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

Department of Computer Engineering

Probability Theory

Working program of the academic discipline
(Syllabus)

Details of the academic discipline

Level of higher education	*First (Bachelor)*
Field of expertise	*12 Information Technologies*
Qualification	*121 Software Engineering*
Educational program	*Computer Systems Software Engineering*
Discipline status	*Normative*
Form of education	*Internal (daytime)*
Year of education (semester)	*2 year, autumn semester*
Discipline volume	*4 credits 120 hours, Lectures - 36 hours, Laboratory - 18 hours, Independent work - 66 hours*
Final assessment form	*Final Test*
Lessons schedule	http://roz.kpi.ua/
Languages of Instruction	*Ukrainian / English*
Information about the course leader	Lecturer: PhD, Associate Professor of the Department of Computer Engineering , Oleksander MARKOVSKYI, markovskyi@comsys.kpi.ua Head of practical classes: PhD, Associate Professor of the Department of Computer Engineering , Oleksandr MARKOVSKYI, markovskyi@comsys.kpi.ua
Placement of the course	https://ecampus.kpi.ua/

Program of the academic discipline

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

The academic discipline "Probability theory" is intended for a thorough study of modern methods of the theory of probabilities and random processes and information theory, as well as the acquisition of skills in the application of these methods to effectively solve practical problems of computer engineering.

The educational discipline contains two main sections:

1. Probability theory.
2. Theory of random processes.

In the framework of the first chapter, the main theoretical provisions of the theory of probabilities, as well as methods of determining the probabilities of random events, characteristics of random variables, random functions, and systems of random variables are considered. Considerable attention is paid to mastering the methods of practical application of the theoretical provisions of the theory of probabilities to solve the problems of effective design of hardware and software of computer systems, assessment of their reliability and efficiency, organization of protection of programs and data. In the framework of the first chapter, the basic provisions of the theory of random processes are also studied, namely: flow theory, mass service systems, discrete and continuous random Markov processes, which find wide practical application in computer engineering. At the overview level, the provisions of information theory, which are important for the effective organization of computing processes and software creation, are studied.

The second section includes the basic scientific provisions of the theory of random processes and statistical processing of measurement results, assessment of the reliability of the obtained measurement results, determination of the parameters of experimental research of phenomena and processes in computer systems and networks. The theoretical and practical aspects of the most important sections of the theory of random processes from the point of view of engineering applications are studied: the analysis of streams of random events and Markov processes. Considerable attention is paid to the study of methods of statistical correlation and regression analysis, creating on this basis models for forecasting computational processes. A prominent place in the section is devoted to the study of modern decision-making methods based on statistical models. Special attention is paid to methods of computer modeling of random events, quantities and processes

The purpose of studying the discipline "Probability Theory" is to train specialists who have modern scientific concepts of the theory of probabilities and random processes, who are able to apply in practice the methods of analysis of random events, values and processes, as well as methods of computer modeling of random values and processes.

The subject of the discipline consists of:

- scientific concepts of probability theory and mathematical statistics;
- mathematical models of random events, values and processes;
- methods of analysis of random events, quantities, as well as systems of such quantities;
- methods of program generation of random events, discrete and continuous random variables with a given distribution law;
- mathematical models and methods of analysis of random processes in application to development of effective software;
- statistical data processing techniques;
- statistical decision-making methods.

The discipline “Probability theory” provides the following competencies and program results of educational program: GC01, GC02, GC06, PC06, PC08, PC11, PC14, PC19, PLO05, PLO20, PLO21.

The discipline "Probability Theory" should teach how to solve applied problems of analysis of random events, quantities and processes, in the process of engineering activities for the design of effective software components of modern computer technologies, as well as the use and analysis of probability

mathematical models in the field of research activities in in the field of building new methods and techniques for creating effective software tools.

