?

107. Name the coordinate systems in space known to you?

108. Why is the method of zero displacement with subsequent correction necessary?

109. What linear mathematical operations are used to convert bipolar variables into unipolar ones?

110. What values of constants (when shifting a variable and/or when shifting an inverted variable) are used to obtain the direct code of the binary number system?

111. What values of constants (when shifting the variable and/or when shifting the inverted variable) were used to obtain the modified direct code of the binary number system?

112. What values of constants (when shifting a variable and/or when shifting an inverted variable) are used to obtain the reverse code of the binary number system?

113. What values of constants (when shifting the variable and/or when shifting the inverted variable) are used to obtain the modified binary code of the binary number system?

114. What values of constants (when shifting a variable and/or when shifting an inverted variable) are used to obtain the complementary code of the binary number system?

115. What values of constants (when shifting a variable and/or when shifting an inverted variable) are used to obtain a modified complementary code of the binary number system?

116. What values of constants (when shifting the variable and/or when shifting the inverted variable) are used to obtain the shifted code of the binary number system?

117. What values of constants (when shifting a variable and/or when shifting an inverted variable) are used to obtain a modified shifted code of the binary number system?

118. What values of constants (when shifting the variable and/or when shifting the inverted variable) were used to obtain the modified reverse code 8421+3 of the binary-decimal numbering system 8421?

119. Why is the method of equivalent transformation of systems of linear algebraic equations used?

120. Why is the method of equivalent transformation of differential equations used?

121. What number of equations will the system of differential equations of the first order (universal form УВ1) have with the equivalent transformation of a differential equation of the nth order, which has derivatives of one variable?

122. What is the simplest version of the matrix of coefficients for the system of linear algebraic equations connecting the initial variable and its derivatives with new variables, with the equivalent transformation of the differential equation of the nth order, which has derivatives of

one variable, to the system of differential ration equations of the first order (of the universal form BB1)?

123. What is the "normal form of NF1" in the case of an equivalent transformation of an n-th order differential equation, which has derivatives of one variable, to a system of first-order differential equations (universal form BB1)?

124. What matrix of coefficients does the normal form of NF1 have in the equivalent transformation of an nth-order differential equation that has derivatives of one variable to a system of first-order differential equations (universal form УВ1)?

125. What is the "canonical form of КФ1" in the case of an equivalent transformation of an nth-order differential equation that has derivatives of one variable to a system of first-order differential equations (universal form УВ1)?

126. What matrix of coefficients does the canonical form of КФ1 have when equivalently transforming an nth-order differential equation, which has first-order derivatives, to a system of first-order differential equations (universal form УВ1)?

127. What number of equations will the system of equations of the first order (universal form УВ2) have with the equivalent transformation of a differential equation of the nth order, which has derivatives of two variables?

128. What number of differential equations will the system of equations of the first order (universal form УВ2) have at the equivalent transformation of the differential equation of the nth order, which has derivatives of two variables?

129.. What equation, in addition to differential equations, will the system of equations of the first order (universal form УВ2) have with the equivalent transformation of the differential equation of the nth order, which has derivatives of two variables?

130. What is the "normal form of NF2" in the equivalent transformation of an n-th order differential equation, which has derivatives of two variables, to a system of equations of the first order (universal form XB2)?

131. How to get the normal form of NF2 from the normal form of NF1?

132. What is the "canonical form of КФ2" in the case of an equivalent transformation of an n-th order differential equation, which has derivatives of two variables, to a system of equations of the first order (universal form УВ2)?

133. How to obtain the canonical form of KF2 from the canonical form of KF1?

134. What is the number of initial conditions for the differential equation of the nth order, which has the derivatives of two variables?

135. What number of initial conditions will the system of equations of the first order (universal form УВ2) have with the equivalent transformation of a differential equation of the nth order, which has derivatives of two variables?

136. What is the number of initial conditions for a differential equation of the nth order, which has derivatives of N variables?

135. What number of initial conditions will the system of equations of the first order (universal form of UVN) have at the equivalent transformation of the differential equation of the nth order, which has derivatives of N variables?

136. How many equations will the system of equations of the first order (universal form of UVN) have at the equivalent transformation of a differential equation of the nth order, which has derivatives of N variables?

128. How many differential equations will the system of equations of the first order (universal form of UVN) have at the equivalent transformation of a differential equation of the nth order, which has derivatives of N variables?

