МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ ЕКОНОМІЧНИЙ УНІВЕРСИТЕТ
ІМЕНІ СЕМЕНА КУЗНЕЦЯ

ЗАТВЕРДЖЕНО
на засіданні кафедри
вищої математики та економіко-
математичних методів
Протокол № 1 від 21.08.2023 р.

ПОГОДЖЕНО
Проректор з навчально-методичної роботи
_____ Каріна НЕМАШКАЛО

ТЕОРІЯ ЙМОВІРНОСТЕЙ ТА МАТЕМАТИЧНА СТАТИСТИКА
робоча програма навчальної дисципліни (РПНД)

Галузь знань	**07 «Управління та адміністрування»**
Спеціальність	**073 «Менеджмент»**
Освітній рівень	**перший (бакалаврський)**
Освітня програма	**«Логістика»**

Статус дисципліни	**обов'язкова**
Мова викладання, навчання та оцінювання	**англійська**

Розробник:
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Завідувач кафедри
вищої математики та
економіко-математичних методів Людмила МАЛЯРЕЦЬ

Гарант програми Тетяна КОЛОДІЗЄВА

Харків
2023

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
SIMON KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS

APPROVED
at the meeting of higher mathematics and economic mathematical methods
Protocol № 1 of 21.08.2023

AGREED
Vice-rector for educational and methodical work
Karina NEMASHKALO

Probability Theory and Mathematical Statistics

Program of the course

Field of knowledge	**07 Management and administration**
Specialty	**073 Management**
Study cycle	**first (bachelor)**
Study programme	**Logistics**

Course status	**mandatory**
Language	**English**

Developers:
PhD (Technics),
Associate Professor _____ Ievgeniia MISIURA

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Kharkiv
2023

INTRODUCTION

Probability theory and mathematical statistics are used in various fields of science and technology, but one of the most important areas of their use is economics. Without the help of probability theory, the issues of organization and planning, which are related to the need to take into account random events, cannot be solved, and the study of certain phenomena by mathematical statistics makes it possible to solve many questions posed by science and practice (correct organization of the technological process, the most appropriate planning and others).

The main purpose of teaching is forming future specialists' basic mathematical knowledge for solving theoretical and practical problems in professional activity of competent specialists in a service sphere, skills of analytical thinking and skills of using mathematical knowledge for formation of real processes and developments, and for solving economic problems.

The main tasks that should be solved in the process of teaching the discipline are: giving students knowledge of the basic parts of probability probability and mathematical statistics; definitions, theorems, rules; proving of the main theorems; mastering the fundamentals of a methodology of a mathematical investigation of the applied economic problems; independent broadening of knowledge, development of logical and algorithmic thinking; the obtainment of primary skills for independent-learning of mathematical and applied Bibliography by students.

The subject of the discipline "Probability probability and mathematical statistics" is the fundamentals of probability theory and mathematical statistics.

The object of study of the discipline is a system of mass phenomena, trials and experiments, the results of which are certain random events, as well as the study of the results of these phenomena.

A modern tendency in higher education is a reorientation of students of higher educational institutions from a process of education to a result, from knowledge to skills, forming definite competences.

The learning outcomes and competencies formed by the course are defined in Table 1.

Table 1

Learning outcomes and competencies formed by the course

Competencies	Learning outcomes
GC4	LO4
SC2, GC8	LO6
SC2	LO7
SC2	LO8
GC3, GC9	LO16

where GC3. An ability to abstract thinking, analysis and synthesis.
GC4. An ability to apply knowledge in practical situations.
GC8. Skills in the use of information and communication technologies.
GC9. An ability to learn and master modern knowledge.

SC2. An ability to analyze results of an activity of an organization, compare them with the factors of an influence of an external and an internal environment.
LO4. Demonstrate skills in defining problems and a justification of management decisions.
LO6. Demonstrate skills of a search, a collection and an analysis of information, a calculation of indicators to justify management decisions.
LO7. Demonstrate skills of organizational design.
LO8. Apply the methods for management to ensure efficiency activities of the organization.
LO16. Demonstrate skills of an independent work, a flexible thinking, an openness to new knowledge, be critical and self-critical

COURSE CONTENT

Content module 1: Probability Theory.

Topic 1. Empirical and logical foundations of probability theory. Basic theorems of probability theory, their economic interpretation.

1.1. The subject and problems of this course.

The role of this course as a theoretical base of a mathematical modeling of economic processes and phenomenons, which take into consideration of possible risks.

