National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"

Department of Automation of Electrical and Mechatronic Complexes

Statistical modeling of operating modes of electrical and mechatronic complexes

Working program of the academic discipline (Syllabus)

Details of the discipline

Higher education level	***Second (Master's)***
Field of Knowledge	*14 Electrical Engineering*
Speciality	*141 Electric Power Engineering, Electrical Engineering and Electromechanics*
Educational program	*Statistical modeling of operating modes of electrical and mechatronic complexes*
Discipline status	*Custom*
Form of study	*Full-time (daytime)*
Year of preparation, semester	*1st year, spring semester*
Scope of discipline	*4 credits / 120 hours*
Semester control / control measures	*Test*
Class schedule	*http://rozklad.kpi.ua/*
Language of instruction	*English*
Information about the course leader / teachers	Lecturer and practical classes: *Candidate of Technical Sciences, Associate Professor Kulakovsky Leonid Yaroslavovych; e-mail: kulakovskiyl@ukr.net; tel. +38-097-453-65-46 (08:00 – 16:00)*
Course placement	

Program of the discipline

1. Description of the academic discipline, its purpose, subject of study and learning outcomes

The syllabus of the educational component "Statistical modeling of operating modes of electrical and mechatronic complexes" is compiled in accordance with the educational program for the masters study "Engineering of Intelligent Electrotechnical And Mechatronic Complexes" of specialty 141 – Electric Power Engineering, Electrical Engineering and Electromechanics.

The purpose of the discipline is to form and consolidate the following competencies in students:

Professional Competencies (PC): (PC 01) Ability to apply existing and develop new methods, techniques, technologies and procedures to solve engineering problems of electric power, electrical engineering and electromechanics; (PC 14) Ability to calculate and develop optimal equipment designs and operating modes of simple and complex electromechanical complexes using modern computer methods of mathematical modeling based on the analysis of static and dynamic loads, regime characteristics.

The subject of study of this discipline gives the student the knowledge and skills necessary to solve the problems of developing new modes, algorithms for the operation of electrical and mechatronic complexes and the skills to formalize the plan for conducting experiments, to conduct statistical analysis of the results of experiments when they are completed, to use the necessary methods of statistical modeling, to implement chosen or develop optimal plans for conducting experiments.

Program learning outcomes (PLO), the formation and improvement of which the discipline is aimed at: (PLO03) Analyze processes in electric power, electrical and electromechanical equipment, and related complexes and systems; (PLO07) Plan and implement scientific research and innovative projects in the fields of Electric Power Engineering, Electrotechnics and Electromechanics; (PLO13) Identify the main factors and technical problems that may hinder the implementation of modern methods of control of electric power, electrical and electromechanical systems.

2. Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

To successfully master the discipline, the student must possess the educational components "Higher Mathematics", "Modeling of Electrical and Mechatronic Systems", "Theory of Automatic Control of Electrical Complexes and Mechatronic Systems", "Engineering of electrotechnical and mechatronic systems".

3. Content of the discipline

Chapter 1. Basic concepts of building systems, models and data processing.

Topic 1.1. Concepts, basic concepts and purpose of the model.

Topic 1.2. Basics of data processing. Data structure.

Topic 1.3. Fundamentals of the distribution of random variables.

Chapter 2. Theory of systems modeling. Mathematical schemes for modeling modes of operation of electrical and mechatronic complexes.

Topic 2.1. Basic concepts of systems modeling theory. Classification of types of modeling and possibilities of simulation modeling.

Topic 2.2. Basic approaches for the construction of mathematical schemes for modeling continuously-deterministic models (D-schemes) and continuous-stochastic models (Q-schemes) of operating modes of electrical and mechatronic complexes.

Topic 2.3. Discrete-deterministic models (F-schemes) and discrete-stochastic models (P-circuits) of operating modes of electrical and mechatronic complexes.

Topic 2.4. Network models (N-schemes). Modeling of parallel processes of operation of electrical and mechatronic complexes.

Chapter 3. Planning and processing the results of the experiment of operating modes of electrical and mechatronic complexes.

Topic 3.1. Basic principles of planning the experiment. Full Factor Experiment 2^k.

Topic 3.2. Fractional factor experiment.

Topic 3.3. Implementation of the experiment plan for the study of the operating modes of electrical and mechatronic complexes.

Topic 3.4. Processing the results of the experiment for the study of the operating modes of electrical and mechatronic complexes.

Topic 3.5. Regression evaluation. Verification the adequacy of models of operating modes of electrical and mechatronic complexes.

