Ministry of Education and Science of Ukraine

Kharkiv National Automobile and Highway University

Automobile Faculty

Technical Operation and Service of Cars Department named after Govorushchenko M.Ya.

Nazarov A.

Methodological instructions for practical classes from the discipline «Theory and methods of scientific creativity» full-time students in the specialty 274 «Motor vehicle transport» by educational and qualification level – bachelor.

Kharkiv – 2025

UDC 629.01

Nazarov A. Methodological instructions for practical classes from the discipline «Theory and methods of scientific creativity» full-time students in the specialty 274 «Motor vehicle transport» by educational and qualification level – bachelor. Kharkiv: KhNAHU, 2025. 24 p.

Methodological instructions are intended for work on a practical task for students in the field of preparation 274 «Motor vehicle transport» of full-time study at the educational and qualification level of a bachelor in the discipline «Theory and Methods of Scientific Creativity».

These methodological instructions for independent work on practical classes are prescribed for students in the direction of training 274 "Automotive transport" of full-time education at the educational and qualification level of a bachelor in the discipline "Theory and methods of scientific creativity", which is studied in the third year in the 6th semester.

Methodological instructions include the program for the discipline "Theory and methods of scientific creativity", instructions for performing practical work and test tasks for the final control of students (https://dl2022.khadi.kharkov.ua/course/view.php?id=645).

The output data for each practical work during the performance of practical tasks is accepted by the student according to the table. A.1 in accordance with its serial number in the electronic journal.

Based on the results of the completed practical work, the student passes the current control on the relevant topic (see the course "CERTIFICATION OF THE DISCIPLINE"). The last two control questions in each test are related to practical and independent work.

After checking the results of the current control, the student receives the message "enrolled. score' or 'not counted'.

In the latter case, the student prepares for the relevant topic and re-passes the current control, sending the answers to the supervisor.

In the case of a positive assessment of the current control in all topics, the student completes the credit for the discipline, for which he answers control questions from the file "FINAL CONTROL from TMNT" of his option, selected from the list "TEST QUESTIONS FOR BACHELOR CERTIFICATION", the answers to which he sends to the supervisor by e-mail e-mail hefer64@ukr.net in the form: 1-A; 2–B; 3-B ... 10-A.

The final control of 3A students in the 6th semester is carried out based on the current control of topics and test control of credit.

Methodical instructions can be used by students of the sixth year of correspondence education for independent work on a practical task from the course "Theory and methods of scientific research".

1. DISCIPLINE PROGRAM (3A)

The program of the discipline "Theory and methods of scientific creativity" contains a thematic plan of the educational (auditory) load for students of the third year, presented in the table. 1.1.

Table 1.1 – Thematic plan of the student's classroom load (semester 6, 3A)

№ topics	Name of topics (LK, LR, PR, SZ, SR)	Number hours	
		ocular	extramural
1	LK Theory of scientific and technical creativity	2	2
	PR Practical work №1	2	2
	SR Organizational structure of research work in higher educational institutions	2	6
2	LK Creative personality	2	2
	PR -	-	-
	SR Increasing the effectiveness of self-management and self-organization. Self improvement	2	6
3	LK Contradictions in the "person-technical object-environment" system	2	-
	PR Practical work №2.	2	2
	SR The role of the team and the individual in scientific and technical creativity.	4	6
8 4	LK Dialectical principles of technical creativity in the development of technical objects	2	4
	PR -	-	-
	SR Life cycle of complex technical objects	2	4
5	LK Evolutionary ways of creating new technical objects	2	-
	PR Practical work №3	2	-
	SR Scheme of the process of solving a creative problem	2	6
6	LK. Information provision of scientific and technical creativity	2	-
	PR -	-	-
	SR Information and search apparatus of libraries and computer systems	4	4
7	K Methodology of scientific knowledge of the environment	2	-
	PR Practical work №4	2	-
	SR. Types of methodology	4	6
8	LK Methods of theoretical research	2	-
	PR -	-	-
	SR The creative process of theoretical research	2	4
9	LK The method of empirical research	2	-
	PR Practical work №5.	2	-
	SR Varieties of empirical research methods	4	6