According to the requirements of the EPP, after mastering the discipline "Theory of Probabilities", applicants must demonstrate the following learning outcomes:

Knowledge: Basic axioms and theorems of probability theory. Basic theoretical provisions on mathematical models for working with random events, random discrete and continuous values, as well as dependent and independent systems of such values. The fundamental theoretical principles of the theory of random processes and the mathematical models of random flows of events, as well as discrete and continuous Markov random processes, are the most widely used in the practice of program development. Basic theoretical provisions of mathematical statistics, methods of assessing the reliability of measurement results, hypothesis testing, statistical methods of recognition, correlation and regression analysis. Basic principles of information theory and its coding

Be able:

- independently analyze random events, calculate their probability;

- analyze discrete and continuous random variables, as well as systems of random variables, calculate probabilistic characteristics of variables with different distribution laws, independent and interconnected;

- apply methods of probability theory to calculate performance characteristics and reliability of software components of computer systems;

- perform program generation of random events, discrete and random values, systems of interconnected random values;

- process the results of measurements, obtain estimates of the characteristics of random variables and their systems, determine estimates of the reliability of measurements, conduct correlation and regression analysis;

- independently evaluate the conformity of the measurement results with the theoretical distribution, analyze the statistical homogeneity of several measurement results;

- apply decision-making methods in conditions of statistical uncertainty;

- analyze random processes, apply the methods of the theory of random processes to the analysis of programs;

- determine parameters of the transient process and stationary characteristics of discrete and continuous random Markov processes;

- independently apply the mathematical apparatus of mass service theory to analyze the characteristics of information processing processes during program execution;

- to determine the quantitative characteristics of information, to optimize the coding of data taking into account their informational characteristics;

- independently develop programs for solving scientific and technical calculations related to random events, values and processes, programs for generating random values with given distribution characteristics.

Experience: the student must know the basic principles of determining the probabilistic characteristics of events, values and processes in computer systems, be able to build mathematical models of software and hardware components, as well as processes in computer systems and networks, apply probabilistic mathematical models to optimize the organization of computing processes and data transmission processes in networks.

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

The educational basis of the course is the volume of mathematical knowledge provided within the framework of educational disciplines:

GM 10 “Mathematical Analysis”.
GM 11 “Linear Algebra and Analytic Geometry”
GM 13 “Computer Discrete Mathematics”

The discipline "Probability Theory" provides the following educational disciplines:

PM 07.2 “Software Engineering Components. Part 2. Software modeling”
PM 07.4 “Software Engineering Components. Part 4. Quality and testing Software ”
PM 09 “Software Security”
PM 19 “Agile Programming Techniques”
PM 20 “Risk and Quality Management of Projects”
PM 21 “Basics of Computer Games Development”
PM 23 “Complex Systems Design”
PM 24 “Artificial Intelligence Technologies”

Content of the academic discipline

The academic discipline "Probability Theory " includes the study of the following topics.

Chapter 1. The theory of probabilities

Topic 1.1. Basic provisions of the theory of probabilities

Basic concepts of probability theory. Classical, geometric and statistical methods of determining probability. Basic axioms of probability theory.

Topic 1.2. Basic formulas for determining event probabilities

Formula of full probability, features of its application in practice. A posteriori probability and its definition using the Bayes formula. Model of post-tests, Bernoulli's formula, features of its application, formulas of approximate calculations. Poisson's formula. Analysis of heterogeneous Bernoulli's models.

Topic 1.3. Discrete random variables

Concept of discrete and continuous random variables. The concept of distribution laws, the main numerical characteristics of random variables. Binomial distribution.

Topic 1.4. Continuous random variables

Continuous random variables. Distribution density, integral distribution function. Numerical characteristics of continuous random variables. Uniform distribution law. Exponential law of distribution, its application for evaluating the reliability of program components. Generalization of the complete probability formula for continuous random variables.

Topic 1.5. Central boundary theorem

Normal distribution law, calculation of probabilities using Laplace functions, determination of distribution parameters according to a given probability. Central limit theorem. The Moivre-Laplace theorem and its application for calculating probabilities in the binomial distribution.

Topic 1.6. Systems of random variables

Systems of random variables. Dependent and independent random variables. Covariance and correlation are characteristics of the measure of dependence of quantities. Methodology for calculating probabilities for dependent random variables. Generalization of the central limit theorem for systems of dependent random variables.

Topic 1.7. Functions of random variables
Definition of the distribution law of the function of random variables. Distribution of sum, difference and product of random variables.

Topic 1.8 Methods of building mathematical models of random variables.
Assessment of the reliability of hypotheses regarding the distribution law of a random variable. Kolmogorov, Wilcoxon and Neumann-Pearson methods. Methodology for assessing the reliability of the hypothesis regarding the homogeneity of two samples.

