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

Department of Aircraft and Rocket Engineering

STATISTICAL RESEARCH METHODS IN AVIATION AND COSMONAUTICS

Work program of the discipline (Syllabus)

Details of the discipline

Level of higher education	*Second (master's)*
Field of knowledge	*13 Mechanical engineering*
Specialty	*134 Aviation and rocket and space technology*
Educational program	*Airplanes and helicopters*
Status of the discipline	*Cycle of professional training*
Form of study	*internal (daily)*
Year of preparation, semester	*1 course, spring*
The scope of the discipline	*105 hours*
Semester control / control measures	*Exam/modular control work*
Class schedule	*http://rozklad.kpi.ua*
Language of instruction	*Ukrainian /english*
IInformation about course leader / teachers	*Lecturer: Doctor of Technical Science, V.V. Kabanaychyi, vkabanyachyi@ukr.net* *Laboratory: asst. Soldatenko O.M., oksana.hubina2811@gmail.com*
Placement of the course	*https://campus.kpi.ua*

Curriculum

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

This discipline is designed to provide students with basic knowledge and skills, methods and techniques of statistical research of phenomena and processes. In particular, students learn to independently analyze quantitative relationships between phenomena and processes, trends and regularities of their formation, forecast development, and identify relationships in the aviation and space industries.

1. The purpose and tasks of the discipline.

1.1. The purpose of the discipline is to form students' abilities to::

- • apply professional knowledge in practical situations, the ability to identify, pose and solve problems, make informed decisions;
- • develop proposals for the formation and improvement of the company's policy, taking into account the maximum satisfaction of the needs of the aviation and space industry;

- • search, collection and analysis of information, calculation of indicators to substantiate professional decisions;
- • adequately analyze statistical information, form one's own opinion based on available statistical facts, think statistically;
- • perceive new information and interpret it in the context of already learned information.

1.2. The main tasks of the discipline.

After mastering the discipline, the following learning outcomes must be demonstrated:

knowledge of: methodological principles of organizing statistical observations, in particular selective, systematization and generalization of statistical data; analytically solve practical problems using the methods acquired during classes; methods of analysis of patterns of distribution, evaluation of variation, differentiation and concentration of phenomena and processes; methods of analyzing relationships and evaluating the effects of the influence of factors on the variation and dynamics of the studied phenomena;

ability: logical substantiation and calculation of statistical indicators, composite indices and rating assessments, which differ in their analytical function; measuring the intensity of dynamics, identifying and extrapolating development trends, evaluating fluctuations; choose methods of summarizing and organizing data, summarizing and grouping using computer technologies;;

experience of: apply graphical and visual methods of generalization and data analysis

2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program))

The study of the material requires students to have the skills of using personal computers at the level of an experienced user, as well as the knowledge and skills they will acquire during the study of the disciplines of the first (bachelor) level of training in the specialty "134 Aviation and rocket and space engineering".

3. The content of the discipline

Table 1

Names of sections and topics	Number of hours			
	In total	including		
		Lectures	Laboratory	SIW
Розділ 1. Засади статистики.				
Topic 1.1. Methodology of observations.	23	4	4	15
Topic 1.2. Laws of distribution.	32	6	6	20
Topic 1.3. Random variables.	34	6	8	20
Control work	16	2	–	14

Hours in general:	**105**	**18**	**18**	**69**

4. Educational materials and resources

Basic literature:

1.1. Schervish, Mark J. (1995). *Theory of statistics* New York: Springer. ISBN 0387945466

1.2. Chance, Beth L.; Rossman, Allan J. (2005). *Investigating Statistical Concepts, Applications, and Methods*. Duxbury Press. ISBN 978-0-495-05064-3

1.3. Lakshmikantham, D.; Kannan, V. (2002). *Handbook of stochastic analysis and applications*. New York: M. Dekker. ISBN 0824706609

1.4. Mosteller, F.; Tukey, J.W (1977). *Data analysis and regression*. Boston: Addison-Wesley.

1.5. Mann, Prem S. (1995). *Introductory Statistics*. Wiley. ISBN 0-471-31009-3.

1.6. Rubin, Donald B.; Little, Roderick J.A. (2002) Statistical analysis with missing data, New York: Wiley

1.7. Nikoletseas, M.M. (2014) "Statistics: Concepts and Examples." ISBN 978-1500815684

Auxiliary literature:

2.1. Lim, M. (2021). "Gauss, Least Squares, and the Missing Planet". *Actuaries Digital*.

2.2. Helen Mary Walker (1975). *Studies in the history of statistical method*. Arno Press. ISBN 978-0405066283.

2.3. Stigler, S.M. (1989). "Francis Galton's Account of the Invention of Correlation". *Statistical Science*. **4** (2): 73–79. doi:10.1214/ss/1177012580