10	LK Heuristic methods of finding ideas and solving scientific and technical problems. Intuition and logic	2	-
	PR -	-	-
	SR Basic laws of mathematical logic	2	4
11	LK Heuristic methods of finding ideas and solving scientific and technical problems. Method of trial and error. Associative methods	2	-
	PR Practical work №6.	2	-
	SR Methods of psychological activation of creative activity	4	6
12	LK Heuristic methods of finding ideas and solving scientific and technical problems. Modifications of the "brainstorming" method.	2	-
	PR -	-	-
	SR Procedure for applying the "brainstorming" method	2	4
13	LK Heuristic methods of finding ideas and solving scientific and technical problems. Method of control questions	2	-
	PR Practical work №7	2	-
	SR Application of the method of heuristic questions	4	6
14	LK. Heuristic methods of finding ideas and solving scientific and technical problems. The "bouquet of problems" and inversions method	2	-
	PR -	-	-
	SR Critical selection and assessment of creative problem solving ideas	2	4
15	LK Evaluation of the results of scientific and technical creativity and their legal protection	2	-
	PR Practical work №8	2	-
	SR. The main functions of a trademark.	4	6
16	LK Modeling in scientific and technical creativity	2	-
	PR -	-	-
	SR Group of Mathematical Research Methods	2	4
Together	**LK**	**32**	**4**
	PR	**16**	**4**
	SR	**42**	**82**

2. METHODOLOGICAL INSTRUCTIONS FOR INDEPENDENT WORK STUDENTS IN THE SIXTH SEMESTER (3A)

PRACTICAL WORK №1.
Determination of statistical characteristics the results of measuring parameters of the technical system

The goal of the work is to master the method of determining the statistical characteristics of the results of measuring the parameters of the technical system.

Condition. According to the voltage and current measurement data during the diagnosis of λ-probes (Table A.1), set the sample average value of the measurement results.

Brief theoretical data

1. The sample average value of the parameter (estimate of mathematical expectation a) is determined separately according to the formula [1-3]

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i , \qquad (1.1)$$

where x_i – the value of the parameter at the i-th point of intersection;

n – the number of parameter measurement points.

2. With a limited number of measurements (limited sample), the sample variance (estimate of the general variance) is determined by the formula [1-3]

$$S^2 = \frac{1}{n-1} \cdot \sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2 . \qquad (1.2)$$

3. Dispersion (general dispersion) characterizes the spread of measurement results. Therefore, the dispersion can characterize the accuracy of the technique, the uniformity of the measurement results.

Sample mean square deviation S, according to the formula

$$S = \sqrt{\frac{1}{n-1} \cdot \sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2} . \qquad (1.3)$$

4. The sample coefficient of variation is determined by the formula [1-3]

$$V = \frac{S}{\bar{x}} \cdot 100\%. \quad (1.4)$$

The coefficient of variation shows how significant the dispersion is compared to the mean value.

PRACTICAL WORK №2.
Construction of a confidence interval

Condition. Based on the parameter measurement data (table A.1), set confidence intervals.

Brief theoretical data

The first task that arises during the evaluation of the measurement results is the determination of the measurement error of the mathematical expectation a based on a limited sample.

The value only approximates a, i.e. $(\bar{x} - \delta) \le a \le (\bar{x} + \delta)$.

Note that δ is also a random variable and it can be implemented differently in different series of measurements.

Therefore, when estimating δ, we set reliability - a confidence probability with which the occurrence of an error that does not exceed the limits of δ is guaranteed.

If we denote the confidence probability P, then the degree of risk [1-3]

$$1 - P = \alpha, \quad (2.1)$$

where α – level of significance.

The values of all statistical criteria are expressed in terms of significance level or confidence probability. Usually in engineering, α=0.05 is accepted, which corresponds to 95% reliability.

If the number of measurements is large and the value of the dispersion is known, then it is not difficult to determine δ - the confidence interval for different values of the confidence probability.

If the number of measurements is limited, then the confidence interval is determined by the formula [1-3]

$$\delta = t_{\alpha;m} \cdot S / \sqrt{n}, \quad (2.2)$$

where $t_{\alpha;m}$ – Student's coefficient (Table A.2);

m – number of degrees of freedom (taken as m=n-1);

S – sample mean square deviation (see practical work #1);

n – number of measurements.

Therefore, the confidence interval for the mathematical expectation will thus be written as

$$\bar{x} - \frac{S}{\sqrt{n}} \cdot t_{\alpha;m} \le a \le \bar{x} + \frac{S}{\sqrt{n}} \cdot t_{\alpha;m}. \qquad (2.3)$$

PRACTICAL WORK №3.
Determination of the scope of measurement

Condition. According to the parameter data (table A.1), set the measurement volume with a given degree of accuracy and reliability.