Topic 1.9. Correlation and regression analysis.
Linear and non-linear regression. method of reproducing linear regression dependence for many variables. Estimating the regression error.

Topic 1.10. Statistical methods of decision-making
Decision-making methods under conditions of uncertainty. Decision-making errors of the first and second kind. Decision-making according to the criteria of the margin of error and the Neumann-Pearson method. Comparative analysis of methods and their selection for application.

Chapter 2. Random processes

Topic 2.1. Basic provisions of the theory of streams of random events
Basic characteristics and classification of random processes. Flows of events, their types, characteristics and methods of their determination. Poisson flows, methods of their calculations, methods of computer modeling and application in programs.

Topic 2.2. Discrete and continuous random Markov processes.
Determination of the characteristics of the transient process and the method of calculating stationary probabilities. Non-ergodic Markov processes and methods of determining their characteristics. Application of the apparatus of Markov processes for the analysis of computing processes.

Topic 2.3. Elements of mass service theory.
Formulas for determining the main characteristics: average queue length, delay time in the system and their variances. Mass service systems with an arbitrary distribution of service time. Systems of mass service with priorities.

Topic 2.4. Basic concepts of information theory.
Determination of the amount of information and entropy. Optimization of data coding from the standpoint of information theory.

Educational materials and resources

Basic:

1. Kallenberg O. Foundation of Modern Probability. – 2021. – 327 p.
2. Lana R.G., Rohatgi V.K. Probability Theory.- 2020. – 388 p.
3. Sheldon M. Introduction to Probability and Statistics for Engineers and Scientist. 5-th Edition.- 2014- 478 p.
4. Papoulis A. Probability, random variables and stochastic processes. McGraw-Hill.-2008.- 576 p.
5. Dudley R.M. Real Analysis and Probability.-2017.- 387 p.
6. Shaldon M.R. Introduction to Probability Models.-2019. – 314 p.
7. Klenke A. Probability Theory.-2020. – 405 p.
8. Durrett R. Probability Theory and Examples. – 2019. – 296 p.

Additional:

1. Meyer M.C. Probability and Mathematical Statistics. – 2019. – 276 p.

2. Bremaud P. Probability Theory and Stochastic Processes.- 2020.- 411 p.

3. Alajaji F., Chaen Po-Ning. An Introduction to Single-User Information Theory.-2018.- 196 p.

4. Knill O. Probability Theory and Stochastic Process with Applications.- 2021.- 355 p.

Equipment needed for classes

Lecture classes are held in a classroom equipped with a projector, laboratory classes are held in a computer classroom.

Methods of mastering an educational discipline (educational component)

The structure of the academic discipline "Theory of Probability" is presented in Table 1.

Table 1

The structure of the academic discipline "Theory of probability"

Names of sections, topics	Number of hours			
	Total	Including		
		Lecture	Practical lessons	IW
Topic 1. Probability theory				
Topic 1.1. Basic provisions of the theory of probabilities Basic concepts of probability theory. Classical, geometric and statistical methods of determining probability. Basic axioms of probability theory.	8	2	2	4
Topic 1.2. Basic formulas for determining event probabilities Formula of full probability, features of its application in practice. Aposteriori probability and its definition using the Bayes formula. Model of post-tests, Bernoulli's formula, features of its application, formulas of approximate calculations. Poisson's formula. Analysis of heterogeneous test sequences.	12	4	2	6
Topic 1.3. Discrete random variables Concept of discrete and continuous random variables. The concept of distribution laws, the main numerical characteristics of random variables. Binomial distribution.	6	2		4
Topic 1.4. Continuous random variables Continuous random variables. Distribution density, integral distribution function. Numerical characteristics of continuous random variables. Uniform distribution law. Exponential law of distribution, its application for reliability assessment of computer system components.	8	2		6

