Ministry of Education and Science of Ukraine

Kyiv National University of Technologies and Design

B. Zlotenko, T. Kulik

# METHODOLOGY OF MODERN SCIENTIFIC RESEARCH WITH THE BASICS OF INTELLECTUAL PROPERTY

Textbook

Recommended by the Academic Council of the Kyiv National University of Technology and Design for students of the second (master's) level of higher education in all specialties

Kyiv
2 0 2 1

UDK [001.891+347.77]:378(075.8)
З-68

Reviewers:

O. Polishchuk, Dr. of Science, Professor, Head of Department of Machines and Apparatuses, Electromechanical and Power Systems, Khmelnytsky National University.

O. Synyuk, Dr. of Science, Professor, Professor of Department of Machines and Apparatuses, Electromechanical and Power Systems, Khmelnytsky National University.

N. Zashchepkina, Dr. of Science, Professor, Professor of Department of Information and Measurement Technologies, National Technical University of Ukraine. “Igor Sikorsky Kyiv Polytechnic Institute”.

Recommended by the Academic Council of the Kyiv National University of Technology and Design as a textbook for students of the second (master's) level of higher education in all specialties (Minutes № 3 of October 28, 2020)

**Zlotenko B.**

З-68 Methodology of modern scientific research with the basics of intellectual property : Textbook / B. Zlotenko, T. Kulik. Kyiv : KNUTD, 2021.155 p.

ISBN 978-617-7506-76-7

The textbook is devoted to the coverage of general methods of modern scientific research, experimental research methodology, mathematical planning and analysis of experimental research, master's work preparation stages, basics of intellectual property, patent application for invention (utility model), application for goods and services sign, copyright and related rights. The content of the textbook corresponds to the program of the discipline "Methodology of modern scientific research with the basics of intellectual property". The book is recommended for students of the second (master's) level of education.

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ISBN 978-617-7506-76-7

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# INTRODUCTION

***Methodology*** (from gr. *methodos* – way, method and *logos* – science, knowledge) – teaching about the rules of thinking in the creation of the theory of science. The methodology is regarded as the doctrine of scientific methods of cognition, or as a system of scientific principles on the basis of which research is based and the choice of cognitive means, methods of research is made.

***Research methodology*** is a set of specific forms, methods and means of theoretical and applied research in a certain area of knowledge (the direction of the researcher's professional activity). Methodology is a systematic set of techniques of research; it is a system of rules for the use of methods and techniques of research. If this set is strictly consistent from the beginning of the study and until the results are obtained, then it is called an algorithm.

***The scientific method*** is a system of rules and regulations that guide human activity (industrial, political, cultural, scientific, educational, etc.) toward the goal. The choice of research methods is dictated by the nature of the material, the conditions, and the purpose of the particular study.

Scientific methods can be divided into specific, used in individual sciences or in several closely related scientific disciplines, and ***general***, which are used in all or almost all sciences.

There is an important requirement for the method of cognition - the relevance of the method to the object of study and the level of cognition, which requires the use of specific scientific methods of cognition. However, different sciences, despite their differences, have many things in common, since the essence of all sciences is the reflection of the laws of the material and nonmaterial worlds, they are all determined on the basis of experience, apply the same laws of thought and serve the interests of society. Therefore, along with special methods, scientific research uses universal scientific methods that are common to a large group of scientific disciplines.

# 1. GENERAL METHODS OF MODERN SCIENTIFIC RESEARCH

General methods of scientific knowledge are usually divided into three large groups:

1) methods of empirical research;

2) methods used at the empirical and theoretical levels;

3) methods of theoretical research.

***Empirical research*** is the identification, accurate description and detailed study of various factors of phenomena and processes.

***Theoretical study*** is the study and identification of causes, relationships and dependencies that allow you to predict the course of phenomena and processes.

## 1.1. Methods of empirical research

The simplest methods of empirical research are observation, comparison, and measurement. More complicated and effective is the experiment.

***Observation*** is a systematic, focused study of an object. Observation is an active cognitive process that relies primarily on the work of the human senses and observer's substantive material activity.

This is the most elementary method, which is usually a component of other empirical methods.

***Comparison*** is the process of establishing the similarities and differences between objects and phenomena of reality, as well as finding a common feature of two or more objects.

***Measurement*** is the procedure for determining the numerical value of a quantity by a unit of measure.

***Experiment*** is a method of scientific research that involves the active and purposeful interference with the natural conditions of the existence of objects and phenomena, or the reproduction of certain sides of objects and phenomena

in specially created conditions in order to study them without concomitant circumstances complicating the process.

Experimental studies can be laboratory and production. ***Laboratory experiments*** are carried out using standard devices, special modeling plants, stands, equipment, etc.

These experiments, in the case of a sufficiently complete scientific justification for the experiment (mathematical planning), allow to obtain high-quality scientific information with minimal cost. However, such experiments do not always fully reflect the actual course of the studied process, so there is a need for a production experiment.

***Industrial experimental*** studies are conducted in order to study the process in real conditions, taking into account various factors of the production environment.

One type of production experiment is the collection of materials in organizations that accumulate standard data in one form or another.

***Graphic methods*** are widely used in the processing of measurement and observation results.

Graphic representation gives the clearest idea of the results of experiments, allow to better understand the physical nature of the studied process, to identify the general nature of the functional dependence of the studied variables, to establish the presence of maximums and minimums of functions.

***Correlation analysis*** is used to study the patterns of interaction between processes (phenomena) that depend on many, sometimes unknown factors. The relationship between these factors is manifested in the mutual consistency of the observed changes.

The correlation coefficient between the variables is calculated. The higher it is the more accurate one can predict the value of one variable by the value of the other.

***Factor analysis*** makes it possible to establish multidimensional relationships of variables based on several attributes. On the basis of paired correlations obtained as a result of correlation analysis, they get a set of new, aggregated features - factors.

As a result of the sequential procedure, the factors of the second, third and other levels are obtained.

## 1.2. Methods used at empirical and theoretical levels of research

***Abstraction*** is an imaginary departure from insignificant properties, connections, relations of objects in order to focus on the most important features that are of particular interest to the researcher. Abstraction makes it possible to replace the cognition of the complex with the simple, but with the simple that reflects the main in the complex.

The process of abstraction in the system of logical thinking is closely linked to other methods of research, and above all to analysis and synthesis.

***Analysis*** is a method of cognition in which the phenomenon is divided into components.

***Synthesis*** is the opposite of analysis method, which is to investigate the phenomenon as a whole, on the basis of combining related elements together. Synthesis allows us to generalize concepts, laws and theories.

***Deduction*** is a method of study in which partial provisions are derived from general ones. The content of deduction as a method of cognition is the use of general scientific provisions in the study of specific phenomena.

***Induction*** is a method of investigation in which general principles and laws are established by specific facts and phenomena (D.I. Mendeleev using some facts about chemical elements formulated a law known as "periodic").

There are several ways of linking scientific induction methods:

- a single similarity method: if two or more cases of the phenomenon under study have only one general circumstance, and all other circumstances are

different, then this circumstance is the cause of the phenomenon under consideration;

- method of sole discrepancy: if the case in which the investigated phenomenon occurs and the case in which it does not occur similar in all and differ only in one circumstance, then this circumstance is the cause of the phenomenon being investigated;

- a combined method of similarity and difference - a combination of the first two methods;

- the method of concomitant change: when the appearance or alteration of one phenomenon causes a certain change in another phenomenon, they are both causally linked;

- method of remainder: if a complex phenomenon is caused by a complex cause, which is a combination of certain circumstances, and it is known that some of them are the cause of part of the phenomenon, then the rest of this phenomenon is caused by the remaining circumstances.

***Modeling method*** is the study of phenomena using models - one of the main in modern research.

There is physical and mathematical modeling. In physical modeling, the physics of the phenomena in the object and model and their mathematical dependencies are the same. In mathematical modeling, the physics of phenomena may be different, but the mathematical dependencies are the same. Mathematical modeling is of particular value when it becomes necessary to study very complex processes.

The model means an artificial system that reflects the basic properties of the object being studied - the original. A ***model*** is an image in a convenient form of numerical information about the object under study. The model is in correspondence with the object, can replace it in the study and allows obtaining information about it.

When building a model object and itself its properties are usually simplified or generalized. The closer the model is to the original and the more

successfully it describes the object the more effective the theoretical study and the closer the results are to the accepted hypothesis of the study. Models can be physical, mathematical, and full-scale.

***Physical models*** allow visualizing the processes occurring in nature. With the help of physical models it is possible to study the influence of individual parameters on the course of physical processes.

***Mathematical models*** are represented in the form of function, equation, system of equations, differential or integral equations.

Mathematical models allow quantifying the phenomena that are difficult to study with physical models.

***Full-scale*** models are scaling objects that allow the most complete exploration of real-life processes.

Various models of the studied processes are investigated by mathematical methods, which can be divided into such main groups:

- analytical methods of research (elementary mathematics, differential and integral equations, variation calculus and other sections of higher mathematics). These methods allow deep and comprehensive investigation of the processes under study, establish accurate quantitative relationships between arguments and functions, deeply analyze the phenomena under study;

- methods of mathematical analysis using experiment (method of analysis, theory of similarity, method of dimensions);

- probabilistic and statistical methods of research (statistics and probability theory, variance and correlation analyzes, Monte Carlo method, etc.) for studying random processes - discrete and continuous;

- methods of system analysis (operations research, queuing theory, control theory, set theory, etc.) have become widespread lately, largely due to the development of computers that provide rapid solution and analysis of complex mathematical problems, and is understood as a set of techniques and methods for studying complex objects - systems that represent a complex set of interacting elements.

## 1.3. Methods of theoretical research

The theoretical study from a methodological point of view belongs to the highest level of scientific knowledge. It reveals and substantiates the deeper and more significant aspects of the phenomena under study. At the theoretical level of research, the following general scientific methods are used: historical, axiomatic, ascent from abstract, idealization, formalization, analysis, synthesis, induction, deduction, hypothesis, theory generation, generalization, etc. Some methods have been described previously. Consider the others.

***The historical method*** allows investigating the emergence, formation and development of processes and events in chronological order in order to identify internal and external relations, patterns and contradictions. This method of research is used mainly in the social and historical sciences. In applied sciences, it is used, for example, in the study of the development and formation of certain branches of science and technology.

***The hypothetical method*** is based on the development of a hypothesis, which is a scientific assumption containing elements of novelty and originality. The hypothesis should more fully and better explain the phenomena and processes, confirmed experimentally and comply with the general laws of dialectics and science. This research method is the main and most common in the applied sciences.

***Ascension from the abstract*** is the process of cognition, according to which thinking goes from concrete in reality to abstract in thinking and from it to concrete in thinking.

In the first stage it is the transition from the sensually concrete, which is concrete in reality to its abstract definitions. A single object is deconstructed and described using a variety of concepts and judgments.

The second stage is the movement of thought from the abstract definitions of the object, i.e. from the abstract in cognition to the concrete in cognition. At

this stage the original integrity of the object is being restored, it is reproduced in all its versatility - but already in thinking.

***Idealization*** is the imaginary creation of objects and conditions that do not exist in reality and cannot be practically created. It enables to give real objects imaginary hypothetical unrealistic features that allow solving the task in its finished form (absolutely black body, ideal gas).

Idealization is achieved by multistage abstraction and valid only within certain limits.

***Formalization*** is a method of studying different objects, in which the basic laws of processes and phenomena are represented in sign form using formulae and special symbols.

The use of symbols and other sign systems allows us to establish patterns between the facts studied. The symbolism of artificial language (chemistry, mathematics and economics) allows to clearly and briefly capture certain values, without allowing different interpretations, which is not possible when using a common language.

***Creating a theory*** is the highest form of generalization and systematization of knowledge. It is a set of basic ideas, concepts and interpretations in a particular field of science, combined into one reliable system of knowledge about the object of theory.

Scientific theory must be adequate to the object or phenomenon being investigated, which allows the experimental studies to be replaced by theoretical ones within certain limits. The theory should be heuristic (prediction, explanation of the possibilities of theory) convenient (simple verification of the basic provisions of the theory) and simple (application of generalized laws, reduction and compaction of information).

***Analogy*** is a method by which new knowledge about objects or phenomena is obtained on the basis that they are similar to others.

# 2. EXPERIMENTAL RESEARCH METHODOLOGY

One of the most important parts of scientific research is ***experiment*** (from the Latin *experimentum* - trial, experiment) - a method of empirical research based on the active and purposeful intervention of the subject in the process of scientific knowledge of real phenomena and objects by creating conditions that are controlled and managed, that allow them to establish and reproduce certain qualities and regular relationships in the object under study.

The experiment is widely used not only in the natural sciences, but also in social practice, where it plays a significant role in the knowledge and management of social processes.

From ordinary, daily, passive observation, the experiment is distinguished by the active influence of the researcher on the phenomenon being studied.

## 2.1. The purpose and functions of scientific experiment

The main purpose of the experiment is to identify the properties of the objects being studied, to confirm the scientific hypotheses, and on this basis to ensure a broader and more in-depth study of the topic of scientific research.

Conducting experimental studies involves the implementation of a number of cognitive operations:

- defining the goals of the experiment on the basis of existing theoretical concepts, taking into account the needs of practice and development of science itself;

- theoretical substantiation of experimental conditions;

- development of basic principles, creation of technical means for conducting the experiment;

- observing, measuring and recording the properties, connections, trends of development of the object being investigated during the experiment;

- statistical processing of experimental results;

- preliminary classification and comparison of statistic data.

The experiment makes it possible to investigate, first, the objects in the so-called pure form; secondly, to do so in extreme conditions, which promotes a deeper penetration into their essence; third, an important advantage of the experiment is its repeatability. There are different types of experiments that can be classified by a number of attributes.

By the purpose of the object under study experiments can be: natural sciences (chemical, biological, physical), industrial, pedagogical, sociological, economic, etc.

By the nature of external influences on the object of study experiments can be: material, energy, information. A real experiment involves studying the effects of different material factors on the state of the object of study, such as the effect of different impurities on the quality of steel.

An energy experiment is used to study the effect of different types of energy (electromagnetic, mechanical, thermal, etc.) on the object of study. An informational experiment is used to study the effect of information on a research object.

By the nature of objects and phenomena studied the experiments can be: technological, socio-metric, etc. A technological experiment is aimed at studying the elements of a technological process (products, equipment, activities of workers, etc.) or the process as a whole. A socio-metric experiment is used to measure existing interpersonal socio-psychological relationships in small groups to further change them.

By the structure of objects and phenomena studied experiments can be: simple and complex. A simple experiment is used to study simple objects that have a small number of interrelated and interacting elements that perform simple functions. In a complex experiment, we study phenomena or objects with a branched structure and a large number of interconnected and interacting elements that perform complex functions.

By the way of forming the conditions experiments can be: natural and artificial. Natural experiments are characteristic of biological, social, pedagogical, psychological sciences, for example, in the study of social phenomena (social experiment) in various circumstances, such as production, life.

Artificial experiments are widely used in many natural or technical studies. In this case, the phenomena isolated to the desired state are studied in order to evaluate the quantitative and qualitative relationships.

By organization experiments can be: laboratory, field, production, open or closed, etc. Laboratory experiments are carried out using typical devices, special modeling plants, stands, equipment, etc. The field experiment is conducted in natural conditions and on real objects.

Depending on the venue, field experiments can be divided into production, open and closed experiments. These types of experiments are field, polygon, etc. Experiments are widespread in psychology, sociology, pedagogy.

In an open experiment, its tasks are openly explained to those under study, in a closed experiment - to obtain objective data, the tasks of the experiment are hidden.

By the nature of the interaction of the experimental research tool with the object of study experiments can be: conventional and model. An ordinary (classic) experiment involves the experimenter, the object of the experimental study, and the means by which the experiment is conducted. A model experiment is based on the use of a model object that can not only replace the actual object in the study, but also the conditions in which it is studied.

According to experimentally controlled values experiments can be: passive and active.

A passive experiment involves measuring only selected indicators (parameters, variables) as a result of observing an object without interfering with its functioning. An active experiment involves the selection of special inputs (factors) and controls the input and output of the system under study.