129.. What equation, in addition to differential equations, will the system of equations of the first order (universal form of УВН) have with the equivalent transformation of a differential equation of the nth order, which has derivatives of N variables?

130. Which of the approximate methods were studied in this course?

131. What is the approximation method?

132. What is "approximation of functions"?

133. What are the criteria for the accuracy of approximation of the approximating function to the approximated function, based on the difference between them?

134. How do you use the criterion of the accuracy of approximation of the approximating function to the approximated function based on the sum of the squared deviations between them for the entire range of the argument change?

135. What is the "method of least squares"?

136. In what cases is the error reduced to a half scale applied?

137. What is "truncation error"?

138. What accuracy criterion is used to assess the accuracy of the approximation?

139. What accuracy criterion is used to select the best of several approximating functions?

140. What methods are used to reduce the approximation error?

141. What is "piecewise constant approximation"?

142. What is "piecewise linear approximation"?

143. What other term is used for piecewise quadratic approximation?

144. What formulas are used to determine the length of the interval when performing the piecewise-pinion approximation?

145. What is a "quadrant" for an elementary nonlinear characteristic (linear with a limit along the ordinate axis at the zero level) and how is it determined?

146. What is a "mode" for an elementary nonlinear characteristic (linear with a limit along the ordinate axis at the zero level) and how is it determined?

147. What is the "defining equation" for the time function?

148. What is the "defining equation" for a function of the dependent variable?

149. What differential equations are most often used as defining equations?

150. What functions of time can be obtained with fundamental accuracy using defining linear differential equations (homogeneous or with constant excitation)?

151. What approximating functions are used for further application of a linear differential equation (homogeneous or with constant excitation) as a defining equation?

152. What defining equation is used to build low-frequency generators of sine-soidal oscillations?

!53. In combination with which method is the "determining equation research method" used?

154. Why is the method of research of the determining equation used in combination with the method of forced polling of the time axis?

155. What is the method of researching an equivalent equation (or an equivalent system of equations) used for?

156. What is the name of the initial (endogenous) variable of an object (system, phenomenon or process) in the theory of experiment planning?

157. What is the name of the input (exogenous) variable of the object (system, phenomenon or process) in the theory of experiment planning?

158. What is the name of the factor value in the theory of experiment planning?

159. What is "sample volume" in the theory of experiment planning?

160. What is a "complete factorial experiment" in the theory of experimental design?

161. How many combinations does a complete factorial experiment have if two levels of factors are used?

162. How many combinations should a complete factorial experiment have if three levels of factors are used?

163. How many combinations would a complete factorial experiment have if five levels of factors were used?

164. When are three levels of factors used in the theory of experimental design?

164. Are four levels of factors used in the theory of experimental design?

165. What is a "fractional factorial experiment" in the theory of experiment planning?

166. At what number of factor levels is a fractional factorial experiment used?

167. What does the term "half-replicate" mean in the theory of experimental planning?

168. What does the term "quarter replicate" mean in the theory of experimental planning?

169. How is a composite design that uses five levels of factors related to a full factorial experiment that uses two levels of factors?

170. Is it possible to use a fractional factorial experiment instead of a full factorial experiment in the compositional plan?

171. What compositional plans are used in the theory of experimental planning?

172. What is a "rotatable composite plan" in the theory of experiment planning?

173. What is the "central orthogonal composite plan" in the theory of experiment planning?

174. What is the difference between the planning matrix of the central orthogonal composite plan and the planning matrix of the central orthogonal composite plan?

175. What is the "response function" in the theory of experiment planning?

176. What is the "response surface" in the theory of experiment planning?

177. What is "feedback reaction" in the theory of experimental planning?

178. What is the "objective function" in the theory of experiment planning?

179. What is "line of the same level" in the theory of experiment planning?

180. In the theory of experiment planning, which series is most often used as an approximating function?

181. How is the regression equation obtained from the approximate response function?

182. How are the coefficients of the regression equation related to the coefficients of the approximate response function?