Names of sections, topics	Number of hours			
	Total	Including		
		Lecture	Practical lessons	IW
Topic 1.5. Central boundary theorem Normal distribution law, calculation of probabilities using Laplace functions, determination of distribution parameters according to a given probability. Central limit theorem. Moivre-Laplace theorem and its application for calculating probabilities in the binomial distribution.	12	4	2	6
Topic 1.6. Systems of random variables Systems of random variables. Dependent and independent random variables. Covariance and correlation are characteristics of the measure of dependence of quantities. Methodology for calculating probabilities for dependent random variables. Generalization of the central limit theorem for systems of dependent random variables.	10	2	2	6
Topic 1.7. Functions of random variables Definition of the distribution law of the function of random variables. Distribution of sum, difference and product of random variables.	6	2		4
Topic 1.8. Methods of constructing mathematical models of random variables. Assessment of the reliability of hypotheses regarding the distribution law of a random variable. Kolmogorov, Wilcoxon and Neumann-Pearson methods. Methodology for assessing the reliability of the hypothesis regarding the homogeneity of two samples.	6	2		4
Topic 1.9. Correlation and regression analysis. Linear and non-linear regression. method of reproducing linear regression dependence for many variables. Estimating the regression error.	6	2	2	4
Topic 1.10. Statistical methods of decision-making Methods of decision-making under conditions of uncertainty. Decision-making errors of the first and second kind. Decision-making according to the criteria of the margin of error and the Neumann-Pearson method. Comparative analysis of methods and their selection for application	10	4	2	4
Control testing 1	1.5		0	
Chapter 2 Stochastic processes			0	
Topic 2.1. Basic provisions of the theory of streams of random events Basic characteristics and classification of random processes. Flows of events, their types, characteristics and methods of their determination. Poisson flows, methods of their calculations, methods of computer modeling and application in programs.	8	2	2	4

Names of sections, topics	Number of hours			
	Total	Including		
		Lecture	Practical lessons	IW
Topic 2.2. Discrete and continuous random Markov processes. Determination of the characteristics of the transient process and the method of calculating stationary probabilities. Non-ergodic Markov processes and methods of determining their characteristics. Application of the apparatus of Markov processes for the analysis of computing processes.	12	4	2	6
Topic 2.3. Elements of mass service theory. Formulas for determining the main characteristics: average queue length, delay time in the system and their variances. Mass service systems with an arbitrary distribution of service time. Systems of mass service with priorities.	6	2	0	4
Topic 2.4. Basic concepts of information theory. Determination of the amount of information and entropy. Optimization of data coding from the standpoint of information theory.	8	2	20	4
Control testing 2	1.5		0	
Final test	**3**		0	
Total:	**120**	**36**	**18**	**66**

The topics of lectures, which are formed in accordance with the topics considered within the framework of the academic discipline, are listed in Table 2.

Table 2

Lecture classes

№	The name of the topic of the lecture and a list of main questions (a list of didactic tools, references to the literature and tasks on the IW)
1	**Basic provisions of the theory of probabilities** Basic concepts of probability theory. Classical, geometric and statistical methods of determining probability. Basic axioms of probability theory. **Tasks on IW.** Choice combinatorics and partition combinatorics. (Lecture 1 and presentation on site http://amodm.pp.ua) Literature. Kallenberg O. Foundation of Modern Probability. – 2021. – 327 p.
2	**Basic formulas for determining event probabilities** Formula of full probability, features of its application in practice. A posteriori probability and its definition using the Bayes formula. **Tasks on IW.** The use of the Bayes formula in computer technology to diagnose the condition of hardware nodes and program components**.** (Lecture 2 and presentation on site http://amodm.pp.ua) Literature. Kallenberg O. Foundation of Modern Probability. – 2021. – 327 p.
3	**Model of word tests.** Bernoulli's formula, features of its application, formulas of approximate calculations. Poisson's formula. Analysis of heterogeneous test sequences. **Tasks on IW.** Use of approximations for calculation according to Poisson's formula. Algorithms for efficient calculation of combinatorial expressions**.** (Lecture 3 and presentation on site http://amodm.pp.ua)