By the number of factors that vary in the study experiments can be: one-factor and multi-factor. A one-factor experiment involves: highlighting the necessary factors; stabilization of interfering factors; variation of factors of interest to the researcher. The strategy of a multi-factor experiment is that all variables are varied at once, and each effect is evaluated by the results of all the experiments conducted in this series of studies.

As to the purpose of research experiments can be: transformative, ascertaining, controlling, searching, decision making. A transformative (creative) experiment involves actively altering the structure and functions of the research object in accordance with the hypothesis, forming new relationships between the components of the object or between the object being studied and other objects. The ascertaining experiment is used to test the appropriate predictions. In the course of such an experiment, there is a definite relationship between the impact on the research object and the result.

The controlling experiment is reduced to controlling the results of external influences on the object of study, taking into account its condition, nature of the effect and the expected effect. Sometimes there is a need to conduct exploratory experimental studies. They are necessary if there are difficulties in classifying all the factors affecting the phenomenon being studied due to the lack of sufficient preliminary data.

A decision making experiment is designed to test the validity of the basic assumptions of fundamental theories in the case where two or more hypotheses are equally consistent with many phenomena. Such consistency leads to difficulties in determining the correctness of hypotheses. The decision making experiment answers the question "yes or no".

Experiments can be performed for different purposes, and their results will be different. One of the most common types of experiment is studies that allow us to determine the effect of an input factor (or factors) on the output (investigated) value. In this case, both qualitative and quantitative relationships can be explored. In the first case, only the nature of the relationship between the

input and output quantities is examined (if the input quantities are of a qualitative nature, or, for example, if it is only necessary to determine the nature of the influence of the input quantity on the output: as the value of the input parameter increases, the output value will increase or decrease, how sharp this increase or decrease is etc.). In order to establish a quantitative relationship, one must obtain an analytical relationship between a variable $y$ and one or more variables $x_1, x_2, \dots, x_k$. The resulting expression will be a statistical mathematical model of the phenomenon or process under study.

***The methodology of the experiment*** is the general structure (technique) of the experiment, that is, the formulation and sequence of the experimental studies.

The experiment includes the following main steps:

- developing a plan - an experiment program;

- evaluation of measurement and choice of means for conducting the experiment;

- conducting the experiment;

- processing and analysis of experimental data.

The given number of steps is characteristic of a traditional experiment. At the same time, mathematical theory of experiment has been widely used lately, which can greatly improve the accuracy and reduce the volume of experimental studies.

In this case, the experiment involves the following steps: developing a plan – an experiment program; evaluation of the measurement and choice of means for the experiment; mathematical planning of the experiment with simultaneous conducting of experimental research, processing and analysis of the obtained data.

Let us dwell a bit more on the individual stages of the experimental study.

## 2.2. Development of the experiment plan

The first task is to determine the purpose and objectives of the experiment, to determine the initial value to be investigated and the factors that have the greatest impact on it. The experiment plan contains the name of the research topic, the working hypothesis, the technique of the experiment, a list of required materials, devices, installations, a list of performers of the experiment, a calendar of works and an estimate for the experiment.

The plan includes the name of the research topic, the working hypothesis, the technique of the experiment, the plan of creating the experimental situation, the list of necessary materials, devices, installations, the list of performers of the experiment, the calendar plan of works and the cost estimate for the experiment. In some cases, the plan-program includes works on the design and manufacture of products, devices, apparatus, their methodological examination, as well as programs of research work at enterprises.

One of the most important steps in drawing up a program is to determine the ***purpose and objectives of the experiment***. Well-founded tasks are a significant contribution to solving them.

The basis of the program is the ***technique of conducting the experiment***. In the technique, the design of the experiment is projected in detail. First, the sequence of the measurement and observation operations is established. Then, each operation is carefully described, taking into account the means chosen for the experiment. Particular attention is paid to the methods of quality control of operations, which should provide with a minimum (previously established) number of measurements high reliability and set accuracy. Journal forms to record measurement results and observations are developed.

The rationale for measuring instruments is the choice of instruments, equipment, machines, apparatus, etc. required for observations and measurements. A very important part is to establish the accuracy of

measurements and errors. Measurement methods should be based on the laws of metrology science.

An important section of the methodology is the choice of methods for processing and analysis of experimental data. Data processing is reduced to systematization of all figures, classification and analysis. The results of the experiments should be summarized in such forms of records - tables, graphs, formulae, which allow to quickly and accurately correlate the obtained results. Particular attention in the methodology should be given to mathematical methods of processing and analysis of the obtained experimental data - the establishment of empirical dependencies, the approximation of the relationship between the varying characteristics, the establishment of criteria, etc.

After the development of the methodology the volume and complexity of experimental studies, which depend on the depth of theoretical developments, the degree of accuracy of the measurement tools are determined. The clearer the theoretical part of the study is formulated, the smaller the volume of the experiment. The size and complexity of the experiment is significantly influenced by the type of experiment.

After establishing the volume of the experimental work, a list of necessary measuring instruments, materials, a list of performers, a calendar plan and a cost estimate are established.

Equally important is the indispensable development of a so-called experimental situation plan within the experimental program plan. ***An experimental situation*** is a set of conditions under which an experiment is conducted.

An experimental situation plan is always associated not only with the tasks, the methodology, but also with the specific object on which the tasks are to be solved and the methodology itself to be implemented.

At the end, the plan of the experimental study is considered by the scientific supervisor, discussed in the scientific team and approved in due course.

***Measurement evaluation and selection.*** The rationale for measuring instruments is the choice of instruments, equipment, machines, apparatus, etc. required for observations and measurements. Measuring instruments may be standard or manufactured individually.

A very important part is to establish the accuracy of measurements and errors. Measurement methods should be based on the laws of special science – metrology.

### 2.3. Conducting the experiment

***Conducting the experiment.*** Experimental studies should be carried out in accordance with the approved plan-program and experimental procedure. It is mandatory to keep a research journal. The result of the experiment will largely depend on the correct choice of research methods, on the accuracy and conformity of the laboratory equipment, and on the integrity and responsibility of the researcher.

Conducting an experiment is a crucial and time-consuming step. Experimental studies should be carried out in accordance with the approved program plan and especially the experimental methods. At the beginning of the experiment, the method of its conduct and the sequence of tests are finally specified. The following general requirements must be met when conducting the experiment:

- the object of study should correspond to the system of variables that determine its functioning;

- qualitative and quantitative measurements of factors that affect the object of study, change its state or behavior during the experiment should be provided;

- the description of the object of the experimental study should be made in the system of its components;

- mandatory definition and description of the conditions of existence of the object under study;

- a clearly established experimental hypothesis about the existence of cause and effect relationships should be provided;

- substantive definition of the concepts of the hypothesized experiment should be stated;

- reasonable allocation of independent and dependent variables is required;

- the description of the specific conditions of activity of the research object (place, time, socio-economic situation, etc.) is required.

The workplace of the experimenter is the part of the workspace that is directly affected by the experimenter in the research process. The workspace is a part of a laboratory or workroom equipped with the necessary experimental facilities, serviced by one or a group of researchers. Workspace can be stationary (in laboratories, research facilities, landfills, etc.); conditionally stationary (in mobile laboratories, on temporary landfills); mobile (in moving laboratories).

***The laboratory*** is a specially equipped room for experimental research. The researcher (experimenter) in the laboratory performs responsible work, which depends on the correctness of the theoretical or practical problem in general. Accuracy in the execution of the study methodology, diligence in planning and preparation of the experiment, care in its conduct – are the basic conditions for the effectiveness of the experimental work. An essential requirement for experimenting is to keep a journal. The log form may be arbitrary, but it is best to follow the process under study for maximum fixation of all factors. In the process of experimental work it is necessary to strictly comply with the requirements of industrial sanitation, personal safety, fire safety. The results of some laboratory and most production experiments are formulated in a protocol signed by the production manager and experimenter.

## 2.4. Experimental data processing

***Processing and analysis of experimental data.*** The experiment ends with a transition from empirical study to processing of the obtained data, logical generalizations, analysis and theoretical interpretation of the obtained factual material. Different modern software products, such as Mathcad, SPSS, and STATISTICA can be used to process and analyze experimental data.

Data processing is reduced to systematization of all received figures, classification and analysis. The results of the experiments should be presented in readily accessible formats such as tables, graphs, formulae etc. Particular attention is paid to the analysis of research data – the establishment of empirical dependencies, the approximation of relationships between characteristics, the establishment of criteria and confidence intervals. That is, you need to get an analytical expression - the relationship between the input value $x$ and the response function $y$. Statistical analysis methods are widely used at this stage.

For example, consider a study related to improving the quality of polyvinyl chloride (PVC) products. As a function of response, we take the tensile strength of the test sample of PVC, the input parameter is the percentage of filler added to the material during its processing.

The experiment is carried out as follows: under the same conditions of processing experimental samples containing different amount of filler are made, each of them is signed. Specimens are tested on a breaking machine and the results are recorded. The received data is written to the table 2.1.

The next stage is the processing of the experimental data obtained. An analytical formula should be established to describe the relationship between the input quantity (filler amount) and the output (specimen strength).

The process of selecting empirical formulae consists of two steps. In the first stage, the measurement data is plotted on a grid of rectangular coordinates, the experimental points are connected with a smooth curve, and the approximate formula is chosen.

Table 2.1

Experimental data

| Specimen number | Amount of filler $c$, % | Tensile strength $\sigma$, MPa |
|---|---|---|
| 1 | 0 | 2,5 |
| 2 | 2 | 3,0 |
| 3 | 4 | 3,5 |
| 4 | 6 | 4,1 |
| 5 | 8 | 4,2 |
| 6 | 10 | 4,8 |
| 7 | 12 | 5,0 |
| 8 | 14 | 5,1 |
| 9 | 16 | 4,7 |
| 10 | 20 | 4,0 |

In the example (Fig. 2.1), the desired dependence most likely looks like a parabola - function of the form $f(x) = a_0 + a_1x + a_2x^2$.

In the second step an approximation is performed - some analytical function is defined that roughly describes the experimental points obtained, that is, calculate the parameters that will best fit the formula. However, you do not need to find a dependency that exactly goes through all the experimental points, since it is known in advance that the experimental data contain errors. The selection of empirical formulae should start with the simplest expressions. The simplest option is to approximate by a straight line (first degree polynomial).

The choice of functional dependence is normalized problem, since the same curve in a given area can be described with different analytical dependencies with approximately the same accuracy. Even in the widespread use of computers, the decision to choose a mathematical model remains after the researcher. Only the experimenter knows for what purposes in the future this model will be used, based on which concepts its parameters will be interpreted.

Mathcad allows you to select different types of dependencies. Let's look at some of them.

$PE :=$

| | 0 | 1 |
|---|---|---|
| 0 | 0 | 2.5 |
| 1 | 2 | 3 |
| 2 | 4 | 3.5 |
| 3 | 6 | 4.1 |
| 4 | 8 | 4.2 |
| 5 | 10 | 4.8 |
| 6 | 12 | 5 |
| 7 | 14 | 5.1 |
| 8 | 16 | 4.7 |
| 9 | 20 | 4 |

$c := PE^{\langle 0 \rangle}$ $\sigma := PE^{\langle 1 \rangle}$

$c =$

| | 0 |
|---|---|
| 0 | 0 |
| 1 | 2 |
| 2 | 4 |
| 3 | 6 |
| 4 | 8 |
| 5 | 10 |
| 6 | 12 |
| 7 | 14 |
| 8 | 16 |
| 9 | 20 |

$\sigma =$

| | 0 |
|---|---|
| 0 | 2.5 |
| 1 | 3 |
| 2 | 3.5 |
| 3 | 4.1 |
| 4 | 4.2 |
| 5 | 4.8 |
| 6 | 5 |
| 7 | 5.1 |
| 8 | 4.7 |
| 9 | 4 |

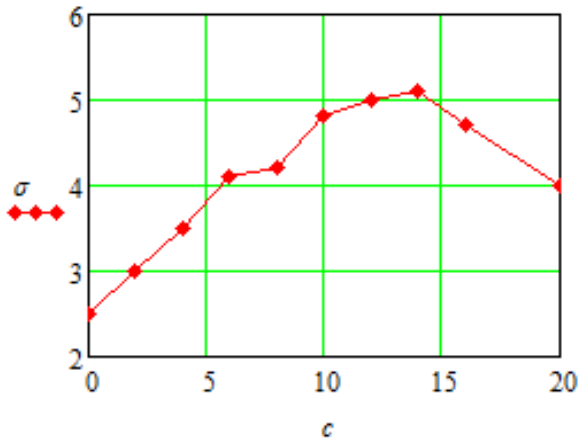



Fig. 2.1. Construction of experimental points and approximate determination of dependency type

***1. Linear regression.*** Linear dependence is an expression of the form $y = b_0 + b_1 x$. The *line* function is used to determine the coefficients of linear dependence. This function has the format of *line (x, y).* The linear approximation for our example is presented in Fig. 2.2. The approximation function in this case is of the form $y = 3.181 + 0.099x$.