1.2. Basic definitions, rules and types of events

A probabilistic model of an experiment. Sure (certain), random and impossible events. Rules of operations with random events. A space of elementary events.

1.3. Basic concepts and formulas

A classical definition of a probability and its calculation. Basic formulas of combinatorics. A statistical definition of a probability. Axiomatics of Kolmogorov. A geometrical definition of a probability. Venn-Euler diagram.

1.4. Basic definitions and multiplication theorems of probabilities

Probabilistic space. Dependent and independent events. A conditional probability. Multiplication theorems of probabilities.

1.5. Basic concepts and addition theorems of probabilities

A complete group of events. Complementary events. Joint (compatible) and disjoint (incompatible) events. Addition theorems of probabilities.

1.6. The probability of at least one event

The probability of at least one event. The probability that an event will occur at least once. Calculation of a necessary number of trials, which occur with a definite reliability in order to guarantee an occurrence of a random event at least once.

1.7. Formula of a total probability and Bayes formula

Formula of a total probability. Bayes formula (the theorem of hypothesis).

Topic 2. Scheme of independent tests.

2.1. Repeated independent trials and Bernoulli's scheme

A scheme of repeated independent trials. Bernoulli's formulas.

2.2. Local theorem of Moivre – Laplace

Local theorem of Moivre – Laplace. Gauss's function, its properties, an application to approximate calculations of a probability of an occurrence of a random event of a definite number times in series of independent trials.

2.3. Integral theorem of Moivre – Laplace

Integral theorem of Moivre – Laplace. Laplace's function, its properties and an application to approximate calculations of a probability that values of a random variable lies in a definite interval. A relationship between Gauss and Laplace functions.

2.4. Poisson's theorem

Low-probability events. Poisson's theorem.

Topic 3. Distribution laws and numerical characteristics of a discrete random variable.

3.1. Definition of a discrete random variable and a distribution function of probabilities

A definition of a discrete random variable. A distribution function of probabilities, its properties.

3.2. Basic and additional numerical characteristics

Basic numerical characteristics of a random variable: a mathematical expectation, a variance and a root-mean-square deviation. Properties of basic numerical characteristics. Additional numerical characteristics of a distribution: a mode, a median, an excess. Initial and central theoretical moments, their application to a calculation of numerical characteristics of a distribution of a random variable.

3.3. Basic types and properties of distribution laws of a discrete random variable

Distribution laws of probabilities for a random variable and ways of finding (tabular, graphic and analytical). Distribution laws of a discrete random variable, which are often used in social and economic investigations: a binomial distribution, a geometrical distribution, a hypergeometrical distribution. Specificities and properties of these distributions, their basic numerical characteristics and the economic meaning.

Topic 4. Distribution laws and numerical characteristics of a continuous random variable.

4.1. Definition of a continuous random variable

A definition of a continuous random variable.

4.2. A density distribution function and its properties

A density of a distribution and its probable meaning. A density distribution function of a random variable and its properties.

4.3. Basic types and properties of distribution laws of a continuous

random variable

Distribution laws of a continuous random variable, which are often used in social and economic investigations: a uniform distribution, a normal distribution and an exponential distribution. Properties of these distributions and their basic numerical characteristics. An influence of parameters of a distribution on a density function of probabilities at a normal distribution law.

Content module 2: Mathematical Statistics

Topic 5. Primary processing of statistical data. Statistical estimations of parameters of a distribution.

5.1. Basic definitions and problems of mathematical statistics

Basic problems of mathematical statistics. A sampling method. Definitions of a population and its sample.

5.2. Discrete and interval statistical series

An empirical distribution law. Ways of a presentation of sampling totalities and a representation of results of observations. Discrete and interval statistical series, rules of its construction. A defining limits of an interval by Sturges's formula.

5.3. A graphical presentation of a statistical distribution

A graphical presentation of a statistical distribution. A polygon and a histogram.

5.4. Basic numerical characteristics

Basic sampling numerical characteristics and their asymptotic behavior.

5.5. Basic statistical estimations and their properties

Statistical estimations of parameters of a distribution of a population and their properties: an unbiasedness, possibility and an efficiency. An asymptotic efficiency of maximally plausible estimations.

5.6. Types of estimations

The method of moments. Point and interval estimations. An confidence interval for a mathematical expectation of a normal population.

Topic 6. Testing statistical hypotheses

6.1. Types of statistical hypothesis and kinds of errors

Main and alternative statistical hypothesis. A statistical test. A construction of critical domains for a statistical test. Errors of the first and the second kinds. A concept of power of a test.