№	The name of the topic of the lecture and a list of main questions (a list of didactic tools, references to the literature and tasks on the IW)
	Literature. Kallenberg O. Foundation of Modern Probability. – 2021. – 327 p.
4	**Discrete random variables.** Concept of discrete and continuous random variables. The concept of distribution laws, the main numerical characteristics of random variables. Binomial distribution**.** **Tasks on IW.** Modeling of discrete random variables in computer systems. (Lecture 4 and presentation on site http://amodm.pp.ua) Literature. Klenke A. Probability Theory.-2020. – 405 p.
5	**Continuous random variables** Continuous random variables. Distribution density, integral distribution function. Numerical characteristics of continuous random variables. Uniform distribution law. **Tasks on IW.** Exponential law of distribution, its application for reliability assessment of computer system components. (Lecture 5 and presentation on site http://amodm.pp.ua) Literature. Meyer M.C. Probability and Mathematical Statistics. – 2019. – 276 p.
6	**Central bounder theorem** Normal distribution law, calculation of probabilities using Laplace functions, determination of distribution parameters according to a given probability. Central bounder theorem. **Tasks on IW.** Peculiarities of determining the mean square deviation of the sum for discrete and continuous values. Error when using the central limit theorem**.** (Lecture 6 and presentation on site http://amodm.pp.ua) Literature. Klenke A. Probability Theory.-2020. – 405 p.
7	**The Moivre-Laplace theorem** and its application for calculating probabilities in the binomial distribution. **Tasks on IW.** Estimation of the error when applying Moivre-Laplace theory. Using the central limit theorem to ensure the specified measurement accuracy**.** (Lecture 7 and presentation on site http://amodm.pp.ua) Literature. Klenke A. Probability Theory.-2020. – 405 p.
8	**Systems of random variables** Systems of random variables. Dependent and independent random variables. Covariance and correlation are characteristics of the measure of dependence of quantities. Methodology for calculating probabilities for dependent random variables. **Tasks on IW.** Methodology for calculating probabilities for systems of independent and dependent random variables distributed according to the normal law. (Lecture 8 and presentation on site http://amodm.pp.ua) Literature. Lana R.G., Rohatgi V.K. Probability Theory.- 2020. – 388 p.
9	**Functions of random variables** Definition of the distribution law of the function of random variables. Distribution of sum, difference and product of random variables. **Tasks on SRS.** Distribution of the sum of discrete random variables and determination of the characteristics of the distribution of the sum**.** (Lecture 9 and presentation on site http://amodm.pp.ua) Literature. Klenke A. Probability Theory.-2020. – 405 p.
10	**Methods of constructing mathematical models of random variables.** Assessment of the reliability of hypotheses regarding the distribution law of a random variable.

№	The name of the topic of the lecture and a list of main questions (a list of didactic tools, references to the literature and tasks on the IW)
	Kolmogorov, Wilcoxon and Neumann-Pearson methods. Methodology for assessing the reliability of the hypothesis regarding the homogeneity of two samples. **Tasks on IW.** Use of hypothesis testing techniques to assess the state of hardware of computer systems and detect virus programs**.** (Lecture 10 and presentation on site http://amodm.pp.ua) Literature. Lana R.G., Rohatgi V.K. Probability Theory.- 2020. – 388 p.
11	**Correlation and regression analysis.** Linear and non-linear regression. method of reproducing linear regression dependence for many variables. Estimation of regression error **Tasks on IW.** Algorithms for building regression prognostic models and their use in information technologies**.** (Lecture 11 and presentation on site http://amodm.pp.ua) Literature. Dudley R.M. Real Analysis and Probability.-2017.- 387 p.
12	**Statistical methods of decision-making** Decision-making methods under conditions of uncertainty. Decision-making errors of the first and second kind. **Tasks on IW.** The use of statistical decision-making theory in software diagnostic tasks and to detect hacker attacks. (Lecture 12 and presentation on site http://amodm.pp.ua) Literature. Dudley R.M. Real Analysis and Probability.-2017.- 387 p.
13	**Statistical methods of decision-making.** Decision-making according to the criteria of the margin of error and the Neiman-Pearson method. Comparative analysis of methods and their selection for application. **Tasks on SRS.** Using the theory of statistical decision-making in pattern recognition tasks**.** (Lecture 13 and presentation on site http://amodm.pp.ua) Literature. Dudley R.M. Real Analysis and Probability.-2017.- 387 p.
14	**Basic provisions of the theory of streams of random events** Basic characteristics and classification of random processes. Flows of events, their types, characteristics and methods of their determination. Poisson flows, methods of their calculations, methods of computer modeling and application in programs. **Tasks on IW.** Methodology for calculating probabilistic characteristics for Poisson flow and Erlang flow. (Lecture 14 and presentation on site http://amodm.pp.ua) Literature. Papoulis A. Probability, random variables and stochastic processes.
15	**Discrete random Markov processes.** Determination of the characteristics of the transition process and the method of calculating stationary probabilities. Non-ergodic Markov processes and methods of determining their characteristics. Application of the apparatus of Markov processes for the analysis of computing processes. **Tasks on IW.** Methodology for determining the characteristics of Markov processes using equivalent systems of linear equations and Kolmogorov-Chapman procedures**.** (Lecture 15 and presentation on site http://amodm.pp.ua) Literature. Papoulis A. Probability, random variables and stochastic processes.
16	**Continuous random Markov processes.** Determination of transition process functions of continuous Markov processes and stationary probabilities. The use of Markov processes as a