Brief theoretical data

Justification of the scope of measurements in order to determine quantitative characteristics with a given degree of accuracy and reliability is the main task of measurement planning.

In general, the sample size n is set depending on the accuracy δ and reliability α, as well as depending on the type of statistical characteristics determined by the formulas given in [1-4].

With the known value of the statistical characteristic S, given the level of significance α and the error δ in absolute units of the characteristic that satisfies us, the sample volume n can be found from formula (2.2)

$$n = \frac{t_{\alpha;m} \cdot S}{\delta}. \qquad (3.1)$$

PROCEDURE FOR EXECUTION OF PRACTICAL WORK №1-№3

1. For sample populations, which each student initially selects from the table. A.1 in accordance with its variant, determine statistical characteristics (sample mean value, sample mean squared deviation, sample coefficient of variation) according to formulas (1.1), (1.3) and (1.4).

2. Given the level of significance $\alpha=0.05$, the number of degrees of freedom $m=n-1$, the Student coefficient $t_{\alpha;m}$ is determined, assuming a two-sided restriction.

3. According to the formula (2.2), determine the confidence interval for the mathematical expectation and record the result in the form (2.3).

4. Given the Student coefficient $t_{\alpha;m}$, assuming a one-sided or two-sided restriction, the error δ in absolute units of the characteristic according to formula (3.1) is the sample volume n that satisfies the selected conditions.

5. Analysis of the obtained results is carried out and appropriate conclusions are drawn.

PRACTICAL WORK №4.
Establishing the relationship between the experimental and theoretical value using the regression equation in Excel

Purpose: to master the technique of constructing regression equations in MS Excel.

Condition. According to the parameter data (table A.1), establish the presence of a relationship between the experimental values of voltage y and the theoretical value x (current strength) and find the regression equation. Build regression equations in MS Excel.

Brief theoretical information

One of the tasks of any research is to determine cause-and-effect relationships between phenomena, that is, to establish patterns of influence of one measurement on others (Fig. 4.1).

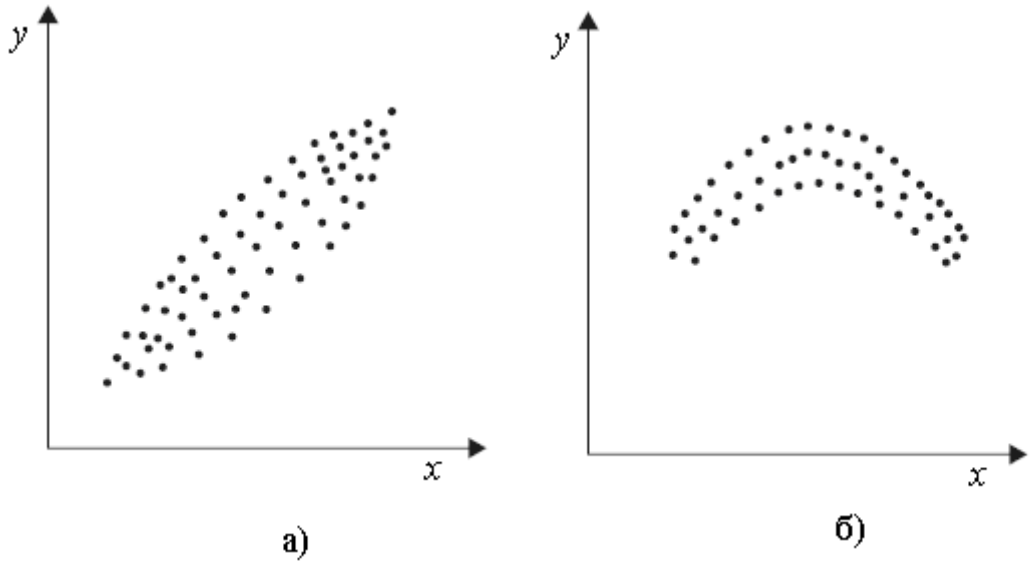

Figure 4.1 – Typical types of correlation fields:
a) linear correlation; b) non-linear correlation

1. In a separate case, to determine the relationship between two measured quantities, the pair correlation coefficient r is calculated according to the following formula [1-3]

$$r = \frac{S_{xy}}{\sqrt{S_x S_y}}, \tag{4.1}$$

where S_x, S_y, S_{xy} are determined by the formulas, respectively

$$S_x = \sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2, \tag{4.2}$$

$$S_y = \sum_{i=1}^{n} \left(y_i - \bar{y}\right)^2, \tag{4.3}$$

$$S_{xy} = \sum_{i=1}^{n} \left(x_i - \bar{x}\right)\left(y_i - \bar{y}\right), \tag{4.4}$$

where n – number of data pairs;

S_x, S_y – mean square deviations of a separate measurement of x and y values;

$\bar{x}$, $\bar{y}$ – arithmetic mean values of x and y;

x_i i y_i – numerical values of random variables x and y in the ith experiment;

S_{xy} – covariance.