6.2. Different types of tests for checking of a statistical hypothesis

A checking of a statistical hypothesis about a defining of a distribution law for a population using results of an investigation of a sample. Pearson and Kolmogorov fitting tests. The fitting test relative to a frequency. A checking of a statistical hypothesis about an equality of two population means at an assumption of a normal distribution law. Student's fitting test. A comparison of variances. Fisher-Snedeker fitting test. A checking of a hypothesis about an equality of a sampling mean and a mathematical expectation.

Topic 7. Elements of correlation theory. Elements of regression theory

7.1. Basic definitions and problems of correlation analysis

Problems of correlation analysis.

7.2. Basic coefficients and their properties

A sampling coefficient of a correlation, its properties and a confidence interval. A coefficient of determination. A correlation ratio, its properties.

7.3. Basic concepts of regression analysis and LSM

Problems of regression analysis. A correlation dependence. A correlation table. Empirical lines of a regression. An estimation of parameters of a pair regression equation using the least-squares method (LSM). Point estimations.

7.4. A significance and a confidence interval of a pair regression line

A checking of a significance of parameters of a pair regression equation. A confidence interval for a line of a pair regression.

Topic 8. Elements of variance analysis

8.1. Basic definitions and problems of variance analysis

Problems of variance analysis. The role of variance analysis in economic investigations.

8.2. Single-factor variance analysis

Single-factor analysis as a procedure of a checking of hypotheses about a lack of a factor influence on a feature, which is investigated.

A general, an external and intrinsically group variances.

8.3. Multidimensional variance analysis

A concept of multidimensional variance analysis.

The list of practical (seminar) studies in the course is given in Table 2.

Table 2

The list of practical (seminar) studies

Name of the topic and/or task	Content
Topic 1 Task 1	Solving problems using a classical definition of a probability of random events and elements of combinatorics. A calculation of a conditional probability, using the theorems of a multiplication and an addition of probabilities. Formula of a total probability and Bayes' formula.
Topic 2 Task 2	Solving problems using Bernoulli's formulas. A calculation of the most probable number of occurrences of a random event. An application of asymptotic theorems of Moivre – Laplace and Poisson.
Topic 3 Task 3	A calculation of basic numerical characteristics of a discrete random variable using definitions. A calculation of additional characteristics of a discrete random variable using definitions.
Topic 4 Task 4	Solving problems with random variables, which are distributed by a normal law. Solving problems with random variables, which are distributed by a uniform law. Solving of problems with random

	variables, which are distributed by an exponential law
Topic 5 Task 5	A construction of a statistical series, a polygon and a histogram. A calculation of basic numerical characteristics of an empirical distribution. Finding Point and interval estimations. A construction of an confidence interval for a mathematical expectation of a normal population
Topic 6 Task 6	A checking of a statistical hypothesis about a definition of a distribution law in a population using results of an investigation of a sample according to Pearson's fitting test. According to Student's test check a statistical hypothesis about an equality of two population means at an assumption of a normal distribution law and variances
Topic 7 Task 7	A calculation of a sample correlation coefficient. A construction of a confidence interval of a sample correlation coefficient. A definition of the accuracy of an estimation. A checking of the significance of parameters of an equation of a pair regression. A construction of a confidence interval for a pair regression line. An investigation of the simplest cases of nonlinear regression
Topic 8 Task 8	Using single-factor analysis for checking of a hypothesis of a lack of a factor influence on a feature which is investigated.

The list of laboratory studies in the course is given in Table 3.

Table 3

List of laboratory studies

Name of the topic and/or task	Content
Topic 1	Learning software MS Excel. Learning built-in functions of MS Excel. Using built-in functions of MS Excel for a calculation of a probability of a random event with the help of theorems of a multiplication and an addition of probabilities. Using formula of a total probability (a priori probability) and Bayes formula (a posteriori probability)
Topic 2	A construction of a binomial law and Poisson binomial law of a distribution for the definite values p and n.
Topic 3	A calculation of basic and additional numerical characteristics of a discrete random variable according to a definition and with the help of built-in functions of MS Excel. Calculation of the basic numerical characteristics of a distribution. Investigation of an influence of factors p and n on a form of a polygon of a distribution.
Topic 4	A calculation of basic and additional numerical characteristics of a continuous random variable according to a definition and with the help of built-in functions of MS Excel.
Topic 5	A construction of a statistical interval series, a representation of it with the help of a histogram and a polygon. According to a set sample carry out an estimation of the basic numerical characteristics of a distribution of random variables. Define point and interval (the confidence intervals) estimations of the basic numerical characteristics of a distribution with the help of built-in functions of MS Excel