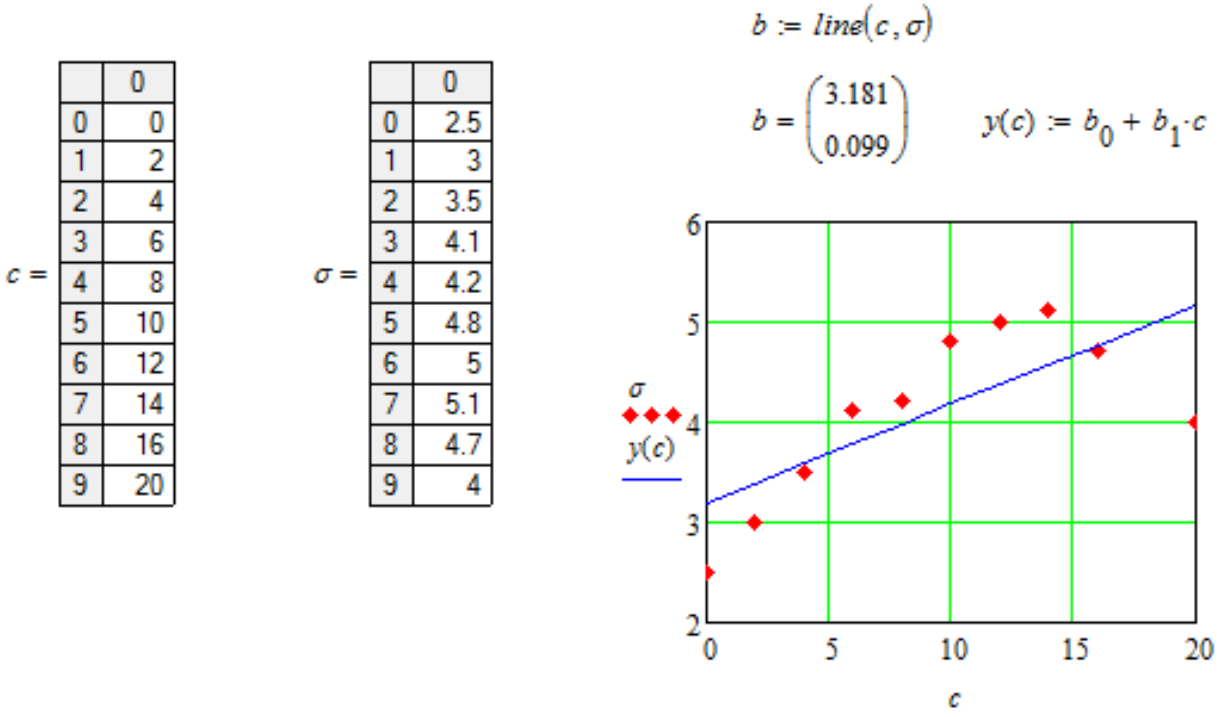



Fig. 2.2. Approximation of experimental points by linear regression

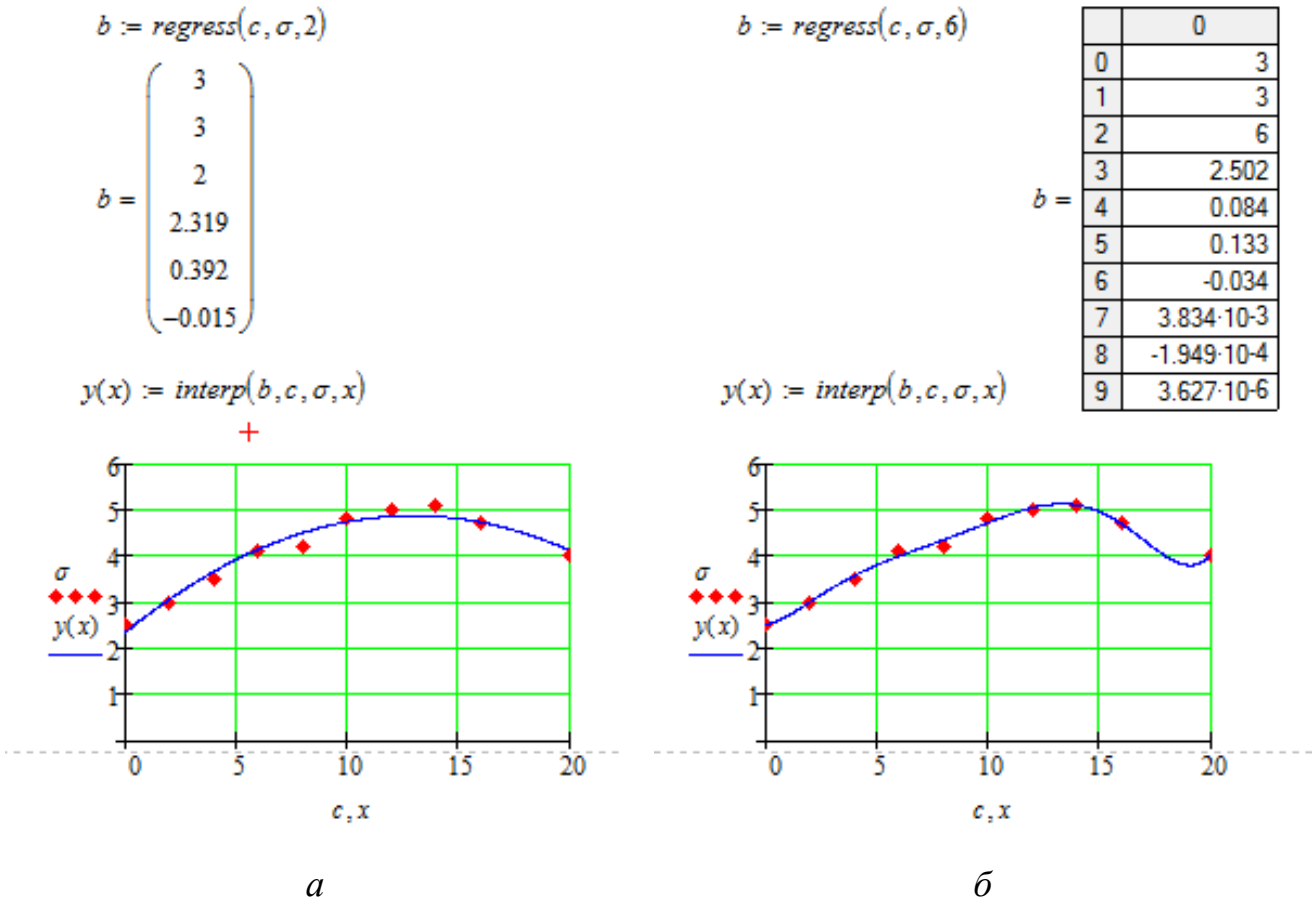
***2. Polynomial regression.*** Polynomial regression implies approximation of the experimental data by a k-degree polynomial: $y = b_0 + b_1 x + b_2 x^2 + b_3 x^3 \ldots$

In Mathcad, polynomial regression is implemented by a combination of *regress* and *interp* functions. The *regress* function is ancillary; it prepares the data required for the *interp* function to work. The format of recording these functions:

*regress (x, y, k)* is a vector of coefficients for constructing polynomial regression of data, where k is the desired degree of polynomial;

*interp (s, x, y, t)* is the result of polynomial regression.

Fig. 2.3 shows the approximation of the required dependence by a polynomial of the 2nd degree (Fig. 2.3a) and a polynomial of the 6th degree (Fig. 2.3b).




*а* *б*

Fig. 2.3. Approximation of experimental points by polynomial regression:
*a* - polynomial of the 2nd degree; *b* - polynomial of 6th degree

The *regress* function returns a vector in which the elements, starting with the fourth, are the coefficients of the approximating polynomial. That is, for the example under consideration, the approximating polynomial regression will look like:

for a 2nd degree polynomial: $y = 2.319 + 0.392x - 0.015x^2$

for a 6th degree polynomial: $y = 2.502 + 0.084x + 0.133x^2 - 0.034x^3 +$

$$+ 3.834 \cdot 10^{-3} x^4 - 1.949 \cdot 10^{-4} x^5 + 3.6279 \cdot 10^{-6} x^6 .$$

Obviously, in this case it is not necessary to select a polynomial of such a high degree, since the coefficients, starting with $x^4$, are negligible. They do not play any role, but significantly complicate the model. Care must be taken in choosing the type of dependency, as high detail will complicate the model, make

it cumbersome and difficult to calculate, and excessive simplification may cause the model to be unable to adequately describe the process under study.

***3. Other types of regressions.*** In addition, several types of three-parameter regressions are built into Mathcad.

Their implementation is slightly different from the above regression variants in that, in addition to the data set, some initial values of the coefficients *a, b,* and *c* are required.

An appropriate type of regression can be used if you can well imagine what dependency describes the considered data set. When a type of regression reflects poorly the sequence of data, its result is often unsatisfactory and may even vary greatly depending on the choice of initial values. Each function outputs a vector of specified parameters a, b, and c.

*expfit (x, y, g)* is the regression of the exponent $y = a_0 e^{a_1 x} + a_2$;

*igsfit (x, y, g)* - regression by logistic function $y = \frac{a_0}{1 + a_1 e^{-a_2 x}}$;

*sinfit (x, y, g)* is a sine wave regression $y = a_0 \cdot \sin(x + a_1) + a_2$;

*pwfit (x, y, g)* - regression by power function $y = a_0 x^{a_1} + a_2$;

*logfit (x, y, g)* is a regression by a logarithmic function $y = a_0 \ln(x + a_1) + a_2$;

*infit (x, y)* is a regression by a two-parameter logarithmic function $y = a_0 \ln(x) + a_1$.

In these expressions: *x, y* are vectors containing input and output values, and *g* is a three-element vector that sets the initial values.

***4. Approximation by a linear combination of functions.*** Mathcad offers users a built-in *linfit* function to approximate least squares data with a linear combination of arbitrary functions.

The *linfit* function has three arguments:

- vector *x* – *x*-coordinates of given points,

- vector $y$ – $y$-coordinates of given points,

- function $F$ – contains a set of functions that will be used to construct a linear combination.

Consider using this function for our example (Fig. 2.4).

$PE :=$

| | 0 | 1 |
|---|---|---|
| 0 | 0 | 2.5 |
| 1 | 2 | 3 |
| 2 | 4 | 3.5 |
| 3 | 6 | 4.1 |
| 4 | 8 | 4.2 |
| 5 | 10 | 4.8 |
| 6 | 12 | 5 |
| 7 | 14 | 5.1 |
| 8 | 16 | 4.7 |
| 9 | 20 | 4 |

$c := PE^{\langle 0 \rangle}$

$\sigma := PE^{\langle 1 \rangle}$

$F(x) := \begin{pmatrix} 1 + x \\ x^2 \\ sin(x) \end{pmatrix}$

$K := linfit(c, \sigma, F)$ $\quad K = \begin{pmatrix} 0.726 \\ -0.029 \\ 0.162 \end{pmatrix}$ $\quad y(x) := K \cdot F(x)$

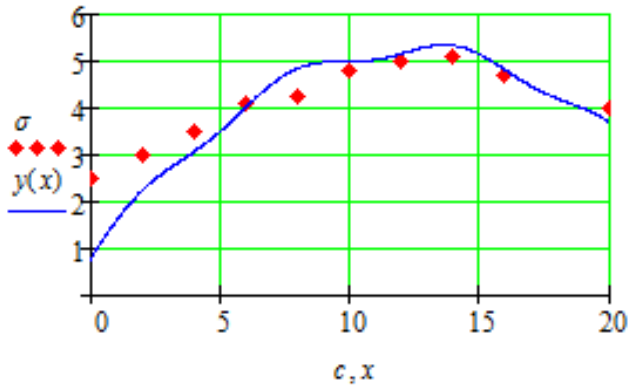



Fig. 2.4. Approximation of experimental points by a combination of functions

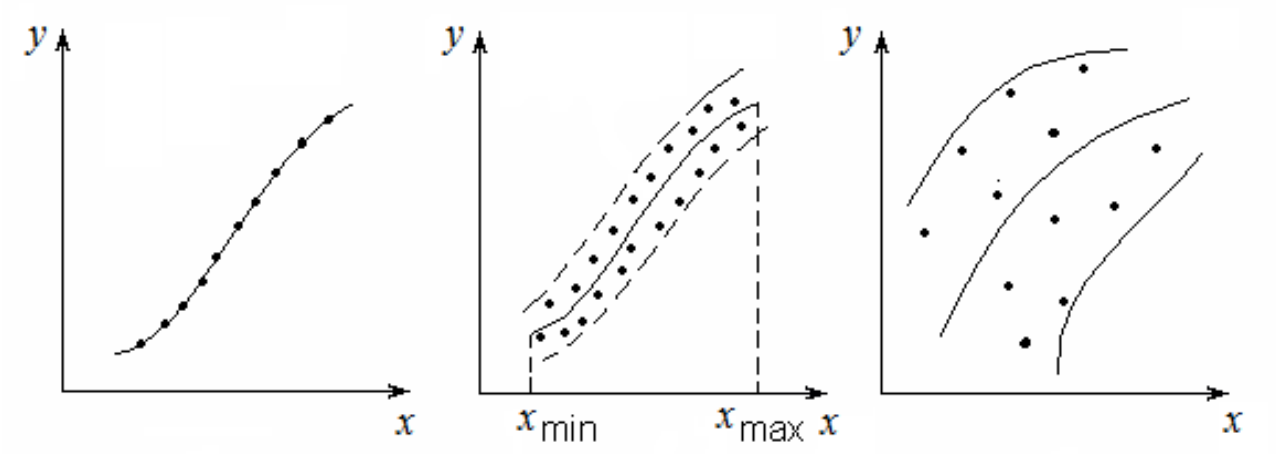
The vector $K$ is a vector of coefficients for the corresponding members of function $F$. In the example considered, the approximating function will be: $y(x) = K \cdot F(x) = 0.726(1+x) - 0.029x^2 + 0.162\sin(x)$.

You can select any number of functions of any type as function *F*. With a successful selection, you can get an approximation of the required accuracy.

Therefore, as a result of processing the experimental data, the researcher obtains a dependency that describes the relationship between the input factor (factors) and the function being investigated.

This dependence is an empirical model of the process. With this model, you can predict the behavior of the object under different conditions and determine the optimal process parameters or limits for the corresponding parameters, etc.

In addition to determining the regression line equation, it is worth quantifying the relationship between the two sets of observations *x* and *y*. Closeness refers to the closeness of the experimental data grouping to the accepted model equation. Fig. 2.5 shows the types of connections that can be observed in an experiment.




*a* *b* *c*

Fig. 2.5. Types of connections:

*a* - functional connection, all points lie on the line;

*b* - the connection is tight enough, the points are clustered around the regression line, but not all lie on it;

*c* - connection is weak

Of course, the closer the experimental points are located around the approximation curve, the more reliable the model is. Significant scattering of points around the curve may indicate that the measurement errors are unacceptably large or the selection of input parameters is unsuccessful.

For example, if in our study of the strength of a PVC sample as the input parameter we select the ambient temperature, then it is obvious that we will get a set of unrelated points. Their approximation is likely to be impossible since there is no relationship between ambient temperature (under normal conditions, without extreme heating or cooling to very low temperatures) and the strength of the polymer product.

The same pattern will be observed if all the factors that have a significant impact on the process under study have not been taken into account. The stronger the influence of unaccounted factors, the further the points will be from the regression line.

The measure of correlation between the dependent random variables is the correlation coefficient. It shows how well, on average, one of the values can be represented as a function of the other.

The correlation coefficient can range from ± 1 (functional dependence when all measured points lie on the regression line) to 0 (no correlation between the factor $x$ and the response $y$ in the regression equation).

You can determine the correlation coefficient in the Mathcad environment using the *corr (x, y)* function.

In Fig. 2.6–2.10 some other examples are given of linear, exponential, polynomial, and generalized regression dependencies of the original variable $y$ on the input variable $x$ obtained when processing the results of experimental studies in the Mathcad environment.

$$VX := \begin{pmatrix} 0.95 \\ 1.8 \\ 2.9 \\ 4.1 \\ 4.8 \end{pmatrix} \qquad VY := \begin{pmatrix} 4.2 \\ 11 \\ 15 \\ 19 \\ 24 \end{pmatrix}$$

$$ORIGIN := 1$$

$a := intercept(VX, VY)$ $\qquad$ $b := slope(VX, VY)$

$i := 1..5$ $\qquad$ $f(x) := a + b \cdot x$

$a = 0.938$ $\qquad$ $b = 4.709$ $\qquad$ $corr(VX, VY) = 0.987$

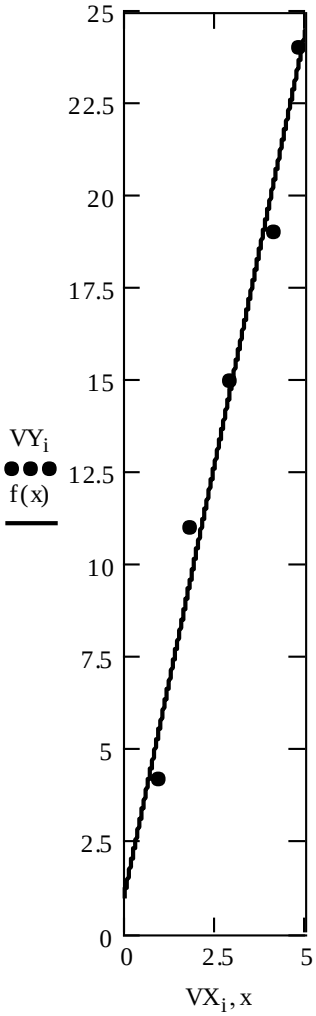



Fig. 2.6. Linear regression in Mathcad

$$x := \begin{pmatrix} 2 \\ 4 \\ 6 \\ 8 \\ 9 \end{pmatrix} \qquad y := \begin{pmatrix} 3.5 \\ 6.2 \\ 13 \\ 23 \\ 38 \end{pmatrix}$$

$$f(x, a, b, c) := a \cdot \exp(b \cdot x) + c$$

$$S := \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix}$$

$$K := \text{expfit}(x, y, S)$$

$$K = \begin{pmatrix} 0.554 \\ 0.459 \\ 2.713 \end{pmatrix}$$

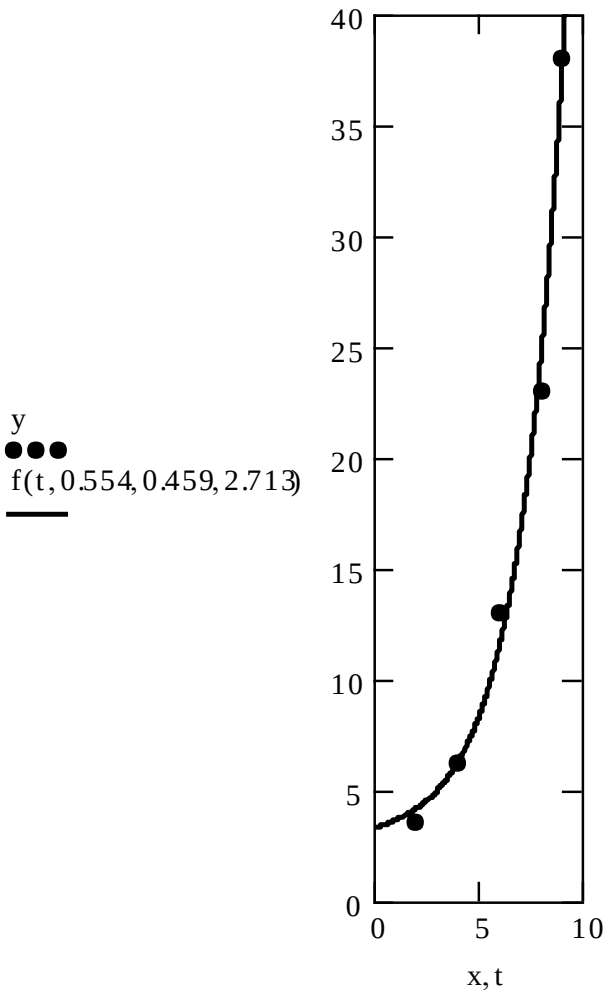



Fig. 2.7. Exponential regression in Mathcad

$$x := \begin{pmatrix} 2 \\ 4 \\ 6 \\ 8 \\ 10 \end{pmatrix} \qquad y := \begin{pmatrix} 3.5 \\ 6.2 \\ 13 \\ 23 \\ 43 \end{pmatrix}$$