№	The name of the topic of the lecture and a list of main questions (a list of didactic tools, references to the literature and tasks on the IW)
	mathematical model of software reliability**.** **Tasks on IW.** Methodology for determining the characteristics of continuous Markov processes using equivalent systems of linear differential equations**.** (Lecture 16 and presentation on site http://amodm.pp.ua) Literature. Papoulis A. Probability, random variables and stochastic processes.
17	**Elements of mass service theory.** Formulas for determining the main characteristics: the average length of the queue, the delay time in the system and their variances. Mass service systems with an arbitrary distribution of service time. Systems of mass service with priorities. **Tasks on IW.** Methodology for calculating the average length of the queue and the time spent in the system for the MM1 type LS. (Lecture 17 and presentation on site http://amodm.pp.ua) Literature. Papoulis A. Probability, random variables and stochastic processes.
18	**Basic concepts of information theory.** Determination of the amount of information and entropy. Optimization of data coding from the standpoint of information theory. **Tasks on IW.** Algorithms and methods of data archiving and compression in computer systems. (Lecture 18 and presentation on site http://amodm.pp.ua) Literature. Papoulis A. Probability, random variables and stochastic processes.

Independent work of student

The student's independent work consists of a theoretical and a practical component. The theoretical component involves the study of additional material that deepens the knowledge obtained at the lecture. The material that needs to be further studied and the literary sources for studying this material are listed in Table 3. The practical component of the student's independent work consists in performing laboratory work, the list of which is given in Table 3.

The purpose of conducting a cycle of practical classes is for students to acquire the necessary practical skills in the use of methods of probability theory and the development of effective algorithms for their implementation in solving problems.

Table 3

List of practical classes

№	Topic of practical lesson	Number of hours
1	Classical definition of probability. Using combinatorics to determine the number of options. Geometric definition of the probability of random events.	2
2	Formula of full probability, features of its application in practice. A posteriori probability and its definition using the Bayes formula. Model of post-tests, Bernoulli's formula, features of its application, formulas of approximate calculations. Poisson's formula.	2
3	Normal distribution law, calculation of probabilities using Laplace functions, determination of distribution parameters according to a given probability. Central limit theorem.	2
4	Systems of random variables. Dependent and independent random variables. Covariance and correlation are characteristics of the measure of dependence of	2

	quantities. Methodology for calculating probabilities for dependent random variables.	
5	Correlation and regression analysis. Methodology for building linear and non-linear prognostic models	2
6	Decision-making methods under conditions of uncertainty. Decision-making errors of the first and second kind. Decision-making according to the criteria of the margin of error and the Neuman-Pearson method.	2
7	Methods of analysis and calculation of streams of Poisson random events. Central limit theorem for streams.	2
8	Formulas for determining the main characteristics: average queue length, delay time in the system and their variances. Mass service systems with an arbitrary distribution of service time Mass service systems with priorities.	2
9	Definition of information entropy and amount of information. The method of optimal coding. Principles of operation of archiver programs.	2

Policy and control

Policy of academic discipline (educational component)

During classes in the academic discipline "Probabilities Theory", students must adhere to certain disciplinary rules:

• it is forbidden to be late for classes;

• at the entrance of the teacher, as a sign of greeting, persons studying at "KPI Igor Sikorsky", must stand up;

• extraneous conversations or other noise that interferes with classes are not allowed;

• leaving the classroom during the lesson is allowed only with the teacher's permission;

• the use of mobile phones and other technical means is not allowed without the teacher's permission.

In the course of training, the teacher has the right to award up to 5 incentive points for solving problems on the spot, for a demonstrated creative approach when completing an individual task, or for actively participating in the discussion of issues related to the topic of a lecture or practical session.

Students must adhere to the rules of academic integrity when conducting control measures and when completing tasks in practical classes.

Types of control and rating system for evaluating learning outcomes (ELO)

Types of control from the academic discipline "Probability Theory" include:

Practical training.