Topic 6	According to a criterion to check a hypothesis of distribution law of a population by examples of uniform, exponential and normal laws of a distribution. Plot a histogram of relative frequencies and cumulative curve with the help of built-in functions of MS Excel.
Topic 7	A calculation of basic numerical characteristics of a distribution of two-dimensional random variables according to a definition and with the help of built-in functions. A construction of an empirical equation of a regression equation with the help of built-in functions and superstructures of MS Excel.
Topic 8	A construction of a confidence interval of a regression line with the help of built-in functions of MS Excel. Using of variance analysis in order to check a significance of a correlation between two random variables

The list of self-studies in the course is given in Table 4.

Table 4

List of self-studies

Name of the topic and/or task	Content
Topic 1-8	Search, selection and review of literature on a given topic
Topic 1-8	Preparation for practical classes
Topic 1-8	Preparation for laboratory classes
Topic 1-8	Performing a creative task
Topic 1-8	Preparing for the final exam

The number of hours of lectures, practical (seminar) and laboratory studies and hours of self-study is given in the technological card of the course.

TEACHING METHODS

In the process of teaching the course, in order to acquire certain learning outcomes, to activate the educational process, it is envisaged to use such teaching methods as:

Verbal (problem lectures (Topic 2, Topic 4, Topic 5, Topic 7–8), lecture-discussion (Topic 1–8), brainstorming (Topic 1, Topic 5, Topic 7).

Visual (demonstration (Topic 1–8)).

Practical (individual research work (Topic 1–8)).

FORMS AND METHODS OF ASSESSMENT

The University uses a 100-point cumulative system for assessing the learning outcomes of students.

Current control is carried out during lectures, practical, laboratory and seminar classes and is aimed at checking the level of readiness of the student to perform a specific job and is evaluated by the amount of points scored:

− for courses with a form of semester control as an exam: maximum amount is

60 points; minimum amount required is 35 points.

The final control includes current control and an exam.

Semester control is carried out in the form of a semester exam or grading.

The final grade in the course is determined:

− for disciplines with a form of exam, the final grade is the amount of all points received during the current control and the exam grade.

During the teaching of the course, the following control measures are used:

Current control: colloquiums (estimated at 6 points (two colloquiums during the semester – the total maximum number of points – 12)); written tests (maximum score – 6 points (two written tests during the semester, total maximum number of points – 12)); homework (maximum score – 2 points (seven homework during the semester, total maximum number of points – 14 points)); laboratory work (maximum score – 2 points (eight laboratory work during the semester, total maximum number of points – 16 points)); an independent creative task (maximum score – 6 points).

Semester control: Grading including Exam (40 points).

More detailed information on the assessment system is provided in technological card of the course.

An example of an exam card and assessment criteria.

An example of examination paper

SEMEN KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS

Study cycle: first (bachelor)

Term 2

Educational discipline: "Probability theory and mathematical statistics"

Examination paper (EXAMPLE)

Task 1 (7 points). The probability of successful solving a Math test by the first student is 0.9, by the second student is 0.6, by the third student is 0.8. What is the probability of solving this test by: a) one student only; b) only the third student; c) all of the students; d) at least one of students?

Task 2 (7 points). The pizza delivery department receives 75% brand pizza orders. Find the probability that among 100 received orders there will be (a) 72 brand pizza orders; (b) from 70 to 78 brand pizza orders. (c) Find the most probable number of brand pizza orders.

Task 3 (8 points). The integral function of X is given:

$$F(x)=\begin{cases}0, & x\le 2\\ \frac{1}{16}\left(x^2-4x+4\right), & 2<x\le 6\\ 1, & x>6\end{cases}$$

Calculate: a) the density function $f(x)$; b) the mathematical expectation $M(X)$ and the variance; c) the probability P(4<X<7).

Task 4 (8 points). The continuous statistical series is given in the table:

$[x_i, x_{i+1})$	13 - 15	15 - 17	17 - 19	19 - 21	21 - 23
m_i	8	10	23	6	3

a) Find the mean, the variance and the root-mean-square deviation for this sample. b) Plot the histogram and make the assumption about the distribution law. c) Find the confidence interval for the population mean with the probability 0,95. d) Make an analysis of the obtained values.