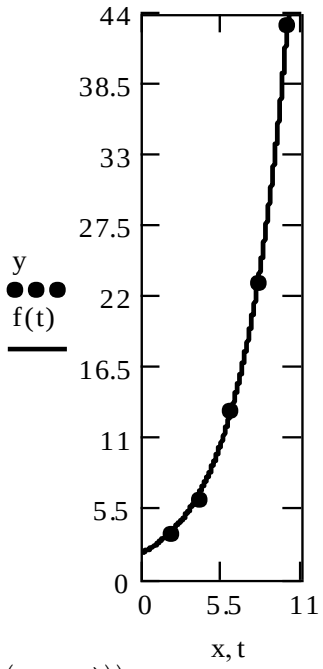
$f(x, a, b) := a \cdot \exp(b \cdot x)$ $\quad a := 1 \quad b := 1$

Given

$f(x_0, a, b) = y_0 \quad f(x_1, a, b) = y_1 \quad f(x_2, a, b) = y_2 \quad f(x_3, a, b) = y_3 \quad f(x_4, a, b) = y_4$

$\begin{pmatrix} a \\ b \end{pmatrix} := \text{MinErr}(a, b) \qquad a = 1.933 \qquad b = 0.31$

$f(x) := a \cdot \exp(b \cdot x)$




$a1 := \exp\left(\text{intercept}\left(x, \overrightarrow{\ln(y)}\right)\right) \qquad b1 := \text{slope}\left(x, \overrightarrow{\ln(y)}\right)$

$f1(x) := a1 \cdot \exp(b1 \cdot x)$

$a1 = 1.839 \qquad b1 = 0.316 \qquad \text{corr}\left(x, \overrightarrow{\ln(y)}\right) = 0.999$

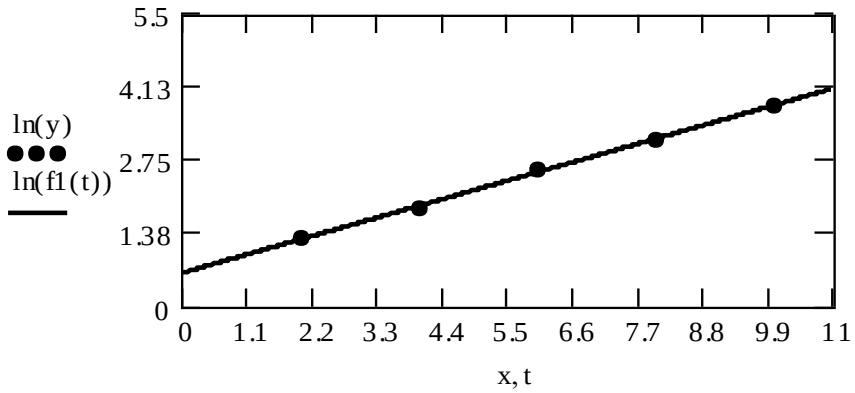



Fig. 2.8. Exponential and linearized regressions in Mathcad

$$\text{data} := \begin{pmatrix} 5 & 16 \\ 10 & 21 \\ 15 & 25 \\ 20 & 23 \\ 25 & 15 \end{pmatrix}$$

$$X := \text{data}^{\langle 0 \rangle} \qquad Y := \text{data}^{\langle 1 \rangle} \qquad n := \text{rows}(\text{data})$$

$$k := 2 \qquad S := \text{regress}(X, Y, k)$$

$$\text{fit}(x) := \text{interp}(S, X, Y, x) \qquad \text{coeffs} := \text{submatrix}(S, 3, \text{length}(S) - 1, 0, 0)$$

$$\text{coeffs}^{T} = (4 \quad 2.743 \quad -0.091)$$

$$\frac{\overrightarrow{\sum (\text{fit}(X) - \text{mean}(Y))^2}}{\overrightarrow{\sum (Y - \text{mean}(Y))^2}} = 0.962$$

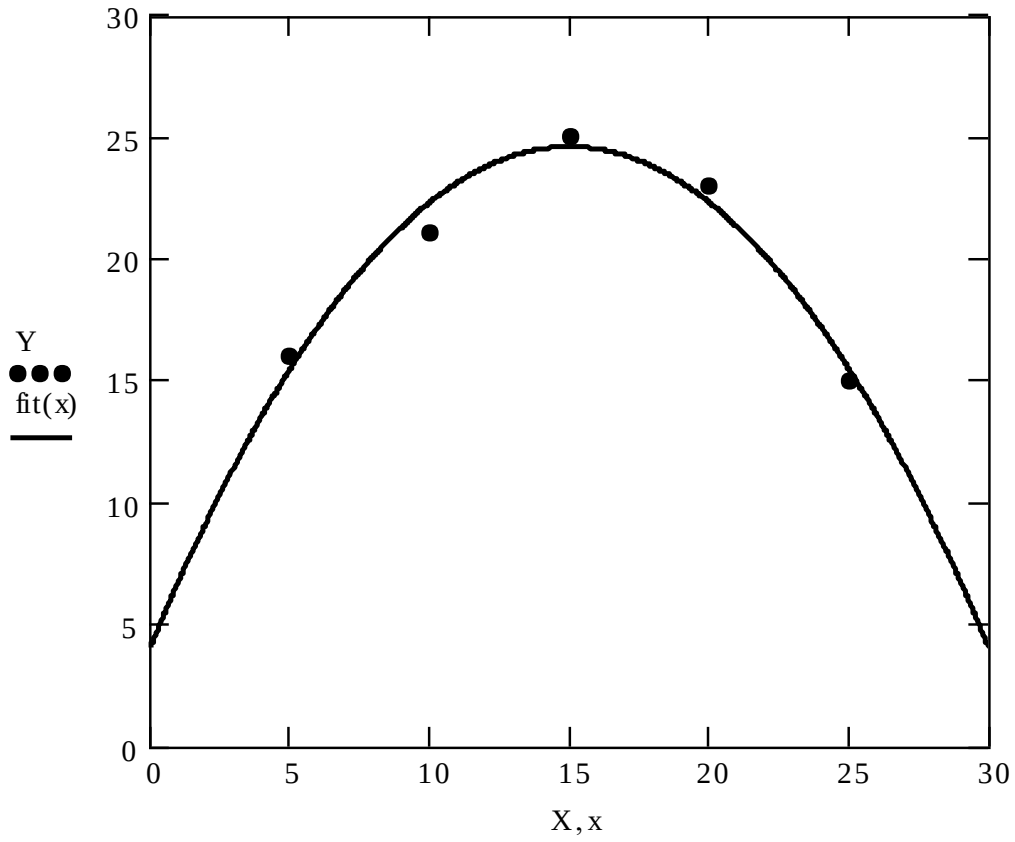



Fig. 2.9. Second-degree polynomial regression in a Mathcad

$$VX := \begin{pmatrix} 1 \\ 2 \\ 3 \\ 4 \\ 4.8 \end{pmatrix} \qquad VY := \begin{pmatrix} 12 \\ 7.5 \\ 9.4 \\ 16.2 \\ 26 \end{pmatrix}$$

$$F(x) := \begin{pmatrix} \frac{1}{x} \\ x^2 \\ \exp(x) \end{pmatrix}$$

$$K := \text{linfit}(VX, VY, F)$$

$$K = \begin{pmatrix} 11.017 \\ 0.4 \\ 0.12 \end{pmatrix}$$

$$g(t) := F(t) \cdot K$$

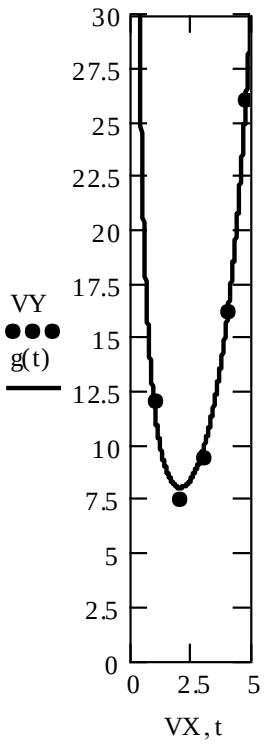



Fig. 2.10. Generalized regression in Mathcad

# 3. MATHEMATICAL PLANNING AND ANALYSIS OF EXPERIMENTAL RESEARCH

In the previous chapter, the method of conducting and processing the results of a ***one-factor*** experiment, that is, an experiment in which the influence of one factor on the function under study was considered.

Such an experiment is carried out by performing a number of measurements at individual times of a single input parameter - factor $x$ and the corresponding values of the output parameter - response $y$. The purpose of such an experiment is to obtain the dependence $y = f$ (x), which will be a mathematical model of the process under study.

## 3.1. Planning of experiment

The geometric representation of the response function in the factor space is the response surface. In a one-factor experiment, the response surface will be a flat curve. It can have any appearance - linear dependence, parabola, hyperbola, exponential, sine wave and so on. But in any case the figure constructed on this dependence will look like a curve on the plane, since the equation $y = f(x)$ includes only one variable – $x$.

**Example.** The quality of the adhesive compound was investigated. The experiment was carried out as follows: a layer of glue was applied to two leather strips, then the interconnected strips were kept under pressure, and then the tensile strength of the obtained connection was determined. The response function was the effort of breaking the test compound $\sigma$, MPa. Bonding pressure, $P$, MPa was chosen as a factor affecting the bond strength.

A series of experiments were carried out during which different values of the bonding pressure produced experimental samples, each of which indicated the applied pressure. After 24 hours, the specimens were tensile: the edges of the upper and lower strips were fixed in the clamps of the tensile machine and the

force at which the delamination of the specimen occurred was recorded. The data obtained (the bonding pressure of the sample and the corresponding tensile strength) were summarized in the table.

As a result of processing the obtained experimental data, a regression dependence of the bonding strength on the pressure applied during bonding was established $\sigma = f(P) = 0.000136 + 0.000097P$. This empirical model can later be used to predict the reliability of the adhesive connection using this adhesive composition - that is, substituting in the formula any arbitrary pressure value, you can calculate the strength that will be provided.

If it is necessary to establish the influence of several factors on a certain process, then a ***multi-factor*** experiment is conducted. As a result of processing the results of such an experiment, we obtain a function of the form $y = f(x_1, x_2, \ldots, x_k)$, where $k$ - is the number of factors. The response surface in a two-factor experiment ($k = 2$) is a surface in three-dimensional space (Fig. 3.1).

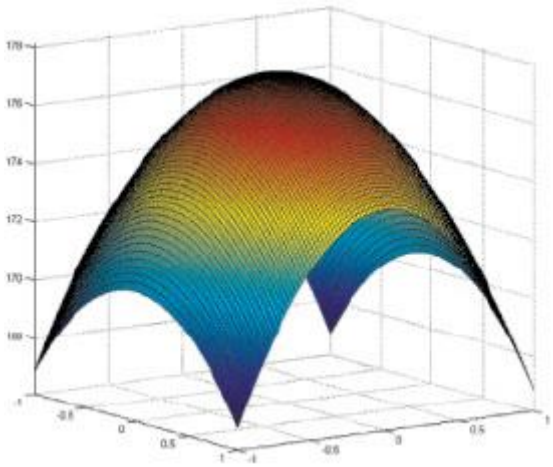


Fig. 3.1. Response surface in a two-factor experiment

To build such a complex figure requires a large number of experimental points, for which it takes a lot of experiments.

In some cases, a multifactorial experiment is performed on the same principle as a one-factor experiment. In the first stage of the study, a series of experiments is conducted in which the value of only the first factor changes,

while the values of other factors stabilize at a stable level - the dependence of the influence of the first factor on the process is obtained. Then change the second factor, leaving unchanged others, etc. However, this method involves a large amount of work and does not allow to obtain a complete mathematical model of the object in the form $y = f(x_1, x_2, \ldots, x_k)$. Therefore, in practice, they often resort to a more effective planned experiment, which allows each experiment to change all factors at the same time.

***Experiment planning*** is a set of techniques that allow the researcher to optimally position the experiment according to the purpose of the study and to obtain the maximum information in a limited number of experiments, as well as to properly process and interpret the results of the experiment.

The experiment planning method has great advantages that provide:

- high efficiency, that is, to obtain the necessary information is put a minimum number of experiments;

- simultaneous study of the impact of several variable parameters of the object on its performance;

- Minimize experiment errors by using custom checks.

Experiment planning mainly uses ***first- and second-order plans***. Higher order plans are rarely used in engineering practice.

### 3.2. First-order plans

***First-order plans*** are those plans that allow you to experiment to find a regression equation that contains only the first power factors and their productions. For example, in the case of two factors, the mathematical model obtained in this way would look like:

$$\hat{y} = b_0 + b_1x_1 + b_2x_2 + b_3x_1x_2$$

Finding the regression equation by experiment planning involves the following major steps:

- selection of the response function, the main factors and their levels, the type of experiment;

- planning and conducting the experiment;

- determination of regression equation coefficients;

- statistical analysis of the results of the experiment.

Consider in detail the algorithm for the preparation and conduct of experimental studies.

***1. The response function y is selected*** - a parameter that allows you to judge the change in the state of an object. This parameter must be quantitative, that is, given a number, and should be easily determined after each experiment.

***2. The factors $x_1$, $x_2$, …, $x_k$, are established***, which have a significant influence on the investigated value and their levels are determined - the limits within which these factors may change.

***Factor –*** is a measurable value that, at some point in time, determines the values and influences the object of study.

If some factor goes unaccounted for and assumes different values in the experiments that are not controlled by the experimenter, this will significantly increase the error of the experiment and may lead to an inadequate model. On the other hand, an excess of factors increases the number of experiments and makes the resulting model cumbersome and difficult to use. Therefore, the choice of factors is an important step in the experiment.

For the intended experiment, the factors must not only be easy to measure but also manageable. That is, it should be possible to maintain the necessary value of the factor throughout the experience.

The factors must also be independent of each other - if it is not possible to establish a factor at any level, regardless of the levels of other factors, then the planning of the experiment will not be possible.

A factor is considered to be given if its name and scope are specified.

Selected factors for the experiment are called the ***factor level***.

In the design of the experiment, the values of the factors corresponding to the determined levels are expressed in coded values.

***The factor variation interval*** is the difference between its two values, taken as the unit of coding.

Particular attention is paid to the choice ***of zero (main) factor level***. If a factor definition area is specified, then the center of the factor area is taken as zero point. After setting the zero point, the intervals of variation of factors are selected. This is due to the determination of the values of the factors that in the coded values correspond to the levels +1 and -1.

***Example.*** In the experiment, the factor varies in the range from 240 to 300 ºC. Then the zero level (0) is assumed to be 270 ºC, and the factor variation interval is 30 ºC. Level (-1) corresponds to 240 ºC and level (+1) to 300 ºC (Fig. 3.2).

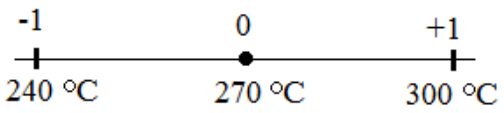



Fig. 3.2. Variation interval

When conducting experiments in different order, the factors may vary at different levels, ie, take values that correspond to levels -1; 0; +1 and more. The number of these levels depends on the amount of experiment and the order of equation that will be obtained. In the general case, the number of experiments is determined depending on the number of factors and the number of levels of their variation as:

$$N = p^n,$$

where $N$ - is the number of experiments; $p$ - is the number of levels of factors; $n$ - is the number of factors.