183. What is "linear regression" in the theory of experiment planning?

184. What is "linear regression taking into account the interaction of factors" in the theory of experiment planning?

185. What is "quadratic regression" in the theory of experiment planning?

186. What requirements apply to factors in the theory of experiment planning?

187. What is "encoded factor values" in the theory of experiment planning?

188. How are coded values of factors denoted in the theory of experiment planning?

189. How is factor values coded in the theory of experiment planning?

190. What is the "factor space" in the theory of experiment planning?

191. What is "star shoulder" in the theory of experiment planning?

192. What does the absolute value of the star arm depend on?

193. How is the magnitude of the star arm calculated in the theory of experiment planning, if a rotatable composite plan is used?

194. How is the magnitude of the star arm calculated in the theory of experiment planning, if a central orthogonal composite plan is used?

195. What designs of factorial experiments are used in the theory of experimental design?

196. In what form is it convenient to provide factorial experiment plans in the theory of experiment planning?

197. According to the requirements of regression analysis, when is it possible to correctly process and use the results of experimental studies?

198. What are the four properties of the design matrix of a complete factorial experiment in the theory of design of experiments?

199. What is "plan symmetry" for the planning matrix of a full factorial experiment in the theory of experimental design?

200. In the theory of experimental planning, what is "plan normalization" for the planning matrix of a factorial experiment in the theory of experimental planning?

201. What is "plan orthogonality" for the planning matrix of a full factorial experiment in the theory of experimental planning?

202. In design of experiment theory, what is "plan rotatability" for the design matrix of a full factorial experiment in design of experiment theory?

203. How is the presence of all four properties of the planning matrix of a fractional factorial experiment achieved in the theory of experimental planning?

204. Which of the four properties of the planning matrix of a full factorial experiment are inherent in the planning matrix for a rotatable composite plan?

205. Which of the four properties of the planning matrix of the full factorial experiment are inherent in the planning matrix for the central orthogonal composite plan?

206. What fractional factorial experiment is needed for three factors in the theory of experiment planning and why exactly this one and not another?

207. What fractional factorial experiment is needed for four factors in the theory of experimental design and why exactly this one and not another?

208. What fractional factorial experiment is required for five factors in the theory of experimental design and why exactly this one and not another?

209. How can we find the optimal version of a fractional factorial experiment for any number of factors?

210. For what number of factors is it sufficient to use a composite plan with three levels of factors in the theory of experimental planning?

211. What coded values of factor levels are used in the planning matrix of a fractional or full factorial experiment in the theory of experimental planning?

212. What coded values of factor levels are used in the planning matrix for composite plans for one factor in the theory of experimental planning?

213. What coded values of factor levels are used in the planning matrix for composite plans for two and more factors in the theory of experimental planning?

214. What method is the basis for calculating the coefficients of the regression equation in the theory of experiment planning?

215. How are the coefficients of the nonlinear regression equation calculated in the theory of experiment planning?

216. What criterion is used to check the significance of the coefficients of the regression equation in the theory of experiment planning?

217. In the theory of experiment planning, what is the difference between the statistical estimation of the variance of the error in determining the coefficients of the regression equation according to the Student's criterion for nonlinear regression and the same statistical estimation for linear regression?

218. Where is the number of significant terms remaining after the null hypothesis taken into account in the theory of experiment planning?

219. What criterion is used to check the adequacy of the original model in the theory of experiment planning?

220. What conclusion is drawn if the calculated value of Fisher's criterion exceeds the critical (table) value of this criterion in the theory of experimental planning?

221. What should be done if the calculated value of Fisher's criterion exceeds the critical (table) value of this criterion in the theory of experimental planning?

222. What conclusion is drawn if the calculated value of Fisher's criterion does not exceed the critical (table) value of this criterion in the theory of experimental planning?

## 7 Policy of academic discipline (educational component)

Teachers and all students undertake to adhere to the following provisions: Regulations on academic integrity of NTUU "KPI named after Igor Sikorsky", Regulations on the rating system of NTUU "KPI named after Igor Sikorsky" and understand that they will bear personal responsibility for violations of these provisions.

All students must attend lectures and laboratory classes, during which they must actively work on learning the educational material. For objective reasons (e.g. illness, international internship), training can take place in online form individually upon agreement with the head of the course. All individual work must be calculated and submitted to the teacher in the form of a separate file at the next laboratory session after the assignment. The practical results of the work must be confirmed by knowledge of the theoretical material on the topic during the defense.

**Deadlines and Rescheduling Policy:**

Laboratory works submitted in violation of the option will not be considered. The rearrangement of such laboratory work takes place with the permission of the head of the department if there are good reasons (for example, sick leave).