2.4. Agresti, Alan; David B. Hichcock (2005). "Bayesian Inference for Categorical Data Analysis" *Statistical Methods & Applications*. **14** (3): 298. doi:10.1007/s10260-005-0121-y

2.5. Fisher, R.A. (1930) The Genetical Theory of Natural Selection. ISBN 0-19-850440

2.6. Freedman, D.A. (2005) *Statistical Models: Theory and Practice*, Cambridge University Press. ISBN 978-0-521-67105-7

Educational content

5. Methods of mastering the discipline (educational component)

Lecture classes.

Table 2

№	**The topic lecture title and list of main questions**
Section 1. Principles of statistics	
Topic 1.1. Methodology of observations	

1	**Lecture 1. Methodological principles of statistics.** The emergence of statistics as a science. Peculiarities of statistics as an independent science. Statistical population. Statistical features and their classification. Statistical regularities and forms of their manifestation. Statistical methodology. Stages of statistical research and specific methods of statistics: statistical observation, summary and grouping, generalizing characteristics. Tasks on SIW: study of modern problems of statistics. Literature: [1.1]
2	**Lecture 2. Statistical observation.** Statistical observation as a method of information provision. Information as a product of data collection and processing. The concept of statistical observation. Primary and secondary observation. Statistics. Probability of data. Data completeness. Timeliness of data. Comparative method of data collection. Purpose of observation. Object of observation. Organizational issues of statistical observation. Error of representativeness and registration. Tasks on SIW: study of continuous and non-continuous observations. Literature: [1.1]
	Topic 1.2. Laws of distribution
3	**Lecture 3. Concept of sampling method in statistics.** The main tasks of the methods of mathematical statistics. General population and sample. Sampling method in statistics. Statistical series. Empirical distribution function. Groups of numerical characteristics of statistical series. Numerical characteristics of the position. Scattering. Forms of distribution. Tasks on SIW: study of the sampling method in statistics. Literature: [1.1]
4	**Lecture 4. Deterministic and random processes.** Deterministic and random processes, sinusoidal periodic process and polyharmonic processes. Classification of random processes. Stationarity of sample functions and main characteristics of random processes. Basic applications of covariance functions. Typical applications of spectral density. Characteristics of errors and random and systematic errors. Tasks on SIW: study of random processes. Literature: [1.3]
5	**Lecture 5. Random variables and laws of their distribution.** Laws of distribution of a discrete random variable. Numerical characteristics of discrete random variables. The distribution function of a random variable. Probability density of a random variable. The probability of a random variable falling into the finite interval (a;b) due to the distribution function F(x). Grouped statistical series. Histogram. Numerical characteristics of random variables. Tasks on SIW: study of the main problems of mathematical statistics. Literature: [1.3]
	Topic 1.3. Random variables.
6	**Lecture 6. Numerical characteristics of a discrete random variable and their properties.** The mathematical expectation of a discrete random variable. The variance of a random variable. Integral distribution function and probability density of a continuous random variable. Mathematical expectation, variance and mean square

	deviation of a continuous random variable. Initial and central moments of random variables, coefficient of asymmetry and kurtosis. Mode and median of a random variable. Task on SIW: study of a discrete random variable. Література: [1.3]
7	**Lecture 7. Laws of distribution of continuous random variables.** Differential and integral functions of uniform distribution. Normal distribution and its parameters. The probability of a normally distributed random variable falling into a given interval. Normal curve and its properties. The rule of three sigma. Exponential distribution and its numerical characteristics. Tasks on SIW: study of the normal distribution of a random variable and other distributions (exponential, Pearson, Fisher, Student, etc.). Literature: [1.10]
8	**Lecture 8. Systems of random variables.** The law of probability distribution of a discrete two-dimensional random variable. Probability densities of components of a two-dimensional random variable. Numerical characteristics of a two-dimensional random variable. Conditional laws of distribution of components of the system of discrete and continuous random variables. Tasks on SIW: research of dependent and independent random variables. Literature: [1.10]

Practical lessons.

There are no practical lessons in the credit module.

Laboratory works.

The main tasks of laboratory work are research and analysis of statistical data.