The minimum number of levels is 2 - the upper and lower levels are denoted by +1 and -1. This number of levels is sufficient to carry out a first-

order experiment that allows one to obtain a linear model. Higher order models require 3, 4, 5 levels, and the presence of odd levels indicates that experiments are conducted including at zero point.

***3. The type of experiment plan is selected.***

In the first stage of research, as a rule, conduct a full first-order factor experiment. The linear model thus obtained contains the smallest number of coefficients, respectively, requiring a minimum number of experiments. If the resulting model is not effective, then move to higher order plans.

During a full-scale first-order factor experiment, factors can acquire in two experiments only two values - upper (+1) and lower (-1) levels.

The number of possible combinations of factors determines the number of different experiments that must be performed to obtain the regression equation. This number of experiments is defined as $N = 2^n$ (for example, for 3 factors $N = 2^3 = 8$). The total number of experiments is calculated taking into account parallel experiments.

***Parallel experiments*** are experiments conducted under the same conditions (ie, at the same point in the factor space). Parallel experiments should be conducted to eliminate the possibility of gross errors, as well as to check the reproducibility of the process and the calculation of the error of the experiment.

If the experiment is conducted with the same number of parallel experiments at each point in the factor space, then the total number of experiments is equal. For example, for three factors in two parallel experiments, the total number of experiments will be $2^3 \cdot 2 = 16$.

When planning an experiment, the values of the factors encode:

$$X_i = (x_i - X_{i0}) / \Delta X_i, \qquad (3.1)$$

where $X_i$ – is the coded value of the factor (dimensionless value); $x_i$ – is the natural value of the factor; $X_{i0}$ – is the zero value of the factor; $\Delta X_i$ – is the factor variation interval.

Factors in coded (dimensionless) form in a full-scale first-order experiment can take the following values:

$$\begin{aligned} \left(X_{i\max} - X_{i0}\right)/\Delta X_i &= +1 \\ \left(X_{i\min} - X_{i0}\right)/\Delta X_i &= -1 \end{aligned} \qquad (3.2)$$

***Construction of the planning matrix and the working matrix of the experiment.*** A plan containing all or a combination of factors in a coded form is called a ***planning matrix.***

Drawing up such a matrix for two factors is not difficult – for four experiments, all possible combinations of factors can be easily found by simple alternation (Table 3.1).

Table 3.1

Combinations of factors

| Experiment number | $x_1$ | $x_2$ |
|---|---|---|
| 1 | +1 | + 1 |
| 2 | -1 | + 1 |
| 3 | +1 | -1 |
| 4 | -1 | -1 |

With the increasing number of factors, this task is complicated. There are several ways to build a scheduling matrix for a multivariate experiment. The simplest of them is based on alternating characters. In the first column, the characters alternate alternately, in the second – after 2, in the third – after 4, etc. by degrees two $2^n$.

The planning matrix thus obtained for the 8 experiments is presented in Table 3.2.

In order to be able to conduct the experiment according to the developed plan, it is necessary to establish the natural (non-coded) values of the factors in each experiment - to make a working matrix of the experiment.

***A working matrix*** is a matrix in which all coded factor values are replaced by their natural values.

According to the entries in the working matrix is an experiment. Table 3.3 presents an example of a working matrix, obtained on the basis of the planning matrix presented in Table. 3.2.

After conducting the experiments, their results are recorded in the working matrix (Table 3.4).

Table 3.2

Planning matrix

| Experiment number | $x_1$ | $x_2$ | $x_3$ |
|---|---|---|---|
| 1 | +1 | + 1 | + 1 |
| 2 | -1 | + 1 | + 1 |
| 3 | +1 | -1 | + 1 |
| 4 | -1 | -1 | +1 |
| 5 | + 1 | + 1 | -1 |
| 6 | -1 | + 1 | -1 |
| 7 | +1 | -1 | -1 |
| 8 | -1 | -1 | -1 |

Table 3.3

Working matrix

| Experiment number | $X_1$,Amp | $X_2$, Ohm | $X_3$,Volt |
|---|---|---|---|
| 1 | 15 | 30 | 225 |
| 2 | 7 | 30 | 225 |
| 3 | 15 | 18 | 225 |
| 4 | 7 | 18 | 225 |
| 5 | 15 | 30 | 215 |
| 6 | 7 | 30 | 215 |
| 7 | 15 | 18 | 215 |
| 8 | 7 | 18 | 215 |

Table 3.4

Working matrix with the results of the experiment

| Experiment number | $X_1$, Amp | $X_2$, Ohm | $X_3$, Volt | $Y_1$, sec | $Y_2$, sec | $Y_m$, sec |
|---|---|---|---|---|---|---|
| 1 | 15 | 30 | 225 | 102 | 105 | 102 |
| 2 | 7 | 30 | 225 | 108 | 103 | 108 |
| 3 | 15 | 18 | 225 | 90 | 85 | 90 |
| 4 | 7 | 18 | 225 | 85 | 87 | 85 |
| 5 | 15 | 30 | 215 | 103 | 104 | 103 |
| 6 | 7 | 30 | 215 | 100 | 97 | 100 |
| 7 | 15 | 18 | 215 | 110 | 115 | 110 |
| 8 | 7 | 18 | 215 | 98 | 100 | 98 |

**5. Drawing up a table of the full factor experiment.**

After the experiment, they compile a table, which in this case will look like the one presented in Table 3.5.

Table 3.5

A table of complete factor experiments for three factors

| Experiment number | Plan | | | | | | | | Result | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $x_0$ | $x_1$ | $x_2$ | $x_3$ | $x_1x_2$ | $x_1x_3$ | $x_2x_3$ | $x_1x_2x_3$ | $y_1$ | $y_2$ | $y_m$ |
| 1 | +1 | +1 | +1 | +1 | +1 | +1 | +1 | +1 | … | … | … |
| 2 | +1 | -1 | +1 | +1 | -1 | -1 | +1 | -1 | … | … | … |
| 3 | +1 | +1 | -1 | +1 | -1 | +1 | -1 | -1 | … | … | … |
| 4 | +1 | -1 | -1 | +1 | +1 | -1 | -1 | +1 | … | … | … |
| 5 | +1 | +1 | +1 | -1 | +1 | -1 | -1 | -1 | … | … | … |
| 6 | +1 | -1 | +1 | -1 | -1 | +1 | -1 | +1 | … | … | … |
| 7 | +1 | +1 | -1 | -1 | -1 | -1 | +1 | +1 | … | … | … |
| 8 | +1 | -1 | -1 | -1 | +1 | +1 | +1 | -1 | … | … | … |

In Table 3.5 new variables are added to the scheduling matrix (columns $x_1$, $x_2$, $x_3$). A dummy variable column $x_0$ is required to determine the free term of the regression equation.

Members containing products $x_i x_j$ are called members of the pairwise interaction of factors, members of the form $x_i x_j x_u$ – members of the triple

interaction. These products take into account the impact on the process of simultaneous change of factors.

The processing of the results of the planned experiment involves the following steps:

***1) Determination of the average value of the result of the experiment in each of the parallel experiments***

For each row of the scheduling, the results of the parallel experiments matrix (Table 3.6) the arithmetic mean of the optimization parameter is found:

$$\bar{y}_j = \frac{1}{m}\sum_{u=1}^{m} y_{ju}, \tag{3.3}$$

where $u$ – number of parallel experiment; $y_{ju}$ – is the value of the optimization parameter in the $u$ th parallel experiment of the $j$ th row of the matrix.

Table 3.6

Results of the parallel experiments

| $Y_1$ | $Y_2$ | $Y_3$ | $\bar{y}_j$ |
|---|---|---|---|
| 102 | 105 | 102 | 103.0 |
| 108 | 103 | 108 | 106.3 |
| 90 | 85 | 90 | 88.3 |
| 85 | 87 | 85 | 85.7 |
| 103 | 104 | 103 | 103,3 |
| 100 | 97 | 100 | 99.0 |
| 110 | 115 | 110 | 111.7 |
| 98 | 100 | 98 | 98.7 |
| | | $\bar{y}$ = | 99.5 |

***2) Check the reproducibility of the experiment***

Each experiment carries a margin of error, so repeating the experiment $m$ times is repeated to improve the reliability of the results for each row of the scheduling table.

In order to estimate the deviations of the parameter *y* from its mean value for each row of the planning matrix, the variance $S_j^2$ is calculated according to the $m$ parallel experiments. The statistical variance is the mean of the square of the deviations of a random variable from its mean:

$$S_j^2 = \frac{1}{m-1}\sum_{u=1}^{m}(y_{ju} - \bar{y}_j)^2. \quad (3.4)$$

After calculating the variances, the hypothesis of their homogeneity is tested. That is, it is necessary to check that some of the conducted experiments do not differ too much in error.

In this case, the check is performed on the maximum of the ordinal variances, bearing in mind that the fulfillment of the condition for it will ensure that it is fulfilled for other variances of smaller value.

With uniform duplication of experiments, the homogeneity of a number of variances is checked using the Cochran's *G-criterion*, which is the ratio of maximum variance to the sum of all variances:

$$G_p = \frac{S_{\max}^2}{S_1^2 + S_2^2 + \ldots + S_N^2} = \frac{S_{\max}^2}{\sum_{j=1}^{N} S_j^2}. \quad (3.5)$$

Variances are homogeneous if the calculated $G_p$-criterion value does not exceed the table value $G_T$:

$$G_p < G_T(q, f_1, f_2).$$

The table value of the Cochran criterion is determined from directories depending on the level of significance, the number of degrees of freedom of each ordinal variance $f_1 = m-1$ estimate, and the number of independent variance estimates $f_2 = N$.

In Table 3.7 lists the Cochran's criterion values for the 5% significance level.

If the condition $G_p < G_T$ is fulfilled, then the process is considered to be reproducible. If not, the variances are heterogeneous.

In this case, it is necessary to increase the number of concurrent experiments, or to increase the accuracy of control of variables, or to change the method of control as a whole.

If the variances $S_j^2$ of experiments are homogeneous, then the reproducibility variance $S_y^2$ is determined by averaging the ordinal variances:

$$S_y^2 = \frac{1}{N}\sum_{j=1}^{N} S_j^2, \tag{3.6}$$

The reproducibility variance characterizes the error of the experiment.

Table 3.7

*G*-criterion values at 5% significance level

| $f_2 = N$ | $f_1 = m-1$ | | | |
|---|---|---|---|---|
| | **1** | **2** | **3** | **4** |
| **2** | 0,9985 | 0,9750 | 0,9392 | 0,9057 |
| **3** | 0,9669 | 0,8709 | 0,7977 | 0,7457 |
| **4** | 0,9065 | 0,7679 | 0,6841 | 0,6287 |
| **5** | 0,8412 | 0,6838 | 0,5981 | 0,5440 |
| **6** | 0,7808 | 0,6161 | 0,5321 | 0,4803 |
| **7** | 0,7271 | 0,5612 | 0,4800 | 0,4307 |
| **8** | 0,6798 | 0,5157 | 0,4377 | 0,3910 |
| **9** | 0,6385 | 0,4775 | 0,4027 | 0,3584 |
| **10** | 0,6020 | 0,4450 | 0,3733 | 0,3311 |
| **12** | 0,5410 | 0,3924 | 0,3264 | 0,2880 |
| **15** | 0,4709 | 0,3346 | 0,2758 | 0,2419 |
| **20** | 0,3894 | 0,2705 | 0,2205 | 0,1921 |

***3) Calculation of regression equation coefficients***

For a three-factor problem, the first-order experimental regression equation in the general case has the form:

$$y = b_0 + \sum_{i=1}^{n} b_i x_i + \sum_{\substack{i,j=1 \\ i \neq j}}^{n} b_{ij} x_i x_j + \sum_{\substack{i,j,u=1 \\ i \neq j \neq u}}^{n} b_{iju} x_i x_j x_u \,, \tag{3.7}$$

where $i = 1, 2, \ldots, n$ – the factor under consideration; $y$ – calculated state variable (response function); $x_i, x_j, x_u$ – factors; $b_i$, $b_{ij}$ and $b_{iju}$ – are the regression equation coefficients.

The regression coefficients are determined by the least squares method.

The free term $b_0$ is determined by the formula:

$$b_0 = \frac{1}{N} \sum_{j=1}^{N} \bar{y}_j . \tag{3.8}$$

The regression coefficients characterizing the linear effects are calculated by the expression:

$$b_i = \frac{1}{N} \sum_{j=1}^{N} x_{ij} \bar{y}_j . \tag{3.9}$$

The regression coefficients characterizing the interaction effects are determined by expression:

$$b_{ik} = \frac{1}{N} \sum_{j=1}^{N} x_{ij} x_{kj} \bar{y}_j . \tag{3.10}$$

$$b_{ikl} = \frac{1}{N} \sum_{j=1}^{N} x_{ij} x_{kj} x_{lj} \bar{y}_j . \tag{3.11}$$

where $i, k, l$ – numbers of factors; $x_{ij}, x_{kj}, x_{lj}$ – coded values of the factors $i, k, l$ in the $j$ th experiment.

The regression coefficients can also be determined as a result of solving matrix equation:

$$B := \left(X^T \cdot X\right)^{-1} \cdot X^T \cdot \overline{Y}$$

After determining the coefficients, equation (3.7) is written with the calculated values of the coefficients. For example, an equation for two factors might look like this

$$Y = 10{,}5 - 8{,}7x_1 + 5{,}3x_2 - 2{,}3x_1x_2 .$$

Each factor in the regression equation characterizes the role of the respective variable in the process or the force of the influence of the factors. The greater the numerical value of the coefficient, the greater the influence of this factor. If the coefficient has a plus sign, then as the value of the factor increases, the response increases if the minus decreases.

***4) Estimation of significance of regression equation coefficients***

When compiling a regression equation, it may be that one (or more) coefficients are very small and insignificant.

Factors that have coefficients slightly different from zero can be deduced from the equation because their effect on the response parameters will be attributed to the error of the experiment.

The significance of the coefficients can be verified using the Student's $t_p$-criterion.

For each coefficient of regression equation $t_p$-criterion is calculated:

$$t_{ip} = \frac{|b_i|}{S_{bi}} \qquad (3.12)$$

and compared with a table one $t_T$. The values $t_T$ for the corresponding values of the number of degrees of freedom $f_0 = N(m-1)$ of the reproducibility variance for the 5% significance level are given in Table 3.8. The coefficient is

significant if $ft_p > t_T$ or the accepted level of significance and the number of degrees of freedom of the variance of reproducibility.

Table 3.8

Student's $t_p$-criterion values at 5% significance level

| $f_0$ | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $t$ | 12,71 | 4,30 | 3,18 | 2,78 | 2,57 | 2,45 | 2,37 | 2,30 | 2,26 | 2,23 | 2,20 | 2,18 |
| $f_0$ | **13** | **14** | **15** | **16** | **17** | **18** | **19** | **20** | **21** | **22** | **23** | **24** |
| $t$ | 2,16 | 2,14 | 2,13 | 2,12 | 2,11 | 2,10 | 2,09 | 2,09 | 2,08 | 2,07 | 2,07 | 2,06 |

Statistically insignificant coefficients are excluded from consideration and the regression equation is recorded only with significant coefficients. The exclusion of insignificant coefficients should be treated with caution so as not to lose the purpose of constructing a mathematical description. Therefore, if necessary, increase the interval of variation of the relevant factors and repeat the experiment.

If, during the test, all the coefficients were found to be significant, this indicates that the mathematical model chosen is insufficient. In this case, you must go to a higher order plan and retry the experiment with new raw data.

***5) Model adequacy check***

After obtaining the mathematical model and verifying the significance of its coefficients, it is necessary to make sure that this equation adequately describes the process under study.

That is, it is necessary to compare the results of the calculations obtained by the model with the results obtained during the experiment.