The topics of practical classes are coordinated in time and content with the topics of lectures. Solving problems in practical classes allows you to acquire practical skills in applying the methods of probability theory and mathematical statistics, as well as to master modern algorithms programming technologies that are built on the basis of these methods.

Current control:

It is planned to involve students to perform practical tasks during practical classes. Control over the performance of practical tasks is carried out by the teacher with the setting of points that depend on the difficulty of the task. Informing students about the level of difficulty of the task is carried out before involving students in its implementation.

Semester control

The semester closed test consists of two attestation tests by sections of the academic discipline. The first certification test on the topics of Chapter 1 contains three problems and lasts 45 minutes.

The second certification test on the topics of Chapter 2 contains two tasks and lasts 30 minutes.

Final Test conducted in the form of an interview with the student to objectively determine the level of knowledge, skills and practical skills acquired during the semester

Since the credit module has a semester certification in the form of credit, the rating evaluation system is built according to the ELO type - 1. The rating of the student from the credit module consists of the points he receives for the types of work according to table 4.

Table 4

Assessment of individual types of student's academic work

Chapter 1		Chapter 2	
Kind educational work	Maximal number of ball	Kind educational work	Maximal number of ball
Solving tasks during practical classes	40	Solving tasks during practical classes	30
Certification test №1	15	Certification test №2	15
Total by chapter 1	55	*Total by chapter 2*	45
Total by semester			**100**

The student's individual semester rating (RD) from the credit module consists of the points he receives for:

1) Solving problems during practical classes.

2) Attestation control test No. 1.

3) Attestation control test No. 2.

Calculation of the scale size (R) of the rating:

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

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

$R = \sum_k r_k$, where r_k maximal rating ball each of the control measures (controls, solving problems in practical classes).

The size of the rating scale from the credit module is:

R = 55 + 45 = 100 balls.

If a student misses classes without a valid reason, fines are charged in the form of 1 point from the total number of points for 1 hour of absence (but not more than 0.1 R).

The student's individual semester rating (final semester rating grade RD) is the sum of points received by the student during the semester by participating in the prescribed control measures (control and laboratory works).

Students who have fulfilled all the conditions for admission to the semester certification of the credit module and have a rating of at least 60 points, receive a corresponding positive rating without additional tests.

Students who scored a credit module rating of less than 60 points during the semester are required to pass an oral assessment in the form of an interview with the teacher.

A necessary condition for a student's admission to credit is his individual semester rating (RD) of not less than 30% of R, i.e. 30 points, 4 laboratory tests passed and one positive certification in the semester. If at least one of the mentioned conditions is not fulfilled, the student will not be admitted to the credit.

The sum of the final semester (RD) and credit rating grades in points constitutes the final semester rating grade, which is converted into grades according to the national scale and the ECTS scale (Table 5).

Table 5

Correspondence of rating balls to grades on the university scale

Numbers of balls	*Rating*
100-95	Perfectly
94-85	Very good
84-75	Good
74-65	Satisfactorily
64-60	Enough
Less than 60	Unsatisfactorily
Admission conditions not met	Not allowed

Additional information on the discipline (educational component)

Teaching the discipline "Probabilities Theory" for the specialty "Software Engineering" has its own specificity, which is related to the fact that the development and operation of computer equipment requires a detailed acquaintance with complex systems. The key elements of these systems are subject to description and analysis using methods of probability theory. Basic concepts of probability theory, mathematical statistics, theory of random processes should be presented taking into account the specifics of special disciplines to facilitate their successful assimilation in further education.

The goal of revitalizing the educational process is to encourage students to engage in educational and cognitive work and independent work. When teaching educational material, the use of such technologies as problem-based lectures, mini-lectures, and brainstorming is envisaged.

Problem-based lectures are aimed at the development of logical thinking, the involvement of students in independently solving the relevant problem both in the discipline "Probabilities Theory " and in other disciplines related to preparation for specialties.

Mini-lectures involve the teaching of educational material in a short period of time and are characterized by a significant capacity of targeted information. A more detailed study of the proposed material is left for independent processing.

Working program of the academic discipline (Syllabus):

Developed by PhD, Ass. prof. Olelsander Markovskyi

Approved: Department of Computer Engineering (protocol № 10 25.05.2022 p.)

Agreed: methodological comity of FICT (protocol № 10 09.06.2022 p.)