2. The correlation coefficient can have a range of values $-1 \le r \le +1$.

In the case of a strong positive correlation, a value close to +1 is reached, and

in the case of a strong negative correlation, a value close to -1 is reached.

3. When r = 1, all data will lie on a straight line, the relationship is beyond doubt. If r = 0 – there is no correlation.

At intermediate values of r, it is necessary to check whether the value of the correlation coefficient is significantly different from zero, that is, whether the characteristics of x and y are not independent.

4. After it is established that the relationship between x and y exists, it is determined in the form of an equation.

In the conditions of a large number of experimental points and their dispersion, the dependence y = f(x) should pass in the most probable way between the experimental points.

5. The analysis of the normal distribution law shows that the most likely position of the approximating function is such that the sum of squared deviations of the experimental values (voltages) y of the function we are looking for, at the corresponding values (current) x, is minimal.

This condition can be written as

$$\sum (y_i - \overline{y})^2 = \min , \qquad (4.5)$$

where y_i – actual ordinates of the field (voltage);

$\overline{y}$ – average value of the ordinate (parameter).

6. The value of the current in each experiment was based on the measured value of the active resistance from the formula

$$x_i = \frac{U_i}{R_i}, \qquad (4.6)$$

where U_i – value of the i-th control voltage on the λ-probe (Table A.1);

R_i – active resistance ($R_i = 0{,}2 - 0{,}8$) Ohm.

The middle line of the correlation field is called the regression line. The most common is a straight line correlation.

Therefore, the correlation field is approximated by a straight line equation, and the regression line is approximated by a regression equation.

The regression equation shows the relationship between the performance indicator y and independent factors x1, x2, etc.

If the independent variable is one, then we are talking about paired regression. If there are several wheres, then the concept of multiple regression is used.

The pairwise regression equation can be represented in the form

$$y = a + bx, \tag{4.7}$$

where a – free member.

b – regression coefficient.

7. Parameters a and b are found by applying the method of least squares [1-3], solving the system of equations.

This method is implemented in several stages.

Find based on available data and formulas

$$\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i , \tag{4.8}$$

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i . \tag{4.9}$$

8. The values of S_x and S_{xy} are calculated according to formulas (4.2) and (4.4).

9. Find the values of the unknown parameters of equation (4.6) b and a using the formulas

$$b = \frac{S_{xy}}{S_x}, \tag{4.10}$$

$$a = \bar{y} - b\bar{x}. \tag{4.11}$$

10. After obtaining the regression equations for the options of practical work (see Table A.1), they are constructed in MS Excel [4].

PROCEDURE FOR PERFORMING PRACTICAL WORK №4

1. For a preliminary assessment of the presence of a relationship between the measured values of voltage y and current strength x, a correlation field should be constructed.

2. If there is a connection between two signs according to formula (4.1), calculate the correlation coefficient and evaluate the closeness of this connection.

3. If the correlation field is approximated by a straight line according to formulas (4.10) and (4.11), calculate the unknown parameters b and a and write the regression equation in the form (4.7).

4. According to the obtained regression equation for two values of the characteristic x, determine the corresponding values of the characteristic y and plot the points with these coordinates on the correlation field, and then draw a regression line through them.

5. In MS Excel, this problem can be solved in different ways, one of which is the following [4]:

a) A series of data is highlighted and the button to build a diagram is clicked;

b) In the diagram construction wizard, select Standard, type: Point

e) On the Options tab, set "Show equation on the diagram".

f) Place the value of the approximation reliability (R^2) on the diagram and click OK.

The task is completed - on the monitor screen you will see the regression equation and a graphical representation of the previous data.

Control questions and tasks

1. Why should a correlation field be constructed for a preliminary assessment of the presence of a relationship between measurement values x and y?