A variance of adequacy $S^2_{ад}$ must be determined. The residual variance, or adequacy variance, characterizes the scattering of the empirical values of y with respect to the calculations determined by the regression equation found. The variance of adequacy is determined by the formula:

$$S^2_{\text{ад}} = \frac{m}{N-p}\sum_{j=1}^{N}(\bar{y}_j - \hat{y}_j)^2, \qquad (3.13)$$

where $p$ – the number of terms of the regression equation remaining after estimating the significance of the coefficients; $\bar{y}_j$ – the arithmetic mean of the state variable in the $j$th experiment; $\hat{y}_j$ – is the value of the state variable, calculated from the obtained regression equation for the conditions of the $j$th experiment.

Checking the adequacy of the found model of this hypothesis is performed by the Fisher's $F$-criterion. The calculated value of the Fisher's criterion is determined by the formula:

$$F_p = \frac{S^2_{\text{ад}}}{S^2_y}. \qquad (3.14)$$

The model is adequate if the calculated criterion value $F_p$ does not exceed the table value $F_T$:

$$F_p < F_T(q, f_{\text{ад}}, f_0).$$

The table value of the Fisher's criterion is determined from the directories depending on the level of significance $q$, the number of degrees of freedom of the variance of adequacy $f_{\text{ад}} = N - p$, and the number of degrees of freedom of the variance of reproducibility $f_0 = N(m-1)$.

Table 3.9 shows the tabulated values of the Fisher's criterion for the 5% significance level.

If the condition is fulfilled, then the model is considered adequate. If not, you need to reduce the parameter variation interval, or include a new factor, or switch to a higher order model.

Table 3.9

Fisher's $F$ -criterion values at 5% significance level

| $f_0 = N(m-1)$ | $f_{ад} = N - p$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| **1** | 161,45 | 199,50 | 215,71 | 224,58 | 230,16 | 233,99 | 236,77 | 238,88 |
| **2** | 18,513 | 19,000 | 19,164 | 19,247 | 19,296 | 19,330 | 19,353 | 19,371 |
| **3** | 10,128 | 9,5521 | 9,2766 | 9,1172 | 9,0135 | 8,9406 | 8,8868 | 8,8452 |
| **4** | 7,7086 | 6,9443 | 6,5914 | 6,3883 | 6,2560 | 6,1631 | 6,0942 | 6,0410 |
| **5** | 6,6079 | 5,7861 | 5,4095 | 5,1922 | 5,0503 | 4,9503 | 4,8759 | 4,8183 |
| **6** | 5,9874 | 5,1433 | 4,7571 | 4,5337 | 4,3874 | 4,2839 | 4,2066 | 4,1468 |
| **7** | 5,5914 | 4,7374 | 4,3468 | 4,1203 | 3,9715 | 3,8660 | 3,7870 | 3,7257 |
| **8** | 5,3177 | 4,4590 | 4,0662 | 3,8378 | 3,6875 | 3,5806 | 3,5005 | 3,4381 |
| **9** | 5,1174 | 4,2565 | 3,8626 | 3,6331 | 3,4817 | 3,3738 | 3,2927 | 3,2296 |
| **10** | 4,9646 | 4,1028 | 3,7083 | 3,4780 | 3,3258 | 3,2172 | 3,1355 | 3,0717 |
| **11** | 4,8443 | 3,9823 | 3,5874 | 3,3567 | 3,2039 | 3,0946 | 3,0123 | 2,9480 |
| **12** | 4,7472 | 3,8853 | 3,4903 | 3,2592 | 3,1059 | 2,9961 | 2,9134 | 2,8486 |
| **13** | 4,6672 | 3,8056 | 3,4105 | 3,1791 | 3,0254 | 2,9153 | 2,8321 | 2,7669 |
| **14** | 4,6001 | 3,7389 | 3,3439 | 3,1122 | 2,9582 | 2,8477 | 2,7642 | 2,6987 |
| **15** | 4,5431 | 3,6823 | 3,2874 | 3,0556 | 2,9013 | 2,7905 | 2,7066 | 2,6408 |
| **16** | 4,4940 | 3,6337 | 3,2389 | 3,0069 | 2,8524 | 2,7413 | 2,6572 | 2,5911 |

***6) Obtaining a natural regression equation***

If the model is adequate, it is translated into natural units, substituting the coded values of the factors.

The resulting model can then be used to optimize an object, predict its properties, or study system behavior under different conditions.

***A complete factor experiment with parallel experiments at one point in the factor space.*** Often the experimenter is aware of the good reproducibility of the experiments at the object of study, which allows him not to check the homogeneity of the variances at each point in the factor space, considering that this condition is a factor established. Such a priori information drastically reduces the number of experiments, since it is not necessary to repeat the experiments for each row of the planning matrix.

In this case, it is sufficient to put several parallel experiments at one of the points in the factor space to calculate the error of the experiment. Usually such a

point is taken by the center of the plan, where 3 ... 4 experiments are implemented and calculated according to the formula:

$$S_y^2 = \frac{1}{N_0 - 1}\sum_{k=1}^{N_0}(y_{ok} - \bar{y}_0)^2; \qquad (3.15)$$

where $y_{0k}$ – is the value of the state variable in the center of the plan; $\bar{y}_0$ – average value of the state variable in the center of the plan; $N_0$ – number of experiments at the center of the plan.

In addition, the above algorithm for calculating the regression equation are excluded from paragraph 2 (test reproducibility of the experiment), and the calculation of the number of degrees of freedom of the variance of reproducibility is carried out by the formula $f_0 = N_0 - 1$.

Otherwise, the procedure for processing the results of the expert remains the same.

In Fig. 3.3-3.9 an example of calculations is shown when planning and processing the results of a three-factor experiment in accordance with the first-order plan in Mathcad environment.

### 3.3. Second-order plans

***Second-order plans*** allow you to find a regression equation that contains second-degree factors. For two factors, the equation obtained in this case will look like:

$$\hat{y} = b_0 + b_1x_1 + b_2x_2 + b_{12}x_1x_2 + b_{11}x_1^2 + b_{22}x_2^2.$$

Rotatable plans are often used, in which the dispersion function that characterizes the accuracy of the model's forecast is constant on circles constructed around the center of the plan (spheres, hyperspheres). Table 3.10 shows the matrix of such a plan.

Initial data input

$$X_{10} := 14 \qquad \Delta X_1 := 0.5 \cdot X_{10} \qquad \Delta X_1 = 7$$
$$X_{20} := 5 \qquad \Delta X_2 := 0.8 \cdot X_{20} \qquad \Delta X_2 = 4$$
$$X_{30} := 21 \qquad \Delta X_3 := 0.3 \cdot X_{30} \qquad \Delta X_3 = 6.3$$

Factors variation levels

$$Xmin_{10} := -\Delta X_1 + X_{10} \rightarrow 7 \qquad Xmax_{10} := \Delta X_1 + X_{10} \rightarrow 21$$
$$Xmin_{20} := -\Delta X_2 + X_{20} \rightarrow 1 \qquad Xmax_{20} := \Delta X_2 + X_{20} \rightarrow 9$$
$$Xmin_{30} := -\Delta X_3 + X_{30} \rightarrow 14.7 \qquad Xmax_{30} := \Delta X_3 + X_{30} \rightarrow 27.3$$

Number of parallel experiments

$$m := 3$$

Experimental results

$$k := \begin{pmatrix} 78.3 & 58.5 & 84.5 & 77 & 90.2 & 75.2 & 78.3 & 58.5 \\ 74.2 & 59 & 87.7 & 74.7 & 88 & 77.4 & 74.2 & 59 \\ 75.5 & 64 & 89.8 & 84.7 & 87 & 85.6 & 75.5 & 64 \end{pmatrix}$$

Matrix of experiment

$$X := \begin{pmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & -1 & 1 & 1 & 1 & -1 & 1 & -1 \\ 1 & 1 & -1 & 1 & -1 & 1 & -1 & -1 \\ 1 & -1 & -1 & 1 & 1 & -1 & -1 & 1 \\ 1 & 1 & 1 & -1 & 1 & -1 & -1 & -1 \\ 1 & -1 & 1 & -1 & -1 & 1 & -1 & 1 \\ 1 & 1 & -1 & -1 & -1 & -1 & 1 & 1 \\ 1 & -1 & -1 & -1 & 1 & 1 & 1 & -1 \end{pmatrix} \qquad Y := k^T = \begin{pmatrix} 78.3 & 74.2 & 75.5 \\ 58.5 & 59 & 64 \\ 84.5 & 87.7 & 89.8 \\ 77 & 74.7 & 84.7 \\ 90.2 & 88 & 87 \\ 75.2 & 77.4 & 85.6 \\ 78.3 & 74.2 & 75.5 \\ 58.5 & 59 & 64 \end{pmatrix}$$

$$N := 8$$

Fig. 3.3. Input of initial data

$$B := \left(X^T \cdot X\right)^{-1} \cdot X^T \cdot Ysr \qquad B = \begin{pmatrix} 75.847 \\ 6.086 \\ 0.189 \\ -0.228 \\ 0.078 \\ -0.039 \\ -7.636 \\ 1.703 \end{pmatrix}$$

$$Su := \sum_{i=0}^{m-1} \left[ \left[ \left( \overrightarrow{Y^{\langle i \rangle}} \right) - Ysr \right]^2 \cdot \frac{1}{m-1} \right] \qquad Su = \begin{pmatrix} 4.39 \\ 9.25 \\ 7.123 \\ 27.43 \\ 2.68 \\ 30.04 \\ 4.39 \\ 9.25 \end{pmatrix}$$

$$G := 0.5157$$

$$Gp := \frac{\max(Su)}{\sum Su} \qquad Gp = 0.318$$

$$G > Gp$$

$$So := \frac{\sum Su}{N} \qquad So = 11.819$$

Fig. 3.4. Determination of regression coefficients

$$Sb := \frac{Su}{N} \qquad Sb = \begin{pmatrix} 0.549 \\ 1.156 \\ 0.89 \\ 3.429 \\ 0.335 \\ 3.755 \\ 0.549 \\ 1.156 \end{pmatrix}$$

$$f0 := N \cdot (m - 1) \qquad f0 = 16$$

$$Tt := 2.12$$

$$Tp := \overrightarrow{\left[ \frac{(sign(B) \cdot B)}{\sqrt{Sb}} \right]} \qquad Tp = \begin{pmatrix} 102.389 \\ 5.66 \\ 0.2 \\ 0.123 \\ 0.134 \\ 0.02 \\ 10.308 \\ 1.584 \end{pmatrix}$$

$$Yp := B_0 + B_1 \cdot X^{\langle 1 \rangle} + B_6 \cdot X^{\langle 6 \rangle}$$

Fig. 3.5. Testing the significance of regression coefficients

$$L := 3$$

$$fag := N - L \qquad fag = 5$$

$$Sag := \left(\frac{m}{N - L}\right) \cdot \sum_{k=0}^{N-1} \left(Ysr_k - Yp_k\right)^2 \qquad Sag = 14.056$$

$$Ft := 3.0069$$

$$Fp := \frac{Sag}{So} \qquad Fp = 1.189$$

$$Fp < Ft$$

$$YP(x1, x2, x3) := B_0 + B_1 \cdot \left[\frac{(x1 - X_{10})}{\Delta X_1}\right] + B_6 \cdot \left[\frac{(x2 - X_{20})}{\Delta X_2}\right] \cdot \left[\frac{(x3 - X_{30})}{\Delta X_3}\right]$$

$$YP(x1, x2, x3) := 75.867 + 6.067 \cdot \left[\frac{(x1 - 14)}{7}\right] + (-7.617) \cdot \left[\frac{(x2 - 5)}{4}\right] \cdot \left[\frac{(x3 - 20)}{8}\right]$$

$$YP(x1, x2, x3) := 39.813 + 0.869 \cdot x1 + 4.78 \cdot x2 + 1.195 \cdot x3 - 0.239 \cdot x2 \cdot x3$$

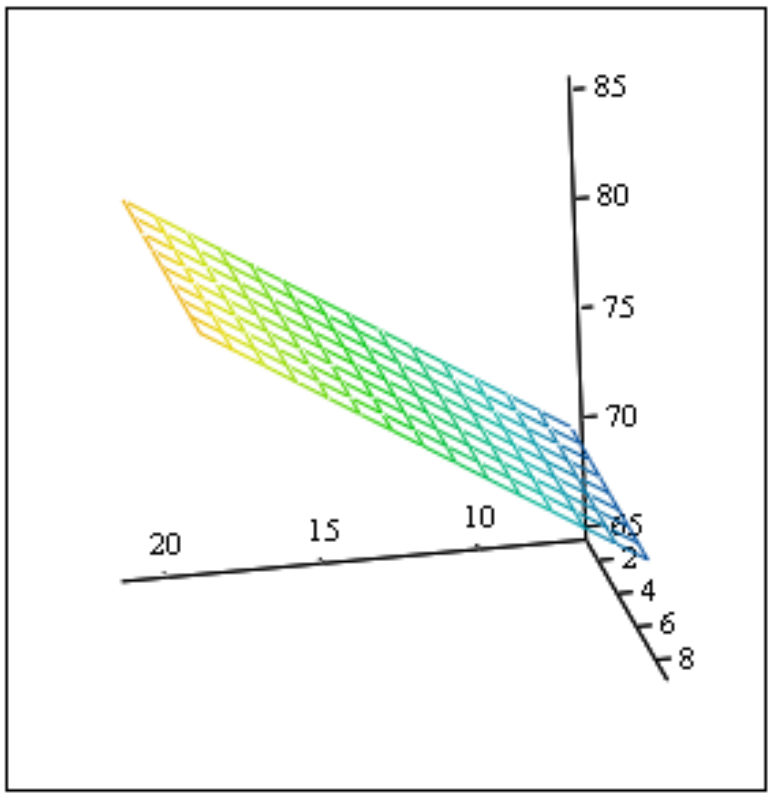
Fig. 3.6. Testing the adequacy of the mathematical model

$$x3 := 20$$

$$Y3(x1, x2) := 39.813 + 0.869 \cdot x1 + 4.78 \cdot x2 + 1.195 \cdot x3 - 0.239 \cdot x2 \cdot x3$$

$$x1 := 6 .. 22 \qquad x2 := 0 .. 10$$

$$M_{(x1, x2)} := Y3(x1, x2)$$




M

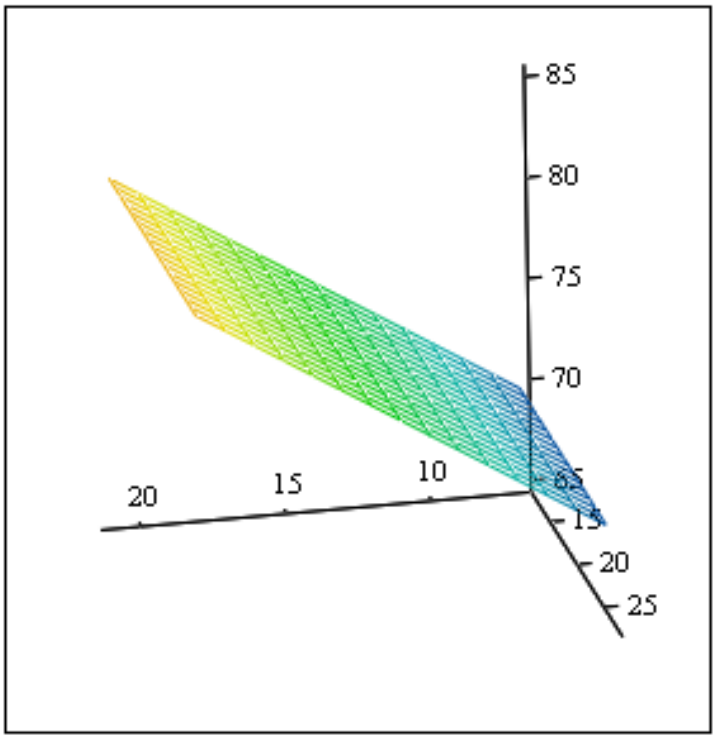
Fig. 3.7. Graphical interpretation of experimental results:
dependence *Y3(x1,x2)*

$$x2 := 5$$

$$Y2(x1, x3) := 39.813 + 0.869 \cdot x1 + 4.78 \cdot x2 + 1.195 \cdot x3 - 0.239 \cdot x2 \cdot x3$$