Only one laboratory work is accepted from the student during half the class. During the examination session, the reception of untimely completed laboratory works is carried out once a week and only for one laboratory work.

**Academic Integrity Policy:**

All laboratory works are checked for plagiarism and accepted for defense with correct textual borrowings of no more than 20%.

## 8 Types of control and rating system for evaluating learning outcomes (RSO)

Distribution of study time by types of classes and tasks in the discipline according to the working study plan.

| Academic Semester | The number of hours according to the curriculum | | | | | | | Exam |
|---|---|---|---|---|---|---|---|---|
| | Overall | Lectures | Practice occupation | Laboratory. occupation | DKR | MKR | Independence work | |
| 5 | 90 | 36 | | 18 | | | 36 | Test |
| In total | 90 | 36 | | 18 | | | 36 | Test |

**The student's credit module rating consists of the points he receives for:**

1. Performance of laboratory work /computer workshop/.
2. Calculation and graphic work (RGR).
3. Control work 1 (KR1).
4. Control work 2 (KR2).
5. Modular control work (MKR).

**System of rating points**

**1. Laboratory works /computer workshop/ (9 works).**

The minimum number of points for each prepared, completed and defended work is **2** points. That is, a student who completed all the work can get **18** points **(R1min=18)**

The number of points for each work, provided that it is completed on time (up to two weeks), is **3** points, that is, up to **9** points can be added.

The number of points for each work, provided that it is completed early (up to one week) – **4** points, that is, up to **18** points can be added (**R1max= 36**)

On the condition that all work is completed, **5** more points are added (**R2min=5**)

On the condition that all work is performed on time (or some of them ahead of time), another **10** points are added (**R2=10**), and on the condition that all work is performed ahead of time, not **10** points are added, but **15** points (**R2max=15**).

**2. Calculation and graphic work (RGR).**

The minimum number of points for RGR is **8** points (**R3min= 8**).

The number of points for the RGR, provided that it is completed on time (up to two weeks), is **16** points, that is, another **8** points can be added.

The number of points for RGR under the condition of its early completion (up to one week) is **24** points, i.e. another **8** points can be added (**R3max= 24**).

**3. Test 1.**

The minimum number of points for KR1 without errors is **3** points (**R4min=3**).

The maximum number of points for KR1 without errors, provided it is completed on time, is **6** points (**R4max=6**).

**4. Test 2 (KR2).**

The minimum number of points for KR2 without errors is 3 points (**R5min=3**).

The maximum number of points for KR2 without errors, provided it is completed on time, is **6** points (**R5max=6**).

**5. Modular control robot (MCR) – 8 tasks.**

The number of points for each task performed without errors is **0.5** points, if their number exceeds 4 tasks out of 8; that is, a student who completed all tasks without errors will receive **4** points, and a student who completed only 4 tasks without errors (or a smaller number) will not receive any points and MKR is not counted.

The number of points for the MKR, provided that all 8 tasks are completed without errors within the deadline (up to two weeks) - 8 points, and if all 8 tasks are completed before time (up to one week) without errors - **12** points. (**R6max=12**).

**Calculation of the size (R) of the student rating:**

The sum of the weighted points of control measures during the semester is: $\mathbf{R_{\Sigma} = R_1 + R_2 + R_3 + R_4 + R_5 + R_6}$, where

- **R1** - the sum of weighted points of control measures for laboratory work,

- **R2** - additional points provided that all work is completed, completed on time and/or ahead of schedule,

- **R3** - points for performing RGR,

- **R4** - points for performing KR1,

- **R3** - points for performing KR2,

- **R3** - points for the implementation of MKR.

The maximum value of $\mathbf{R_{\sum max}}$ can be **99** points:

$$\mathbf{R_{\sum max} = R_{1max} + R_{2max} + R_{3max} + R_{4max} + R_{5max} + R_{6max} = 36+15+24+6+6+12=99.}$$

minimum value $\mathbf{R_{\sum min}}$ under the condition of successful control measures can be made **39.5** points:

$$\mathbf{R_{\sum min} = R_{1min} + R_{2min} + R_{3min} + R_{4min} + R_{5min} + R_{6\,min} = 18+5+8+3+3+2.5 = 39.5.}$$

The size of the rating scale from the credit module is **99** points.