Task 5 (10 points). Data: $\sum x = 1432,\ \sum y = 1714,\ \sum y^2 = 29553,\ n = 100.$

$\sum xy = 24816,\ \sum x^2 = 21756,$

a) Construct a pair linear equation of a regression: $\hat{y}_x = b_0 + b_1 x$ and make an analysis of coefficients. b) Calculate a correlation coefficient *r*, a determination coefficient R^2 and explain obtained results. c) Verify a hypothesis about a statistical significance of a regression equation at the significance level α =0,01.

It was approved at the meeting of the department of higher mathematics and economic mathematical methods
Protocol № _ from ___, 20___

The head of the department L. Malyarets

The lecturer Ie. Misiura

An assessment criteria

Each examination paper contains 5 practical tasks, including two first-level (diagnostic) tasks, two second level (situational) tasks and one third level (diagnostic and heuristic) task.

The structure of the examination paper is given in Table 5.

Table 5

The structure of the examination paper

Task level	The content of tasks after the themes
First	Task 1. A classical definition of a probability and its calculation. Basic formulas of combinatorics. Venn-Euler diagram. Addition theorems of probabilities. Dependent and independent events. A conditional probability. Joint (compatible) and disjoint (incompatible) events. Multiplication theorems of probabilities. A complete group of events. Complementary events. The probability of at least one event. The probability that an event will occur at least one. Formula of a total probability. Bayes formula (the theorem of hypothesis).

	Task 2. A scheme of Repeated independent trials. Bernoulli's formulas. Local theorem of Moivre–Laplace. Integral theorem of Moivre–Laplace. Puasson's theorem.
Second	Task 3. Discrete and continuous random variables. Distribution laws of probabilities for a random variable. A distribution function of probabilities. Basic numerical characteristics of a random variable: a mathematical expectation, a variance and a root-mean-square deviation. Distribution laws of a discrete random variable, which are used often social and economic phenomena: a binomial distribution, a geometrical distribution, a hypergeometric distribution. Task 4. Distribution laws of a continuous random variable, which are used often social and economic phenomena: a uniform distribution, a normal distribution and an exponential distribution. Discrete and interval statistical series. A polygon and a histogram. Basic sampling numerical characteristics. Point and interval estimations. An confidence interval for a mathematical expectation of a normal population. A checking of a statistical hypothesis about defining of a distribution law for a population using results of an investigation of a sample.
Third	Task 5. A sampling coefficient of a correlation. A coefficient of determination. A correlation ratio. A correlation dependence. A correlation table. Empirical lines of a regression. An estimation of parameters of a pair regression equation using the least-squares method. Point estimations. A checking of a significance of parameters of a pair regression equation. A confidence interval for a line of a pair regression.

The task of the first level is assessed as follows (7 points):

7 points, in the case of the exact use of the scientific terminology and symbols in the necessary logical sequence; a creative approach to solving original problems which require a high level of knowledge;

6 points, in the case of the exact use of the mathematical terminology and symbols; irreproachable mastery of mathematical instruments; correct use of mathematical methods, facts, formulas and relations for solving the task of the third level;

5 points, if a logically right sequence of steps of solution has been made. All the key moments of the solution have been grounded. 1–2 slight mistakes or slips are possible in the calculations which don't influence the correctness of the further solution;

4 points, if mastery of a small part of obligatory skills and attainments which are intended for the syllabus of the academic discipline has been demonstrated; in solving the tasks, the conclusions, reproduction of the syllabus material of the discipline has not been always shown;

3 points, if the task has been solved only partially with initial right considerations, but there are mistakes, which considerably influenced the process of the right solution of the task;

2 points, if the task fulfillment has been begun, there are separate correct

considerations, but a logical mistake has been made, which resulted in an incorrect solution;

1 point, if the condition has been written;

0 point, if no task has been fulfilled.

The task of the second level is assessed as follows (8 points):

8 points, if solving the assigned tasks is characterized by a creative use of the theoretical instrument, logical correctness, precision, explanation of conclusions, rationality or using original approaches to solving the tasks;

7 points, if perfect mastery of the skill in the use of mathematical instruments application of information from the other educational courses and discipline has been demonstrated; one slight mistake has been made; a high level of standards of carrying out the tasks;

6 points, if a logically right sequence of steps of solution has been chosen. All the key points of solution have been grounded. 1–2 slight mistakes or slips are possible in the calculations, which don't influence the correctness of the further solution;

5 points, in the case of correct using the terminology of the discipline and the basic methods for solving standard problems; showing the ability to use theoretical knowledge for solving standard (multistep) tasks, availability of some mistakes or deficiencies on the calculating stage of presentation of the solution, the ability to conclude;