$$x1 := 6 .. 22 \qquad x3 := 11 .. 29$$

$$M_{(x1, x3)} := Y2(x1, x3)$$




M

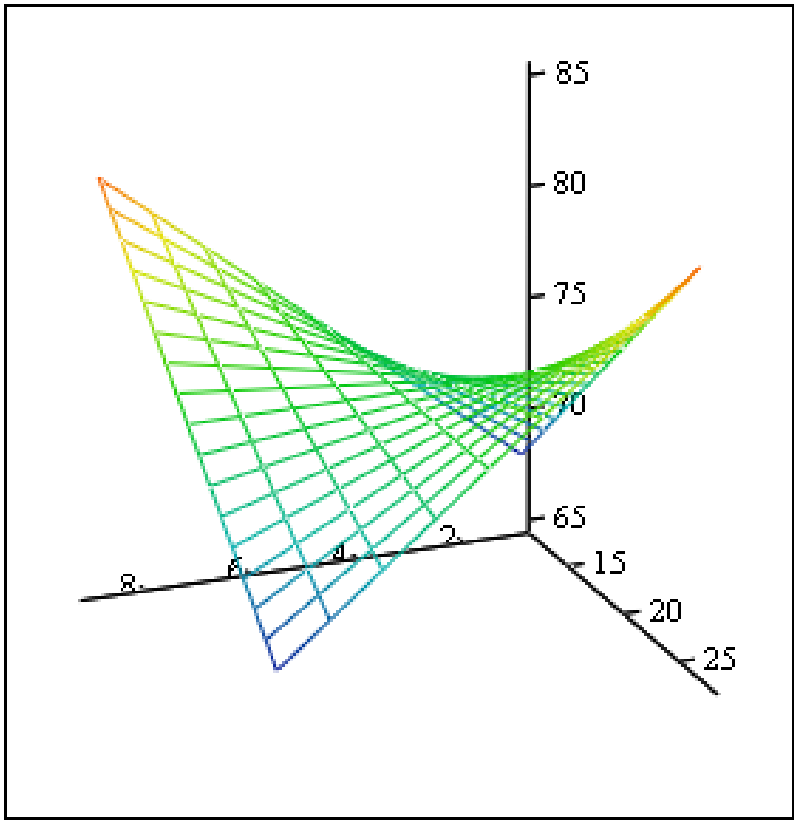
Fig. 3.8. Graphical interpretation of experimental results: dependence Y2(x1,x3)

$$x1 := 14$$

$$Y1(x2, x3) := 39.813 + 0.869 \cdot x1 + 4.78 \cdot x2 + 1.195 \cdot x3 - 0.239 \cdot x2 \cdot x3$$

$$x2 := 0..10 \qquad x3 := 11..29$$

$$M_{(x2, x3)} := Y1(x2, x3)$$




M

Fig. 3.9. Graphical interpretation of experimental results:
dependence Y1(x2,x3)

Table 3.10

Matrix of a rotatable second-order factor experiment plan

| Number of experiment | $x_1$ | $x_2$ | The average value of y in parallel experiments |
|---|---|---|---|
| 1 | – | – | $\bar{y}_1$ |
| 2 | + | – | $\bar{y}_2$ |
| 3 | – | + | $\bar{y}_3$ |
| 4 | + | + | $\bar{y}_4$ |
| 5 | –1,41 | 0 | $\bar{y}_5$ |
| 6 | +1,41 | 0 | $\bar{y}_6$ |
| 7 | 0 | –1,41 | $\bar{y}_7$ |
| 8 | 0 | +1,41 | $\bar{y}_8$ |
| 9 | 0 | 0 | $\bar{y}_9$ |
| 10 | 0 | 0 | $\bar{y}_{10}$ |
| 11 | 0 | 0 | $\bar{y}_{12}$ |
| 12 | 0 | 0 | $\bar{y}_{12}$ |
| 13 | 0 | 0 | $\bar{y}_{13}$ |

The regression equation coefficients are determined by the formulae:

$$b_0 = \frac{A}{n}[2\lambda^2(k+2)\sum_{u=1}^{n} y_u - 2\lambda c\sum_{i=1}^{k}\sum_{u=1}^{n} x_{ui}^2 y_u] \qquad (3.16)$$

$$b_i = \frac{c}{n}\sum_{u=1}^{n} x_{ui} y_u \qquad (3.17)$$

$$b_{i,j} = \frac{c^2}{n\lambda}\sum_{u=1}^{n} x_{ui} x_{ui} y_u \qquad (3.18)$$

$$b_{ii} = \frac{A}{n}\{c^2[(k+2)\lambda - k]\sum_{u=1}^{n} x^2{}_{ui} y_u + c^2(1-\lambda)\sum_{i=1}^{k}\sum_{u=1}^{n} x_{ui}^2 y_u - 2\lambda c\sum_{u=1}^{n} y_u\} \qquad (3.19)$$

In formulae (3.16) - (3.19) the following notation is used:

$$c = \frac{n}{\sum_{u=1}^{n} x_{iu}^2}; \qquad (3.20)$$

$$\lambda = \frac{n2^k}{(\sum_{u=1}^{n} x_{iu})^2}. \quad (3.21)$$

Formulae (3.16) - (3.19) can be rewritten as:

$$b_0 = a_1 \sum_{u=1}^{n} y_u + a_2 \sum_{i=1}^{k} \sum_{u=1}^{n} x_{ui}^2 y_u ;; \quad (3.22)$$

$$b_i = a_3 \sum_{u=1}^{n} x_{ui} y_u ; \quad (3.23)$$

$$b_{ij} = a_4 \sum_{u=1}^{n} x_{ui} x_{uj} y_u ; \quad 3.24(4.17)$$

$$b_{ii} = a_5 \sum_{u=1}^{n} x_{ui}^2 y_u + a_6 \sum_{i=1}^{k} \sum_{u=1}^{n} x_{ui}^2 y^2 - a_7 \sum_{u=1}^{n} y_u ; \quad (3.25)$$

In formulae (3.22) - (3.25) the following notations are taken:

$$a_1 = \frac{A}{n} 2\lambda^2 (k+2); \quad (3.26)$$

$$a_2 = \frac{A}{n} 2\lambda c ; \quad (3.27)$$

$$a_3 = \frac{c}{n}; \quad (3.28)$$

$$a_4 = \frac{c^2}{n\lambda}; \quad (3.29)$$

$$a_5 = \frac{A}{n} c^2 [(k+2)\lambda - k]; \quad (3.30)$$

$$a_6 = \frac{A}{n} c^2 (1-\lambda); \quad (3.31)$$

$$a_7 = \frac{A}{n} 2\lambda c . \quad (3.32)$$

For the two-factor experiment, the coefficients $a_1 - a_7$, calculated by the formulae (3.26) - (3.32) take the following values: $a_1 = 0{,}2$; $a_2 = 0{,}1$; $a_3 = 0{,}125$; $a_4 = 0{,}5$; $a_5 = 0{,}125$; $a_6 = 0{,}187$; $a_7 = 0{,}1$.

In Fig. 3.10-3.15 an example of calculations is shown when planning and processing the results of a two-factor experiment in accordance with the second-order central rotatable plan in Mathcad environment.

Initial data input

Number of factors

$k := 2$

Factors variation levels

$v := (-1.414 \quad -1 \quad 0 \quad 1 \quad 1.414)$

Number of parallel experiments

$m := 4$

Permissible error

$\Delta := 0.1 \cdot 20$

Experimental results

$x1 := 1 \quad x2 := 1$

$x1 := -1 \quad x2 := 1$

$x1 := 1 \quad x2 := -1$

$x1 := -1 \quad x2 := -1$

$x1 := -1.414 \quad x2 := 0$

$x1 := 1.414 \quad x2 := 0$

$x1 := 0 \quad x2 := -1.414$

$x1 := 0 \quad x2 := 1.414$

$x1 := 0 \quad x2 := 0$

$x1 := 0 \quad x2 := 0$

$x1 := 0 \quad x2 := 0$

$x1 := 0 \quad x2 := 0$

$x1 := 0 \quad x2 := 0$

$$r := \begin{pmatrix} 15.576 & 15.878 & 15.618 & 15.236 \\ 13.506 & 13.518 & 13.603 & 13.432 \\ 14.927 & 14.802 & 14.8592 & 14.867 \\ 12.842 & 12.746 & 12.831 & 12.781 \\ 11.509 & 11.516 & 11.506 & 11.504 \\ 15.116 & 15.818 & 15.821 & 15.016 \\ 14.229 & 14.198 & 14.191 & 14.231 \\ 15.206 & 14.414 & 15.493 & 15.209 \\ 16.044 & 16.143 & 16.056 & 16.035 \\ 16.1443 & 15.0443 & 16.0443 & 17.043 \\ 15.043 & 16.058 & 18.029 & 16.063 \\ 16.014 & 16.067 & 16.103 & 16.087 \\ 16.453 & 16.018 & 17.081 & 16.024 \end{pmatrix}$$

$N := 13 \qquad r := r^{T} \qquad i := 1..N \qquad y_i := r^{\langle i \rangle}$

$$ycp_i := \frac{\sum_{t=1}^{m} (y_i)_t}{m}$$

$$s_i := \sqrt{\frac{\sum_{t=1}^{m} \left[(y_i)_t - ycp_i\right]^2}{m-1}} \qquad t := 3.183 \qquad \Delta y := \frac{t \cdot s}{\sqrt{m}}$$

Fig. 3.10. Input of initial data and calculation of measurement errors

$$ycp = \begin{pmatrix} 15.577 \\ 13.5148 \\ 14.8638 \\ 12.8 \\ 11.5087 \\ 15.4427 \\ 14.2123 \\ 15.0805 \\ 16.0695 \\ 16.069 \\ 16.2982 \\ 16.0678 \\ 16.394 \end{pmatrix} \quad \Delta y = \begin{pmatrix} 0.4196 \\ 0.1115 \\ 0.0814 \\ 0.0712 \\ 0.0084 \\ 0.6954 \\ 0.033 \\ 0.7389 \\ 0.0792 \\ 1.3011 \\ 1.9887 \\ 0.0617 \\ 0.7977 \end{pmatrix} \quad \vec{s}^{2} = \begin{pmatrix} 0.0695 \\ 0.0049 \\ 0.0026 \\ 0.002 \\ 2.7583 \times 10^{-5} \\ 0.1909 \\ 4.2892 \times 10^{-4} \\ 0.2155 \\ 0.0025 \\ 0.6683 \\ 1.5614 \\ 0.0015 \\ 0.2512 \end{pmatrix}$$

$$\max(\Delta y) = 1.9887$$

$$g := \text{if}(\max(\Delta y) < \Delta, 1, 0)$$

---

$$g = 1$$

---

$$rez := \text{if}(g = 1, ycp, 0)$$

$$G := \frac{\max(s)^2}{\sum_{i=1}^{N} (s_i)^2} \qquad G = 0.5256$$

Fig. 3.11. Testing the reproducibility of experiments

ORIGIN := 1

N := 13

s2 := (0.2 0.1 0.125 0.25 0.125 0.0187 0.1)

$a := s2^T$

y := rez

x := x2

$$x2 := \begin{pmatrix} v_{1,4} & v_{1,4} \\ v_{1,2} & v_{1,4} \\ v_{1,4} & v_{1,2} \\ v_{1,2} & v_{1,2} \\ v_{1,1} & v_{1,3} \\ v_{1,5} & v_{1,3} \\ v_{1,3} & v_{1,1} \\ v_{1,3} & v_{1,5} \\ v_{1,3} & v_{1,3} \\ v_{1,3} & v_{1,3} \\ v_{1,3} & v_{1,3} \\ v_{1,3} & v_{1,3} \\ v_{1,3} & v_{1,3} \end{pmatrix}$$

$$b_0 := a_1 \cdot \sum_{u=1}^{N} y_u - a_2 \cdot \sum_{i=1}^{k} \sum_{u=1}^{N} \left[ (x_{u,i})^2 \cdot y_u \right] \qquad b_1 := a_3 \cdot \sum_{u=1}^{N} (y_u \cdot x_{u,1})$$

$$b_2 := a_3 \cdot \sum_{u=1}^{N} (y_u \cdot x_{u,2}) \qquad b_{12} := a_4 \cdot \sum_{u=1}^{N} (x_{u,1} \cdot x_{u,2} \cdot y_u)$$

$$b_{11} := a_5 \cdot \sum_{u=1}^{N} \left[ (x_{u,1})^2 \cdot y_u \right] + a_6 \cdot \sum_{i=1}^{k} \sum_{u=1}^{N} \left[ (x_{u,i})^2 \cdot y_u \right] - a_7 \cdot \sum_{u=1}^{N} y_u$$

$$b_{22} := a_5 \cdot \sum_{u=1}^{N} \left[ (x_{u,2})^2 \cdot y_u \right] + a_6 \cdot \sum_{i=1}^{k} \sum_{u=1}^{N} \left[ (x_{u,i})^2 \cdot y_u \right] - a_7 \cdot \sum_{u=1}^{N} y_u$$

$b_0 = 16.1831$ –

---

$b_1 = 1.2111$ $b_2 = 0.332$

---

$b_{12} = -3.875 \times 10^{-4}$

---

$b_{11} = -1.334$ $b_{22} = -0.7489$

---

Fig. 3.12. Determination of regression coefficients

$i := 1..N$ $y_i := r^{\langle i \rangle}$ $s_y := \sqrt{\frac{\sum_{i=1}^{N}\sum_{u=1}^{m}\left[(y_i)_u - ycp_i\right]^2}{\sum_{i=1}^{N}(m-1)}}$ $s_y^2 = 0.2285$

$\alpha 2 := (0.2 \quad 0.125 \quad 0.1438 \quad 0.25)$ $\alpha := \alpha 2^T$

$$\alpha = \begin{pmatrix} 0.2 \\ 0.125 \\ 0.1438 \\ 0.25 \end{pmatrix}$$

$\Delta b_0 := 2\cdot\sqrt{\alpha_1\cdot\frac{s_y}{m}}$ $\Delta b_1 := 2\cdot\sqrt{\alpha_2\cdot\frac{s_y}{m}}$ $\Delta b_2 := 2\cdot\sqrt{\alpha_2\cdot\frac{s_y}{m}}$

$\Delta b_{11} := 2\cdot\sqrt{\alpha_3\cdot\frac{s_y}{m}}$ $\Delta b_{22} := 2\cdot\sqrt{\alpha_3\cdot\frac{s_y}{m}}$

$\Delta b_{12} := 2\cdot\sqrt{\alpha_4\cdot\frac{s_y}{m}}$

$\Delta b_0 = 0.3092$

---

$\Delta b_1 = 0.2445$ $\Delta b_2 = 0.2445$

---

$\Delta b_{12} = 0.3457$

---

$\Delta b_{11} = 0.2622$ $\Delta b_{22} = 0.2622$

---

$b_0 := \text{if}(|b_0| > |\Delta b_0|, b_0, 0)$ $b_1 := \text{if}(|b_1| > |\Delta b_1|, b_1, 0)$ $b_2 := \text{if}(|b_2| > |\Delta b_2|, b_2, 0)$

$b_{12} := \text{if}(|b_{12}| > |\Delta b_{12}|, b_{12}, 0)$

$b_{11} := \text{if}(|b_{11}| > |\Delta b_{11}|, b_{11}, 0)$ $b_{22} := \text{if}(|b_{22}| > |\Delta b_{22}|, b_{22}, 0)$