Topic 3.6. One-factor and two-factor dispersed analysis of models of operating modes of electrical and mechatronic complexes.

Chapter 4. Construction and modeling the imitation models of operating modes of electrical and mechatronic complexes.

Topic 4.1. Random and pseudorandom number generators.

Topic 4.2. Identification of statistical objects of electrotechnical and mechatronic complexes.

Topic 4.3. Monte Carlo method. Features of the method application for the study of the operating modes of electrical and mechatronic complexes.

4. Training materials and resources

Basic

1. Ott, R. L., and Michael Longnecker. *An introduction to statistical methods and data analysis*. Cengage Learning Inc., 2010.

2. Kroese, Dirk P., and Joshua CC Chan. Statistical modeling and computation. New York: Springer, 2014, 400 p.

3. Davidson A.C. Statistical models. Cambridge Series in Statistical and Probabilistic Mathematics. Cambridge University Press, 2008, 382 p.

4. Merzouki, R., Samantaray, A. K., Pathak, P. M., & Ould Bouamama, B. (2013). Intelligent mechatronic systems: Modeling, control and diagnosis. Springer. https://doi.org/10.1007/978-1-4471-4628-5

5. Gasparetto, A., Ceccarelli, M., & Boscariol, P. (Eds.). (2021). Modelling and control of mechatronic and robotic systems. MDPI. https://doi.org/10.3390/books978-3-0365-0683-3

6. Applied Data Analysis and Modeling for Energy Engineers and Scientists Henze, G. P. (2023). Applied Data Analysis and Modeling for Energy Engineers and Scientists (2nd ed.). Springer. https://doi.org/10.1007/978-3-031-34869-3

7. Isermann, R. (2011). Mechatronic systems design: Methods, models, concepts. Springer. https://doi.org/10.1007/978-3-642-17531-2

Secondary

1. Legay, Axel, Benoît Delahaye, and Saddek Bensalem. "Statistical model checking: An overview." International conference on runtime verification. Berlin, Heidelberg: Springer Berlin Heidelberg, 2010.

2. Karnopp, D. C., Margolis, D. L., & Rosenberg, R. C. (2006). System dynamics: Modeling and simulation of mechatronic systems (4th ed.). Wiley-Interscience.

3. Jazar, R. N., & Karimi, H. R. (2014). Intelligent mechatronic systems: Modeling, control and diagnosis. Springer. https://doi.org/10.1007/978-1-4471-4628-5

4. Weron, R. (2006). Modeling and forecasting electricity loads and prices: A statistical approach. Wiley. https://doi.org/10.1002/0470057564

5. Das, S. (2023). Modeling and simulation of mechatronic systems using Simscape. Wiley.

6. Merzouki, R., Samantaray, A. K., Pathak, P. M., & Ould Bouamama, B. (2013). Intelligent mechatronic systems: Modeling, control and diagnosis. Springer. https://doi.org/10.1007/978-1-4471-4628-5

7. Karnopp, D. C., Margolis, D. L., & Rosenberg, R. C. (2006). System dynamics: Modeling and simulation of mechatronic systems (4th ed.). Wiley-Interscience.

8. Zueva, N.Y. 2024. Creating a model using the Monte Carlo method. Information Technologies and Systems in the Field of Document Science. (Oct. 2024), 43-45.

Literature, the bibliography of which is provided with a link, can be found on the Internet. Literature, the bibliography of which does not contain references, can be found in the library of KPI. Igor Sikorsky. Mandatory reading is the basic literature [1]-[7]. All other literary sources are optional, it is recommended to familiarize yourself with them.

Educational content

5. Methods of mastering the academic discipline (educational component)

Active learning strategies are applied, which are determined by the following methods and technologies: problem-based learning methods (research method); person-centered technologies based on such forms and methods of teaching as visualization and information and communication technologies, in particular electronic presentations for lectures. Teaching is carried out in the form of lectures and practical classes.