4 points, in the case of more than one mistake and one or two deficiencies in the calculations, the graphs, the choice of the method of solution, which have caused a wrong final result in the individual cases;

3 points, if task fulfillment has been begun, there are separate correct considerations, but a logical mistake has been made, which resulted in an incorrect solution;

2 points, if numerical gross mistakes have been made in the process of using the concepts of the discipline in the formulas which prove the absence of a minimally necessary part of the compulsory skills and the practical attainments provided for the discipline syllabus;

1 point, if no task fulfillment has been begun, but the condition has been written;

0 point, if no task fulfillment has been begun.

The task of the third level is assessed as follows (10 points):

10 points, if the ability for scientific investigative developments on the problems of the discipline has been shown; perfect skills in the use of mathematical instruments using modern scientific theoretical approaches; a high level of standards of carrying out tasks has been demonstrated;

9 points, in the case of using scientific terminology and symbols in the necessary logical sequence; solving the assigned tasks is characterized by precision,

explanation, a creative approach, rationality of the choice of method of solution, correct necessary calculations and transformations;

8 points, if systematic, deep and full knowledge of all the parts of the academic discipline and the basic questions which go beyond the discipline has been shown; a high level of standards of carrying out the tasks has been demonstrated;

7 points, in the case of solitary slight deficiencies which don't influence the final result; correct use of mathematical methods, facts, formulas and relations for solving the task of different level of complexity;

6 points, if the ability to conclude and compare the theoretical and practical material has been demonstrated; correct (but not always rational) use of mathematical methods of solution, facts, formulas and relations has been shown;

5 points, if half of the tasks have been done, the interpretation of the obtained results is absent; level of standards of carrying out tasks is acceptable;

4 points, if the tasks have been carried out without any logical relationship of the mathematical concepts and practical solutions have not been given sufficient theoretical explanation;

3 points, if acceptable volume of knowledge has been shown within the educational standard; the use of mathematical symbols and terminology has been insufficient and in exact, the knowledge of the basic formulas and concepts on the discipline has not been demonstrated;

2 points, in the case of solving tasks with the theoretical material used only on the level of concepts; the inability to understand the connection of the theoretical material with the practical tasks;

1 point, if the condition has been written;

0 point, if no task fulfillment has been begun.

RECOMMENDED LITERATURE

Main

1. Железнякова Е. Ю. Теорія ймовірностей та математична статистика : практикум [Електронний ресурс] / Е. Ю. Железнякова, Л. О. Норік ; Харківський національний економічний університет ім. С. Кузнеця. – Електрон. текстові дан. (9,34 МБ). - Харків : ХНЕУ ім. С. Кузнеця, 2019. – 320 с. Режим доступу : http://repository.hneu.edu.ua/handle/123456789/21436

2. Теорія ймовірностей та математична статистика : мультимедійні методичні рекомендації до самостійної роботи з теми «Схема незалежних випробувань. Закони розподілу та числові характеристики дискретної випадкової величини» / Уклад. Е. Ю. Железнякова, І. Л. Лебедєва, С. С. Лебедєв – Мультимедійне інтерактивне електрон. вид. комбінованого використ. (62 Мб). – Харків: ХНЕУ ім. С. Кузнеця, 2020. - https://pns.hneu.edu.ua/course/view.php?id=5289

3. Теорія ймовірностей та математична статистика : методичні рекомендації до самостійної роботи з теми «Емпіричні та логічні основи теорії ймовірностей. Основні теореми теорії ймовірностей» для студентів усіх спеціальностей

/Уклад. Железнякова Е.Ю., Лебедєва І.Л., Лебедєв С.С. [Мультимедійний ресурс] – Харків : Вид. ХНЕУ ім. С. Кузнеця, 2018. – http://ebooks.git-elt.hneu.edu.ua/tvms

Additional

4. Теорія ймовірностей та математична статистика : мультимедійні методичні рекомендації до самостійної роботи з теми «Схема незалежних випробувань. Закони розподілу та числові характеристики дискретної випадкової величини» / Е. Ю. Железнякова, І. Л. Лебедєва, С. С. Лебедєв – Мультимедійне інтерактивне електрон. вид. комбінованого використ. (62 Мб). – Х.: ХНЕУ ім. С. Кузнеця, 2020. – Назва з тит. екрана. Режим доступу : https://pns.hneu.edu.ua/course/index.php?categoryid=1047

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