2. Is it possible to calculate the correlation coefficient between two signs using formula (4.1)?

3. Is it possible to estimate the closeness of the correlation between two signs according to formula (4.1)?

4. If the correlation field is approximated by a straight line, how to calculate the unknown parameters b and a and write the regression equation?

5. How to use the obtained regression equation for two values of the characteristic x to determine the corresponding values of the characteristic y and plot the points with these coordinates on the correlation field?

6. In what ways can the task of constructing a regression equation and graphical representation of previous data be solved in MS Excel?

PRACTICAL WORK №5.
Checking the results of measuring parameters, which differ sharply using the Irwin criterion

The purpose of the work is to master the method of checking the results of studies of parameters that differ sharply, for their belonging to the same general population.

Condition. Based on the data of voltage measurement and calculation of current strength (table A.1), using the Irwin criterion, check the results of the study, which differ sharply.

Brief theoretical information

1. Based on the results of the entire set of measurements, the value of the statistical criterion is calculated and compared with the table value.

If the calculated value is less than the table value, then the hypothesis that the questionable result belongs to this general population is accepted and the result is counted, if not, the result is rejected.

2. Irvin's method [1, 3] consists in the fact that first, based on research data, the average arithmetic value of the parameter and the mean square deviation are calculated according to formulas (1.1) and (1.3).

3. All experimental sample data (measurement results) are placed in ascending or descending order (ranked distribution series),

$$x_1 \le x_2 \le \ldots \le x_{n-1} \le x_n .$$

4. From the obtained series, the results (largest or smallest) that cause the greatest doubts are chosen.

For example, in case of doubts about the largest result in a series, values are taken and the value is calculated

$$\lambda = \frac{x_n - x_{n-1}}{S}, \qquad (5.1)$$

where x_n – a result about which there is doubt;

x_{n-1} – the result that is closest to doubtful.

5. According to the table 5.1 depending on the size of the sample at the significance level α=0.05 (confidence probability) find the critical value.

Table 5.1 - The value of the Irwin criterion $\lambda_{0,95}$

Parameter	Parameter value								
n	2	3	10	20	30	50	100	400	1000
$\lambda_{0,95}$	2,8	2,2	1,5	1,3	1,2	1,1	1,0	0,9	0,8

6. If the condition is fulfilled $\lambda \leq \lambda_{0,95}$, the null hypothesis is accepted and the result is counted, when $\lambda \geq \lambda_{0,95}$ - the null hypothesis is rejected and the questionable result is rejected.

In the latter case, after eliminating the gross error, it is necessary to calculate the characteristics again according to formulas (1.1) and (1.3).

Control questions and tasks

1. On the basis of what is the value of Irwin's statistical criterion calculated and compared with the table value?
2. Is the statement true: "If the calculated value is less than the table value, then the hypothesis that the questionable result belongs to this general population is accepted and the result is counted, if not, the result is rejected?"
3. What is the essence of Irwin's method?
4. According to Irwin's method, are all experimental data of the sample (measurement results) placed in ascending or descending order (ranked distribution series)?
5. According to Irwin's method, the results (the largest or the smallest) that cause the greatest doubts are chosen from the ordered series?
6. If the condition is met, is the null hypothesis accepted and the result counted, or is the null hypothesis rejected and the questionable result rejected?

PRACTICAL WORK №6.
Checking the results of measuring parameters, which differ sharply using the Romanovsky criterion

The goal of the work is to master the method of checking the results of studies that differ sharply, for their belonging to the same general population.

Condition. According to the parameters research data (table A.1), using the Romanovsky criterion, check the results of the research, which differ sharply.

Brief theoretical information

1. For samples with a volume of more than 50, deviations of sharply different results are not carried out, since they do not significantly affect the accuracy of the estimation of numerical characteristics and parameters of the distribution of a random variable.

2. For the same purpose, a stricter Romanovsky criterion [1-3] is used, which involves determining the sample mean and sample mean squared deviation according to formulas (1.1) and (1.3), first discarding sharply different values from the sample.

3. After that, determine the value according to the formula

$$t_{\alpha} = \frac{\left| x_i' - \overline{X} \right|}{S}. \qquad (6.1)$$

4. Acceptable values depending on the level of significance α and the number of members of the variation series n are shown in the table. 6.1.