Lectures

No.	*Title of the lecture topic and list of main questions (list of didactic tools, references to literature)*
1	**Lecture 1.** Topic 1.1. The concept of a model. The concept of a model. The purpose of models. Types of models. Levels of modeling. **Literature [1, 3, 5]**
2	**Lecture 2.** Topic 1.2. Fundamentals of Data Processing. Data Structure. Median. Mode. Variance and Standard Deviation **Literature [1, 6, 7]**
3	**Lecture 3.** Topic 1.3. Fundamentals of the random variables distribution of the operating modes of electrical and mechatronic complexes. Frequency of random variable fallout. Integral, differential laws of random distribution. **Literature [2, 6]**
4	**Lecture 4.** Topic 1.4. Distribution moments. Mathematical expectation. Accurate estimates of the distribution. Interval estimates (confidence interval, variance, quantile of a random variable) **Literature [2, 5]**
5	**Lecture 5.** Topic 2.1. Basic concepts of systems modeling theory. Classification of types of modeling and possibilities of simulation modeling. Mathematical schemes for modeling the operating modes of electrical and mechatronic complexes. **Literature [3, 4]**
6	**Lecture 6.** Topic 2.2. Basic approaches to the construction of mathematical schemes for modeling continuously-deterministic models (D-schemes). Basic relations of continuous-stochastic models for the study of operating modes of electrical and mechatronic complexes. Possible applications of Q-schemes. Modeling of the processes of functioning of systems based on Q-schemes. Methods for building modeling algorithms of Q-schemes. Literature **[2, 4, 6]**
7	**Lecture 7.** Topic 2.3. Discrete-deterministic models (F- schemes) of operating modes of electrical and mechatronic complexes. Moore and Moley automata. Basic Ratios of Discrete-Stochastic Models. Discrete-Stochastic Models (P-schemes). Basic Ratios of Discrete-Stochastic Models **Literature [2, 4, 6]**
8	**Lecture 8.** Topic 2.4. Network models (N-schemes) of operating modes of electrical and mechatronic complexes. Basic ratios of network models. Modeling of systems functioning processes based on N-schemes. Synchronization of events in N schemes. Modeling of parallel processes **Literature [2, 5, 6]**
9	**Lecture 9.** Topic 2.5. Combined models (A-circuits) of operating modes of electrical and mechatronic complexes. Basic ratios of combined models. Hierarchical models of functioning processes. Block design of the model. Stages of system modeling **Literature [3, 4, 6]**
10	**Lecture 10.** Topic 3.1. Basic principles of planning an experiment to study the operating modes of electrical and mechatronic complexes. Step principle. Full factor experiment 2^k. **Literature [1, 2, 7]**

11	**Lecture 11.** Topic 3.2. Fractional factor experiment. The concept of a replica. Generating relations and determining contrasts. Replicas of large fractionality. **Literature [1, 2, 7]**
12	**Lecture 12.** Topic 3.3. Conducting an experiment to study the operating modes of electrical and mechatronic complexes. Questionnaire for collecting a priori information. Implementation of the experiment plan. Errors of parallel experiments. Randomization **Literature [1, 2, 7]**
13	**Lecture 13.** Topic 3.4. Processing the results of the experiment for the study of the operating modes of electrical and mechatronic complexes. Fisher and Student's criterion. Checking the significance of coefficients **Literature** [3, 5, 6]
14	**Lecture 14.** Topic 3.5. Regression evaluation. Verification the adequacy of models of operating modes of electrical and mechatronic complexes. Method of least squares. Correlation analysis **Literature [3, 6, 7]**
15	**Lecture 15.** Topic 3.6. One-factor and two-factor dispersed analysis of the study of the operating modes of electrical and mechatronic complexes. Checking the homogeneity of the variance during the experiment. Planning experiments in disperse analysis **Literature [1, 6]**
16	**Lecture 16.** Topic 4.1. Simulation model of operating modes of electrical and mechatronic complexes. Generators of random and pseudorandom numbers. Markov circles. Topic 4.2. Identification of statistical objects. Formulation of the problem of adjusting the parameters of nonlinear models. **Literature [2, 5, 7]**
17	**Lecture 17.** Topic 4.3. Monte Carlo method. Features of the method application for the study of the operating modes of electrical and mechatronic complexes. Numerical integration by the Monte Carlo method. Generation of continuous random numbers of operating modes of electrical and mechatronic complexes. Literature [6, 8]
18	**Lecture 18.** Test assessment

Practical classes:

Practical classes in the discipline are conducted by the teacher according to the curriculum. **The main goal of** practical classes is to consolidate theoretical provisions and acquire the ability to apply them in practice by performing certain appropriately formulated tasks.