№	The title of the laboratory work	Number of classroom hours
1	Random variables: discrete and continuous. The law of distribution of a discrete random variable.	2
2	Analytical distribution laws of a discrete random variable	2
3	Numerical characteristics of random variables: mathematical expectation and its properties.	2
4	Numerical characteristics of random variables: variance and its properties, standard deviation.	2
5	Laws of distribution of continuous random variables: uniform and exponential (exponential) distributions and their numerical characteristics.	2
6	Normal distribution. The rule of three sigma.	2
7	The law of large numbers.	2
8	Bayes theorem.	2
9	Statistics and machine learning in aviation environmental impact analysis.	2

Independent work of students

The student's independent work consists in preparing for classroom classes, familiarization with thematic literature. The volume and topics of students' independent work are shown in Table 1.

Policy and control

6. Policy of academic discipline (educational component)

Grading policy (missed classes, making up for absences): each grade is assigned in accordance with the criteria developed by teacher and announced to students in advance, as well as motivated individually at the student request; if student does not complete all prescribed classes, he will not be admitted to credit; missed classes must be made up. The form and time of practice are mutually agreed upon by student and teacher.

Academic integrity

The policy and principles of academic integrity are defined in Chapter 3 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorsky Kyiv Polytechnic Institute". More details: https://kpi.ua/code

Norms of ethical behavior

Standards of ethical behavior of students and employees are defined in Chapter 2 of the Code of Honor of the National Technical University of Ukraine "Ihor Sikorskyi Kyiv Polytechnic Institute". More details: https://kpi.ua/code

7. Types of control and rating system of evaluation of learning outcomes (RSO)

In the first lesson, students get acquainted with the rating system of the discipline, which is built on the basis of the Regulation on the system of evaluation of learning results https://document.kpi.ua/files/2020_1-273.pdf

Current control is carried out at each practical lesson in accordance with the specific goals of the topic in order to check the degree and quality of material learning. In all classes, objective control of theoretical training and learning of practical skills is used to check the readiness of student for the class. In the process of current control, the student's independent work is evaluated in terms of the completeness of tasks, level of assimilation of educational materials, mastering of practical skills of analytical and research work, etc. The results of current control are entered into the Ihor Sikorsky KPI Campus System.

Calendar control: is carried out twice a semester as a monitoring of current state of fulfillment of the syllabus requirements. In order to receive "credited" from the first intermediate certification (8th week), student will have at least 8 points (provided that at the beginning of the 8th week, according to the calendar of control activities, the "ideal" student must receive 20 points). To receive "credited" from the second intermediate certification (14th week), the student will have at least 28 points (provided that at the beginning of the 14th week, according to the calendar plan of control activities, the "ideal" student should receive 35 points).

Student who scored less than 33 points in the academic discipline during the semester is not admitted to the exam.

The student's rating in the discipline consists of the points he/she receives for the following:

• laboratory works;

• modular control work;

• exam.

1. Laboratory works

Weight score – 5.

The maximum number of points is equal to 5 points x9 = 45 points.

Evaluation criteria:

- full completion of the task — 5

- implementation, but theoretical knowledge is insufficient — 3…4;

- not prepared - 0.

2. Modular control work

Weight score – 10.

The maximum number of points is equal to 10 points x 1 = 10 points.

Evaluation criteria:

• complete completion of the task - 10;

• incomplete completion of the task - 6...7;

• work was not performed - 0.

Penalty and incentive points:

• creative approach to work, active participation in discussion of topics, independent search for topics: +1...3 points;

• absence of missing lectures without valid reasons: +1...3 points;

• absence from class without a valid reason: –1...–5 points.

The maximum number of incentive points is 5.

Calculation of the rating scale (R):

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

R_C = 45 + 10 = 55 points.

A necessary condition for admission to the exam is the completion of all laboratory work and modular control work.

The examination component of the scale is equal to 45% of **R_E**, namely **45** points.

Evaluation criteria:

• fluency in the material, answers to all additional questions — 40 ... 45 points;

• fairly confident mastery of the material, incomplete answers to additional questions - 32...39 points;

• uncertain answer to the main question, no answer to additional questions - 24 points;

• does not have an answer to the main question - 0 points.

Thus, the rating scale for the discipline is:

$R = R_C + R_E$ = 55 + 45 = 100 points.

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

Scores	Rating
100-95	Excellent
94-85	Very good

84-75	Very good
74-65	Satisfactory
64-60	Enough
Less than 60	Unsatisfactory
Admission conditions are not met	Not allowed

8. Additional information on the discipline (educational component)

If a graduate student is transferred from another university it recalculated only if the curriculum is consistent.

Work program of the discipline (syllabus):

Compiled by Professor of the Department of Aircraft and Rocket Engineering, Doctor of Technical Sciences, Kabanyachyi V.V.

Approved by the Department of Aircraft and Rocket Engineering (Minutes № 13 of 22.06.2022)

Approved by the Methodological Commission of the IAT (Minutes № 4 of 30.06.2022)