Table 6.1 - Permissible values at risk $\alpha = 0{,}05$

n	Permissible values at α				n	Permissible values at при α			
	0,05	0,02	0,01	0,001		0,05	0,02	0,01	0,001
2	15,6	39,0	78,0	779,7	15	2,2	2,7	3,1	4,3
3	5,0	8,0	11,5	36,5	20	2,2	2,6	2,9	4,0
4	3,6	5,1	6,5	14,5	25	2,1	2,5	2,9	3,8
5	3,0	4,1	5,0	9,4	30	2,1	2,5	2,8	3,7
6	2,8	3,6	4,4	7,4	40	2,0	2,5	2,7	3,6
7	2,6	3,4	4,0	6,4	60	2,0	2,4	2,7	3,5
8	2,5	3,2	3,7	5,7	120	2,0	2,4	2,6	3,4
9	2,4	3,1	3,5	5,3	∞	2,0	2,3	2,6	3,3
10	2,4	3,0	3,4	5,0					

5. If $t_\alpha \le t'_\alpha$, then with probability $P=1-\alpha$ it can be argued that the value of the variation series is a random result and cannot be rejected.

If $t_\alpha \ge t'_\alpha$, then a value that is drastically different is a gross error and should be discarded.

When applying Romanovsky's method, after excluding from the sample a value that differs sharply, there is no need to recalculate the characteristics.

PROCEDURE FOR PERFORMING PRACTICAL WORK №5 and №6

1. In the table 5.2 enter the data of the research parameters (each student chooses in accordance with his number in the electronic journal according to table A.1).

Table 5.2 – Research results

Parameter	Parameter value									
	1	2	3	4	5	6	7	8	9	10
High-voltage, μV										

2. Listed in the table. 5.2 place voltage values in ascending order

$$x_1 \le x_2 \le \ldots \le x_{n-1} \le x_n .$$

3. Calculate the characteristics: arithmetic mean and mean square deviation S according to formulas (1.1) and (1.3).

4. From the series (item 2), choose the two largest and or the smallest values of the random variable and determine the value according to the formula (5.1).

5. According to Irwin's method from the table. 5.1 depending on the sample size at the level of significance $\alpha = 0{,}05$ are of critical importance $\lambda_{0,95}$

6. Perform a comparison with the tabular value. If $\lambda \le \lambda_{0,95}$, then the result being evaluated is random and should be left. If the condition is met $\lambda \ge \lambda_{0,95}$, then the largest or smallest value should be discarded. In this case, after eliminating the gross error, it is necessary to calculate the characteristics again according to formulas (1.1) and (1.3).

7. According to Romanovsky's method, using formula (6.1), determine , taking the value , which was excluded.

8. Compare the value with the value determined according to the table. 4 for the corresponding sample.

9. If $t_\alpha \le t'_\alpha$, is a random value and cannot be discarded. If ж $t_\alpha \ge t'_\alpha$, then a value that is drastically different is a gross error and should be discarded.

10. When applying Romanovsky's method, after excluding from the sample the value , which differs sharply, there is no need to recalculate the characteristics of and .

11. Compare the results of calculations by the method of Irvin and Romanovsky. Draw appropriate conclusions.

3. TEST TASKS FOR OF THE FINAL CONTROL OF STUDENTS (TMSC, 3A)

The test task includes ten questions according to the table. 3.1, which each student chooses in accordance with the list of test questions presented in the list "Test questions for bachelor's certification".

Table 3.1 - Variants of test tasks in the discipline TMSC (3A)