No.	Name of the topic submitted to the practical class
Practical class No. 1	Analysis of a sample of data from the operating modes of electrical and mechatronic complexes. Analysis of random variables and probabilities.
Practical class No. 2	Construction of Discrete-Determinated Models of Operating Modes of Electrical and Mechatronic Complexes Using Mili and Moore Automata in the Matlab Environment
Practical class No. 3	Construction of Discrete-Determinated Models of Operating Modes of Electrical and Mechatronic Complexes Using Mili and Moore Automata in the Matlab Environment
Practical class No. 4	Construction of Discrete-Determinated Models of Operating Modes of Electrical and Mechatronic Complexes Using Mili and Moore Automata in the Matlab Environment
Practical class No. 5	Modular control work

Practical class No. 6	Planning of production experiments for the operation of electrical and electromechatronic complexes. Selection of factors for planning experiments. Decision-making before planning an experiment.
Practical class No. 7	Development of a plan of production experiments, study of the operating modes of electrical and mechatronic complexes – a complete factor and fractional plan of experiments.
Practical class No. 8	Processing the results of the experiment for the study of the operating modes of electrical and mechatronic complexes (Fisher, Student's criteria). Creation of mathematical models of operating modes of electrical and mechatronic complexes based on their results and checking them for adequacy.
Practical class No. 9	Application of the Monte Carlo method for the generation of random numbers during the operation of electrical and mechatronic complexes

6. Independent work of a student

Independent work of a student involves:
preparation for classroom classes – 56 hours;
preparation for modular control work – 4 hours;
preparation for the test assessment – 6 hours.

Test work

The purpose of the test work is to consolidate and test theoretical knowledge of the educational component, to acquire practical skills for students to independently solve of statistical modeling of operating modes.

Modular control work (MCW) is performed after studying Chapters 1-3 and completing practical classes 1-5. Tests are carried out in the Google Classroom environment.

Policy and control

7. Policy of the academic discipline (educational component)

The policy of the discipline "Statistical modeling of operating modes of electrical and mechatronic complexes" is based on the corporate policy of Igor Sikorsky Kyiv Polytechnic Institute.

KPI named after Igor Sikorsky is a free and autonomous center of education, which is designed to give adequate answers to the challenges of our time, to nurture and protect the spiritual freedom of a person, which makes him able to act according to his own conscience; its civil freedom, which is the basis for the formation of a socially responsible personality, and academic freedom and integrity, which are the main driving factors of scientific progress. The internal atmosphere of the University is built on the principles of openness, transparency, hospitality, respect for the individual.

The study of the discipline "Technologies of Control of Electrical Complexes and Mechatronic Systems" requires: preparation for practical classes of recommended basic and additional literature.

Preparation and participation in practical classes includes: familiarization with the program of the academic discipline and plans of practical classes; study of theoretical material; performing tasks proposed for independent study.

The system of requirements that the lecturer sets for the student:

- Rules for attending classes: it is forbidden to assess the presence or absence of an applicant in a classroom lesson, including awarding incentive or penalty points. In accordance with the rating system of evaluation (RSE) of this discipline, points are awarded for the corresponding types of educational activity in lectures and practical classes;
- rules of behavior in classes: the student has the opportunity to receive points for the relevant types of educational activity in lectures and practical classes, provided for by the RSE of discipline. The

use of communication tools to search for information on the lecturer's Google drive, on the Internet, in a distance course on the Sikorsky platform is carried out subject to the instruction of the lecturer;

- deadline and retake policy: if a student did not pass or did not appear at the MCW (without a valid reason), his result is estimated at 0 points. Retaking the results of the ICW is not provided;
- academic integrity policy: The Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute" https://kpi.ua/files/honorcode.pdf establishes general moral principles, rules of ethical behavior of persons and provides for a policy of academic integrity for persons working and studying at the university, who should be guided in their activities, including the study and preparation of control evaluation the discipline "Intelligent Systems of Acceptance decisions";
- in case of use the digital devices of communication with the lecturer (mobile communication, e-mail, correspondence on forums and social networks, etc.), it is necessary to adhere to generally accepted ethical standards, in particular, to be polite and limit communication to the lecturer's working hours.
- the applicant for higher education must comply with educational and academic ethics and the schedule of the educational process; be balanced, attentive.