A necessary condition for a student's admission to credit is the absence of arrears from laboratory work, MKR. At the same time, the sum of the weighted points of control measures will be $\mathbf{R_{\sum} \geq 39.5}$.

To receive credit from the credit module "automatically" you need to have a rating of at least **60** whites.

Students who have a rating of less than 60 points, as well as those who want to improve their rating, take a test (up to three questions of 7 points each), based on the results of which they can receive additional Rd points (maximum value of Rd = 21). A student's additional Rd points are added to his semester rating $\mathbf{R_{\sum}}$. $R_D = \mathbf{R_{\sum}} + R_{д}$ .

The grade (traditional) is assigned according to the **RD** points scored. The point scored by the student (total rating of the student) is **RD** according to the table.

| The value of the rating from the credit module $\mathbf{R_D}$ | Traditional credit assessment |
|---|---|
| 95-100 | Perfectly |
| 85-94 | Very good |
| 75-85 | Fine |
| 65-75 | Satisfactorily |
| 60-65 | Enough |

| | |
|---|---|
| <60 | Unsatisfactorily |
| There are debts from laboratory work, RGR, KR1, KR2 and MKR | Not allowed |

**The student's credit module rating consists of the points he receives for:**

**1.** Performance of laboratory work /computer workshop/.

**System of rating points**

**1. Laboratory works /computer workshop/ (6 works).**

The minimum number of points for each prepared, completed and defended work is 5 points. That is, a student who completed all the work can get **30** points (**R1min=30**)

The number of points for each work, provided that it is completed within the deadline (up to two weeks), is **10** points, that is, up to **30** points can be added.

The number of points for each work, provided that it is completed early (up to one week) – **15** points, that is, up to **30** points can be added (**R1max= 90**)

On the condition that all work is completed, **2** more points are added **($R_{2min}$=2)**

On the condition that all work is performed on time (or some of them ahead of time), another **5** points are added (**R2=5**), and on the condition that all work is performed on time, not **5** points are added, but **10** points (**R2max=10**).

**Calculation of the size (R) of the student rating:**

The sum of the weighted points of control measures during the semester is:

$$R_{\Sigma} = R_1 + R_2, \text{ where}$$

- $R_1$ - the sum of weighted points of control measures for laboratory work,

- $R_2$ - additional points provided that all work is completed, completed on time and/or ahead of schedule,

Maximum value $R_{\Sigma max}$ can be **100** points:

$$R_{\Sigma max} = R_{1max} + R_{2max} = 90+10=100.$$

Minimum value $R_{\Sigma min}$ under the condition of successful control measures, it can be **32** points:

$$R_{\Sigma min} = R_{1min} + R_{2min} = 30+2= 32.$$

The size of the credit module rating scale is **99** points.

A necessary condition for a student's admission to credit is the absence of laboratory work arrears. At the same time, the sum of the weighted points of control measures will be $R_{\Sigma} \geq 32$.

To receive credit from the credit module "automatically" you need to have a rating of at least **60** whites.

Students who have a rating of less than 60 points, as well as those who want to improve their rating, take a test (up to three questions of 7 points each), based on the results of which they can receive additional Rd points (maximum value of Rd = 21). Additional Rd points of the student are added to his semester rating $\mathbf{R}_{\Sigma}$.

$$R_D = \mathbf{R}_{\Sigma} + R_{д} \quad .$$

The grade (traditional) is assigned according to the points scored $\mathbf{R_D}$**.** The point scored by the student (total rating of the student) is $\mathbf{R_D}$ according to the table.

| The value of the rating from the credit module $\mathbf{R_D}$ | Traditional credit assessment |
|---|---|
| 95-100 | Perfectly |
| 85-94 | Very good |
| 75-85 | Fine |
| 65-75 | Satisfactorily |
| 60-65 | Enough |
| <60 | Unsatisfactorily |
| There are debts from laboratory work, RGR, KR1, KR2 and MKR | Not allowed |

**Working program of the academic discipline (syllabus):**

**Folded** *Bachelor of Technology of Science, Assoc. Selivanov V.L., Candidate of Technical Sciences. Associate Professor Volokita A.M.*

**Approved** by the Department of Computer Engineering (protocol No. 10 dated May 25, 2022)

**Agreed** by the Methodical Commission of FIOT (protocol No. 10 dated 09.06.2022)