№ according to the list in the electronic journal	Variant of the test task	№ questions from the list of test questions
1	№1	1, 11, 21, 31, 41, 51, 61,71, 81, 91
2	№2	2, 12, 22, 32, 42, 52, 62, 72, 82, 92
3	№3	3, 13, 23, 33, 43, 53, 63, 73, 83, 93
4	№4	4, 14, 24, 34, 44, 54, 64, 74, 84, 94
5	№5	5, 15, 25, 35, 45, 55, 65, 75, 85, 95
6	№6	6, 16, 26, 36, 46, 56, 66, 76, 86, 96
7	№7	7, 17, 27, 37, 47, 57, 67, 77, 87, 97
8	№8	8, 18, 28, 38, 48, 58 98, 68, 78, 88
9	№9	9, 19, 29, 39, 49, 59, 69, 79, 89, 99
10	№10	10, 20, 30, 40, 50, 60, 70, 80, 90, 100
11	№11	11, 21, 31, 41, 51, 111, 121, 131, 141, 151
12	№12	12, 22, 32, 42, 52, 112, 122, 132, 142, 152
13	№13	13, 23, 33, 43, 53, 113, 123, 133, 143, 153
14	№14	14, 24, 34, 44, 54, 114, 124, 134, 144, 154
15	№15	15, 25, 35, 45, 55, 115, 125, 135, 145, 155
16	№16	16, 26, 36, 46, 56, 116,126,136, 146, 156
17	№17	17, 27, 37, 47, 57, 117, 127, 137, 147, 157
18	№18	18, 28, 38, 48, 58, 118, 128, 138, 148, 158
19	№19	19, 29, 39, 49, 59, 119, 129, 139, 149, 159
20	№20	20, 30, 40, 50, 60, 130, 140, 150, 160, 170
21	№21	21, 31, 41, 51, 81, 91, 141, 151, 161, 171
22	№22	22, 32, 42, 52, 82, 92, 142, 152, 162, 172
23	№23	23, 33, 43, 53, 83, 93, 143, 153, 163, 173
24	№24	24, 34, 44, 54, 84, 94, 144, 154, 164, 174
25	№25	25, 35, 45, 55, 65, 175, 176, 177, 178, 179
26	№26	26, 36, 46, 56, 66, 180, 182, 183, 184, 185
27	№27	27, 37, 47, 57, 67, 186, 187, 188, 189, 190
28	№28	28, 38, 48, 58, 68, 191, 192, 193, 194, 195
29	№29	29, 39, 49, 59, 69, 196, 197, 198, 199, 200
30	№30	30, 40, 50, 60, 70, 100, 120, 175, 185, 195

LIST OF REFERENCES

1. Статистична обробка експериментальних даних: Навчальний посібник / О.П. Мельниченко, І.Л. Якименко, Р.Л. Шевченко. − Біла Церква, 2006.

2. Статистичні методи обробки результатів фізичного експерименту / І.М. Гасюк, Л.С. Кайкан. – Івано-Франківськ: Видавництво Прикарпатського національного університету імені Василя Стефаника, 2011.

3. Статистична обробка результатів експериментальних вимірювань: методичні рекомендації / В. П. Ржепецький. – Кривий Ріг : Криворізький wherержавний педагогічний університет, 2011.

4. Методи обробки експериментальних даних з використанням MS Excel: Навчальний посібник / А.А. Горват, О.О. Молнар, В.В. Мінькович. – Ужгород: Видавництво УжНУ “Говерла”, 2019.

Table A.1 – Initial data for options for independent work with TMSC (3A)

Dimensional parameter	№ research	№ option														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
$x_i = U$, μV	1	263	701	427	531	322	511	460	602	560	380	263	701	427	531	322
	2	322	511	460	602	560	380	263	701	427	531	322	322	511	460	602
	3	602	560	380	263	701	427	531	322	263	701	427	531	322	322	511
	4	263	701	427	531	322	322	511	602	560	380	263	701	427	531	322
	5	511	460	602	560	380	263	263	263	701	427	531	322	602	560	380
	6	602	560	380	263	602	560	380	263	701	427	531	322	263	701	427
	7	380	263	263	701	427	531	322	511	460	602	560	380	263	380	263
	8	263	602	560	380	263	701	427	531	322	263	701	427	531	322	263
	9	602	560	380	263	602	560	380	263	701	427	531	322	602	560	380
	10	263	701	427	531	322	380	263	602	560	380	263	701	427	531	322
$y_i = I$, μA	1	530	407	1040	407	530	753	644	920	920	407	1040	753	920	920	920
	2	407	867	936	867	407	1040	1040	644	644	867	936	407	530	644	644
	3	867	530	1270	753	867	936	936	530	1040	753	1270	867	407	530	407
	4	920	407	1210	407	920	1270	1270	407	936	1040	1210	753	867	407	867
	5	644	867	753	867	1040	1210	1040	867	1270	936	753	1040	920	867	753
	6	1040	920	530	1040	936	753	936	920	1210	1270	753	936	1040	920	530
	7	936	407	407	936	1270	407	1270	407	753	1210	530	1270	936	1270	407
	8	1270	867	867	1270	1210	867	1210	867	407	753	407	1210	1270	1210	867
	9	1210	920	920	1210	753	920	753	920	867	920	867	753	1210	407	920
	10	1210	920	920	1210	753	920	753	920	867	920	867	753	1210	407	920