8. Types of control and rating system for assessing learning outcomes (RSO)

Current control: MCW (modular control work) is carried out before the second calendar control at the lecture class in the presence of the lecturer (28 points), 9 practical classes (8 points per practical lesson = 9 x 8 = 72). MCW is performed in the form of an answer to a theoretical question from the lecture material and one practical work. At the end of the lesson, the work on the MCW ends and is not subject to rewriting. MCW is evaluated at 28 points according to the following criteria:

− "excellent" – a complete answer to the theoretical question (at least 90% of the required information), appropriate justifications and personal views are provided, and the problem is solved correctly – 28-23 points;

− "good" – a sufficiently complete answer to the theoretical question (at least 75% of the required information), which is made in accordance with the requirements for the level of "skills" or contains minor inaccuracies, the course of solving the problem is correct, but contains minor inaccuracies, mostly in the calculation – 22-17 points;

− "satisfactory" – an incomplete answer to a theoretical question (at least 60% of the required information), performed in accordance with the requirements for the "stereotyped" level and contains some errors, significant errors in solving problems are traced – 16-11 points;

− "unsatisfactory" – unsatisfactory answer and incorrectly solved problem – 0 points.

Tasks within the framework of the practical lesson are evaluated at 8 points according to the following criteria:

− "excellent" – fully completed work (at least 90% of the necessary information), appropriate justifications and personal opinion provided – 8 points;

− "good" – the work contains certain inaccuracies (at least 75% of the necessary information), the provided justifications are not complete enough – 7-6 points;

− "satisfactory" – the work contains significant inaccuracies (at least 60% of the required information), the work is performed in accordance with the requirements for the "stereotyped" level and contains significant errors – 5-5 points;

− "unsatisfactory" – the problem was solved incorrectly – 0 points.

Calendar control: is carried out twice a semester as a monitoring of the current state of fulfillment of the requirements of the syllabus. The condition for a positive first and second calendar control is to obtain at least 50% of the maximum possible rating at the time of the corresponding calendar control.

Semester control: test. A prerequisite for admission to the credit assessment is the writing of a modular test work and a starting rating of at least 30 points.

RC(max) = 28 + 72 = 100 points

RC(min) = 30 points.

Test assessment. Students who have fulfilled all the conditions for admission to the test and have a rating score of 60 or more points receive a grade corresponding to the rating scored without additional tests. The sum of rating points received by the student during the semester is converted to the final grade according to the table.

If the sum of points is less than 60, but the practical ones are completed and passed, the MCW, the student performs the test work. The test work is estimated at 100 points. The control task of this work consists of two theoretical questions from the list provided in the appendix to the syllabus and the problem. Each question is evaluated at 50 points according to the following criteria:

− "excellent" – complete answer (at least 95% of the required information), provided appropriate justifications and personal view – 47-50 points;

− "good" – a sufficiently complete answer (at least 75% of the required information) that has been completed according to the requirements for the level of "skills" or contains minor inaccuracies – 37-46 points;

− "satisfactory" – an incomplete answer (at least 60% of the required information) made in accordance with requirements for the "stereotyped" level and contains some errors – 30-36 points;

− "unsatisfactory" – unsatisfactory answer – >30 points.

Incentive points are set for:

Completing an individual semester assignment	depending on the complexity, but not more than 10 points
Report at relevant student conferences on the subject of the discipline and participation in competitions of works	up to 5 points
Preparation of an abstract work on the topic of the lesson missed by the student, or on the topic proposed by the lecturer (up to 10 sheets)	depending on the student's disclosure of the chosen topic, the validity of the conclusions, but not more than 3 points

Table of correspondence of rating points to grades on the university scale

Rating Points, RD	*University Scale Score*
$95 \le RD \le 100$	Perfectly
$85 \le RD \le 94$	Very good
$75 \le RD \le 84$	Well
$65 \le RD \le 74$	Satisfactory
$60 \le RD \le 64$	Enough
$RD < 60$	Disappointing
Failure to meet the conditions for admission to semester control	Not allowed

Additional information on the discipline (educational component)

As a semester control, according to the curriculum, students take a test evaluation. The list of questions submitted for semester control is given in the appendix to the syllabus.

A higher education applicant has the opportunity to take an online course(s) on one or more topics provided for by the work program of the academic discipline. The applicant can choose an online course independently or on the recommendation of a lecturer. 1 hour of the course is estimated at 0.83 points. The maximum number of hours that can be counted based on the results of non-formal education is 12 hours, respectively, the maximum number of points for such results is 10 points.