Continuation of table A.1

Dimensional parameter	№ research	№ option														
		16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
$x_i = U$, μV	1	602	560	380	263	701	427	531	322	263	701	427	531	322	511	460
	2	701	427	531	322	322	511	460	602	322	511	460	602	560	380	263
	3	322	263	701	427	531	322	322	511	602	560	380	263	701	427	531
	4	602	560	380	263	701	427	531	322	263	701	427	531	322	322	511
	5	263	701	427	531	322	602	560	380	511	460	602	560	380	263	263
	6	263	701	427	531	322	263	701	427	602	560	380	263	602	560	380
	7	511	460	602	560	380	263	380	263	380	263	263	701	427	531	322
	8	531	322	263	701	427	531	322	263	263	602	560	380	263	701	427
	9	263	701	427	531	322	602	560	380	602	560	380	263	602	560	380
	10	602	560	380	263	701	427	531	322	263	701	427	531	322	380	263
$y_i = I$, μA	1	644	920	920	407	1040	753	920	920	920	530	407	1040	407	530	753
	2	1040	644	644	867	936	407	530	644	644	407	867	936	867	407	1040
	3	936	530	1040	753	1270	867	407	530	407	867	530	1270	753	867	936
	4	1270	407	936	1040	1210	753	867	407	867	920	407	1210	407	920	1270
	5	1040	867	1270	936	753	1040	920	867	753	644	867	753	867	1040	1210
	6	936	920	1210	1270	753	936	1040	920	530	1040	920	530	1040	936	753
	7	1270	407	753	1210	530	1270	936	1270	407	936	407	407	936	1270	407
	8	1210	867	407	753	407	1210	1270	1210	867	1270	867	867	1270	1210	867
	9	753	920	867	920	867	753	1210	407	920	1210	920	920	1210	753	920
	10	753	644	753	644	920	753	753	867	753	753	644	753	753	753	644

Table A.2 – Values $t_{\alpha;m}$

The number of degrees of freedom, m	Level of significance α (bilateral restriction)					
	0,10	0,05	0,02	0,01	0,002	0,001
1	6,31	12,7	31,82	63,7	318,3	637,0
2	2,92	4,30	6,97	9,92	22,33	31,6
3	2,35	3,18	4,54	5,84	10,22	12,9
4	2,13	2,78	3,75	4,60	7,17	8,61
5	2,01	2,57	3,37	4,03	5,89	6,86
6	1,94	2,45	3,14	3,71	5,21	5,96
7	1,89	2,36	3,00	3,50	4,79	5,40
8	1,86	2,31	2,90	3,36	4,50	5,04
9	1,83	2,26	2,82	3,25	4,30	4,78
10	1,81	2,23	2,76	3,17	4,14	4,59
11	1,80	2,20	2,72	3,11	4,03	4,44
12	1,78	2,18	2,68	3,05	3,93	4,32
13	1,77	2,16	2,65	3,01	3,85	4,22
14	1,76	2,14	2,62	2,98	3,79	4,14
15	1,75	2,13	2,60	2,95	3,73	4,07
16	1,75	2,12	2,58	2,92	3,69	4,01
17	1,74	2,11	2,57	2,90	3,65	3,96

Continuation of the table. A.2

The number of degrees of freedom, m	Level of significance α (bilateral restriction)					
	0,10	0,05	0,02	0,01	0,002	0,001
18	1,73	2,10	2,55	2,88	3,61	3,92
19	1,73	2,09	2,54	2,86	3,58	3,88
20	1,73	2,09	2,53	2,85	3,55	3,85
21	1,72	2,08	2,52	2,83	3,53	3,82
22	1,72	2,07	2,51	2,82	3,51	3,79
23	1,71	2,07	2,50	2,81	3,49	3,77
24	1,71	2,06	2,49	2,80	3,47	3,74
25	1,71	2,06	2,49	2,79	3,45	3,72
26	1,71	2,06	2,48	2,78	3,44	3,71
27	1,71	2,05	2,47	2,77	3,42	3,69
28	1,70	2,05	2,46	2,76	3,40	3,66
29	1,70	2,05	2,46	2,76	3,40	3,66
30	1,70	2,04	2,46	2,75	3,39	3,65
40	1,68	2,02	2,42	2,70	3,31	3,55
60	1,67	2,00	2,39	2,66	3,23	3,46
120	1,66	1,98	2,36	2,62	3,17	3,37
∞	1,64	1,96	2,33	2,58	3,09	3,29
	0,05	0,025	0,01	0,005	0,001	0,0005
	Level of significance α (unilateral restriction)					