Work program of the academic discipline (syllabus):

Compiled by: Associate Professor of the Department of Automation of Electrical and Mechatronic Complexes, Ph.D., Leonid Kulakovskyi

Approved by the Department of Automation of Electrical and Mechatronic Complexes. Protocol No. 21 of 25.06.24

Agreed: Methodological Commission of the IEE (Minutes No. 18 of 24.06.24)

Appendix to the syllabus of the educational component of the course

"Statistical modeling of operating modes of electrical and mechatronic complexes"

List of tasks submitted for semester control

1. Describe the basic concepts of model construction and indicate the main purposes of the model.
2. Formulate the main stages of data analysis.
3. Describe the data structure (quantitative, qualitative data, by data source).
4. Describe the types of models and levels of modeling the operating modes of electrical and mechatronic complexes.
5. Describe the main characteristics of the normal, uniform and exponential distribution laws of random variables.
6. Describe the main characteristics of the Laplace, Poisson distribution of the normal logarithmic distribution of random variables
7. Describe the features of the integral and differential laws of the distribution the randomness of the operating modes of electrical and mechatronic complexes.
8. Formulate accurate estimates of the distribution and interval estimates (confidence interval, variance, quantile of random variable) of the operating modes of electrical and mechatronic complexes.
9. Describe the basic concepts of the theory of system modeling, the features of the classification of types of modeling and the possibility of simulation modeling of operating modes of electrical and mechatronic complexes.
10. Formulate the main approaches to the construction of mathematical schemes for modeling continuously-deterministic models (D-schemes) and the main relations of continuous-stochastic models of operating modes of electrical and mechatronic complexes.
11. Formulate possible applications of Q-schemes. To describe the features of modeling the processes of functioning of systems based on Q-schemes and methods for building modeling algorithms of Q-schemes of operating modes of electrical and mechatronic complexes.
12. Formulate the main approaches to the construction of discrete-deterministic models (F-circuits) and Moore and Moley automata. Show the main relationships of discrete-deterministic models of operating modes of electrical and mechatronic complexes.
13. Formulate the main approaches to the construction of discrete-stochastic models (P-circuits). To give the main ratios of discrete-stochastic models of operating modes of electrical and mechatronic complexes.
14. Describe the procedure for constructing discrete-determinized models of operating modes of electrical and mechatronic complexes using Mili and Moore automata.
15. Formulate the main approaches to the construction of network models (N-schemes). Show the main correlations of network models of operating modes of electrical and mechatronic complexes.
16. Describe the features of systems functioning modeling of the processes based on N-schemes, synchronization of events in N- schemes and modeling of parallel processes in the application of operating modes of electrical and mechatronic complexes.
17. Formulate the main approaches to the construction of combined models (A- schemes). Describe the main ratios of combined models of operating modes of electrical and mechatronic complexes.
18. Formulate the main approaches to the construction of hierarchical models of functioning processes. Describe the block design of the model of operating modes of electrical and mechatronic complexes and to formulate the main stages of modeling such systems.

19. Formulate and describe the basic principles of planning an experiment for studying the operating modes of electrical and mechatronic complexes, in particular the step-by-step principle.

20. Describe the features of constructing a complete factor experiment 2^k.

21. Describe the features of the application and construction of a fractional factor experiment, to determine the necessary replica for the study of the operating modes of electrical and mechatronic complexes.

22. Describe the features of the formation of generating relations and determining contrasts and the definition of replicas of large fractionality.

23. Describe the features of the conducting the experiment of the operating modes of electrical and mechatronic complexes, the formation of questionnaires for the collection of a priori information and the implementation of the experiment plan.

24. Formulate the features of determining the errors of parallel experiments of operating modes of electrical and mechatronic complexes and the application of randomization

25. Formulate the main features of processing the results of the experiment study of operating modes of electrical and mechatronic complexes, applying the Fisher and Student criteria and checking the significance of the model coefficients

26. Describe the procedure for estimating the model regression of operating modes of electrical and mechatronic complexes and feature for checking the adequacy of models. Features of usage the method of least squares and correlation analysis

27. Describe the main characteristics of one-factor and two-factor disperse analysis of the study of the operating modes of electrical and mechatronic complexes.

28. Describe the procedure for checking the homogeneity of dispersion during the experiment and planning experiments, study the operating modes of electrical and mechatronic complexes during disperse analysis.

29. Formulate the features of the imitation model of the operating modes of electrical and mechatronic complexes and the use of random and pseudorandom number generators. Features of implementation of Markov circles.

30. Describe the features of identification of statistical objects in the operating modes of electrical and mechatronic complexes. Describe a statement of the problem of subtuning the parameters of nonlinear models.

31. Formulate the features of the application of the Monte Carlo method and numerical integration by the Monte Carlo method.

32. Formulate the features of generating continuous random numbers of operating modes of electrical and mechatronic complexes.