$b_0 = 16.1831$

---

$b_1 = 1.2111$ $b_2 = 0.332$

---

$b_{12} = 0$

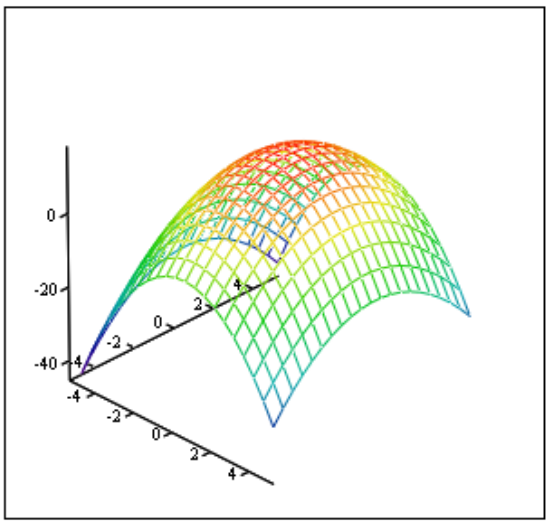
---

$b_{11} = -1.334$ $b_{22} = -0.7489$

---

Fig. 3.13. Testing the significance of regression coefficients

$$y(x1,x2) := 16.1831 + 1.2111 \cdot x1 + 0.332 \cdot x2 - 1.334 \cdot x1^2 - 0.7489 \cdot x2^2$$




y

| y | | | | |
|---|---|---|---|---|
| 15.577 | $x1 := 1$ | $x2 := 1$ | $y(x1,x2) = 15.6433$ | $(15.577 - 15.6433)^2 = 0.0044$ |
| 13.5148 | $x1 := -1$ | $x2 := 1$ | $y(x1,x2) = 13.2211$ | $(13.5148 - 13.2211)^2 = 0.0863$ |
| 14.8638 | $x1 := 1$ | $x2 := -1$ | $y(x1,x2) = 14.9793$ | $(14.8638 - 14.9793)^2 = 0.0133$ |
| 12.8 | $x1 := -1$ | $x2 := -1$ | $y(x1,x2) = 12.5571$ | $(12.8 - 12.5571)^2 = 0.059$ |
| 11.5087 | $x1 := -1.414$ | $x2 := 0$ | $y(x1,x2) = 11.8034$ | $(11.5087 - 11.8034)^2 = 0.0868$ |
| 15.4427 | $x1 := 1.414$ | $x2 := 0$ | $y(x1,x2) = 15.2284$ | $(15.4427 - 15.2284)^2 = 0.0459$ |
| 14.2123 | $x1 := 0$ | $x2 := -1.414$ | $y(x1,x2) = 14.2163$ | $(14.2123 - 14.2163)^2 = 1.6 \times 10^{-5}$ |
| 15.0805 | $x1 := 0$ | $x2 := 1.414$ | $y(x1,x2) = 15.1552$ | $(15.0805 - 15.1552)^2 = 0.0056$ |
| 16.0695 | $x1 := 0$ | $x2 := 0$ | $y(x1,x2) = 16.1831$ | $(16.0695 - 16.1831)^2 = 0.0129$ |
| 16.069 | $x1 := 0$ | $x2 := 0$ | $y(x1,x2) = 16.1831$ | $(16.069 - 16.1831)^2 = 0.013$ |
| 16.2982 | $x1 := 0$ | $x2 := 0$ | $y(x1,x2) = 16.1831$ | $(16.2982 - 16.1831)^2 = 0.0132$ |
| 16.0678 | $x1 := 0$ | $x2 := 0$ | $y(x1,x2) = 16.1831$ | $(16.0678 - 16.1831)^2 = 0.0133$ |
| 16.394 | $x1 := 0$ | $x2 := 0$ | $y(x1,x2) = 16.1831$ | $(16.394 - 16.1831)^2 = 0.0445$ |

$$(\bar{y}_{1,1} - \hat{y}_{1,1})^2 =$$

$$0.0044 + 0.0863 + 0.0133 + 0.059 + 0.0868 + 0.0459 + 1.6 \times 10^{-5} + 0.0056 + 0.0129 + 0.013 + 0.0132 + 0.0133 + 0.0445 = 0.3982$$

$$s^2_{ад} = \frac{\sum_{u=1}^{N} N_p \cdot (\bar{y}_u - \hat{y}_u)^2}{N - \lambda - (n_0 - 1)} = \frac{4 \cdot 0.3982}{13 - 6 - (5 - 1)} = 0.5309$$

$$F = \frac{s^2_{ад}}{s^2_y} = \frac{0.5309}{0.2285} = 2.3234$$

Fig. 3.14. Testing the adequacy of the mathematical model

$$z(t1,t2) := 16.1831 + 1.2111\cdot\left(\frac{t1-240}{27}\right) + 0.332\cdot\left(\frac{t2-45}{17}\right) - 1.334\cdot\left(\frac{t1-240}{27}\right)^2 - 0.7489\cdot\left(\frac{t2-45}{17}\right)^2$$

$$16.1831 - \frac{1.2111}{27}\cdot 240 - \frac{0.332}{17}\cdot 45 - \frac{1.334}{27^2}\cdot 240^2 - \frac{0.7489}{17^2}\cdot 45^2 = -106.111$$

$$\frac{1.2111}{27} + \frac{1.334}{27^2}\cdot 2\cdot 240 = 0.9232$$

$$\frac{0.332}{17} + \frac{0.7489}{17^2}\cdot 2\cdot 45 = 0.2528$$

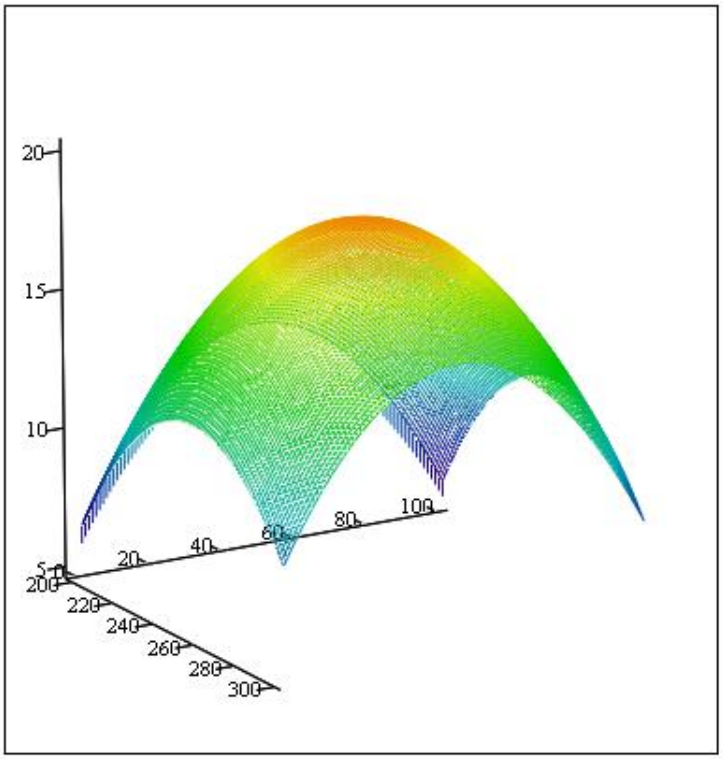
$$\frac{1.334}{27^2} = 0.0018$$

$$\frac{0.7489}{17^2} = 0.0026$$

$$z(t1,t2) := -106.111 + 0.9232\cdot t1 + 0.2528\cdot t2 - 0.0018\cdot t1^2 - 0.0026\cdot t2^2$$

$t1 := 200..300$ $t2 := 0..100$

$$M_{(t1,t2)} := z(t1,t2)$$




M

Fig. 3.15. Graphical interpretation of experimental results

# 4. MASTER'S WORK PREPARATION STAGES

A master's degree is an educational degree obtained at the second level of higher education and awarded to a higher education institution as a result of successful completion of the relevant educational program by the higher education applicant. The master's degree is obtained by an educational-professional or educational-scientific program.

## 4.1. Master's graduation work

Master's graduation work (hereinafter - MGW), Master's degree project (hereinafter - MDP) or Master's thesis (hereinafter - MT) are the final qualification research work, which has internal unity and reflects the course and results of development of the chosen topic in accordance with current development trends of masters programs and European standards of national education. The Regulations have been developed in accordance with the requirements of the Law of Ukraine “On Higher Education”, “Regulations on the Organization of the Educational Process at KNUTD”.

**The aims** of writing master's graduation work are:

- systematization, consolidation, expansion and application of the student's knowledge in performing specific research tasks;
- development of independent research skills;
- mastering the methods of research and conducting experiments in solving scientific problems;
- diagnosis of the student's level of readiness for practical or research activities and entry to higher level of education.

Preparation of master's graduation work involves the following tasks:

- systematization, consolidation and expansion of the theoretical and practical knowledge obtained during training at the University and the

application of this knowledge in solving specific scientific and industrial problems;

- conducting bibliographic work with the use of modern information technologies;

- ability to critically evaluate and summarize theoretical provisions;

- ability to use legislative, regulatory materials, as well as to critically comprehend data of literary sources and practice materials on the chosen topic;

- ability to systematize and summarize data of statistical collections and materials of economic entities;

- development of author's suggestions for improvement and development of the studied phenomenon or process;

- development of skills of independent work, improvement of skills in the application of methods of scientific knowledge in solving the problems developed in the work;

- development of public discussion skills, protection of one's own scientific ideas, suggestions and recommendations;

- presentation of the results of the work in the form of reports, abstracts, articles, designed in accordance with existing requirements, with the use of modern editing and printing tools.

Mandatory components of the MGW preparation are:

1. Publication of the article on the results of scientific research in specialized editions;

2. Testing of work at conferences and seminars on the results of scientific research.

Mandatory components of the MDP preparation are:

1. Obtaining an act of approbation of the results of the design part of work or obtaining a patent (utility model application) or publication of an article in specialized editions on the results of the research;

2. Testing of work at conferences and seminars on the results of the study.

Mandatory components of the MT preparation are:

1. Publication of at least two articles based on the results of scientific research, including one in a foreign edition;

2. A single author presentation with a report on the topic of the master's thesis no less than at two scientific conferences, and at least one outside author’s higher education institution;

3. Publication of abstracts at international conferences in foreign language.

The scientific supervisor of master's graduation work is an appointed scientific and pedagogical worker who has a scientific degree of doctor or candidate of science, academic rank of professor or associate professor and carries out scientific research in the relevant field.

Master's graduation work is performed on the basis of in-depth study of special domestic and foreign literature, best practices of research on the selected problem, as well as the results of own research of a real object.

The work should contain the results of theoretical, analytical and experimental studies.

Master's graduation work must be written in the national language. It is important to meet the basic requirements for the scientific level of a master's work (project) or thesis, its content, structure, form of presentation of material, as well as design.

The main stages of master's graduation work preparation are the following:

1. Appointment of a scientific supervisor and choosing the topics of master’s research work.

2. Work with scientific-information sources in the chosen direction of research work, identification of scientific problems and formation of bibliography.

3. Approval of the topic of master's graduation work in accordance with the problematic of research and scientific supervisor by order of the University

within 30 days from the beginning of the 1st semester of the 1st year of study in the master's program.

4. Obtaining the task and drawing together with the scientific supervisor of the calendar plan, which includes the basic issues and terms of their implementation.

5. Preparation and approval of the Annex to the individual master's curriculum.

6. Organizational meetings of teachers and students on the preparation, writing and defense of master's graduation work (held by graduating departments).

7. Collection of information about the object of study in undergraduate practice;

8. Elaboration and presentation of the results of research, arrangement of master's graduation work and verification by the scientific supervisor, obtaining supervisor’s comment.

9. Appointment of a reviewer and reviewing master's graduation work.

10. Checking with the head of the master's graduation work monitoring department for signs of plagiarism.

11. Verification by the head of the masters department of the performance of individual work of the student, which is reflected in the Appendix to the individual master’s curriculum.

12. Admission by the head of the graduating department of master's graduation work to the defense in the examination committee (not later than 5 days before the defense).

13. Defense of the master's graduation work at the meeting of the examination committee.

Prior to the beginning of the undergraduate practice, the student receives a task for master's graduation work, which specifies a calendar plan for the implementation of each of its components and research tasks.

Changes and refinements to the topics of master's graduation work are possible as an exception, but not later than the first two months of the 2nd year of study under the master's program.

Changes are made by order of the rector, the project of which is made by the head of the masters department on the basis of the official note of the head of the department on the grounded statement of the student, agreed with the scientific supervisor.

Master's graduation work that does not meet the requirements for content and design, written without following the content of the approved plan, does not contain valid proposals, fulfilled in violation of the approved schedule, contains signs of plagiarism is not allowed to be defended.

Students who fail to complete a full-time individualized work plan are not allowed.

### 4.2. Substantiation of the actuality of research

The substantiation of the actuality is a necessary step in any scientific study. In the master's work the relevance of the topic is indicated in the introduction.

The actuality of the topic is presented in the form of analysis and ways of solving the problem, substantiating the importance of work for the development of a particular area of knowledge and activity.

By critical analysis and comparison with known solutions to the problem (scientific problem), the actuality and feasibility of work for the development of the relevant field of science or production, especially for the benefit of Ukraine is substantiated.

Actuality coverage should not be verbose. With just a few sentences to say the main thing: the essence of the problem or scientific task.

It is necessary to specify the degree of elaboration of the topic, place of one`s own work among other similar researches in the same field, briefly

describe the necessity of conducting researches for the solution of a specific problem (problem), development of specific directions in the relevant branch of science or production, reflect the importance of the solved questions for Ukraine.

From the point of view of the compositional structure of the master's work, substantiation of the relevance of the topic should occupy approximately half a page to page of the introduction and contain an explanation of why it is advisable to address this topic right now, what its scientific and practical necessity is, in what state modern scientific ideas about the subject of research are.

### 4.3. Arranging the list of references

Doing a master's thesis, like any scientific study, should begin with a study of literary sources. When processing the literature and compiling the entries, it should be noted that they can be complete and accurate (literal) or abbreviated (summary).

For example, you can do: a detailed record of the main provisions of the work, the actual material, etc.; short notes, with or without reflections; extracts in the form of quotations.

During the work with various sources (scientific and educational literature, periodicals) the student writes quotes. Scientific etiquette requires accurate reproduction of the quoted text, as the reduction may distort the content stated by the author. In the theoretical part, on one page of the text it is possible to give 2-3 quotations of different authors.

The general requirements for citation are as follows:

- the text of the quotation begins and ends with quotation marks and is presented in the grammatical form in which it is given in the source, while preserving the features of the author's writing.

Scientific terms proposed by other authors are not marked by quotation marks, except for those that have caused general controversy. In these cases, the expression "so-called" is used;

- the citation should be complete, without arbitrary reduction of the author's text and without distortion of the author's thoughts.

The omission of words, sentences, paragraphs when quoting an author's text is indicated by three dots, which can be placed at the beginning, inside and at the end of the quote;

- each quotation must be accompanied by a reference to the source;

- in case of indirect citation (translation, presentation of the opinions of other authors in their own words) should be as accurate as possible about the author's opinions, correct in evaluating their results and make appropriate references to sources;

- citation should be optimal, given that excessive citation gives the impression of compilation, and insufficient - reduces the scientific value of the material presented.

It is recommended that you refer to the latest authors, publications from which you have borrowed material or individual results. Earlier editions can be cited in cases where the works containing the necessary material have not been republished.

References to sources in the master's work are given in square brackets, indicating the source number, for example [1], [1, 4], where digits 1 and 4 correspond to the serial number of the work or source in the list of sources used.

If the references to the sources are from 1 to 4, then references are written as [1-4].

Non-referenced sources cannot be included in the list of references!

The recommended number of titles in the list of sources corresponds to ± 20% of pages. At least 50 sources.

This list includes all publications of domestic and foreign authors, which are referenced in the work.

The list of sources used is given at the end of the MGW, MDP or MT (after conclusions). The list is in the form of numbered sources, written in alphabetical order (preferably) or in the order as the sources are mentioned in the text of the work (allowed).

All sources are indicated in the language in which they are published.

Today, there are more than 6,000 different styles (rules) for citing sources in scientific papers that have been developed by various professional scientific associations. The rules for the arranging of citations and references have been introduced into the system of international ISO standards and national DSTU standards.

To date, there are two approved National Standards in Ukraine responsible for the arranging of bibliographic information in scientific work:

- DSTU 8302: 2015. Information and documentation. Bibliographic reference. General Terms and Conditions of Arranging [Effective from 07.01.2016];

- DSTU GOST 7.1: 2006. A system of standards for information, library and publishing. Bibliographic record. Bibliographic description. General requirements and rules of Arranging [Effective from 01.07.2007];

Also, when compiling a list of sources used, you can follow one of 9 international styles that reflect different areas of research: MLA (Modern Language Association) style; APA (American Psychological Association) style; Chicago (Turabian) style; Harvard style, ACS (American Chemical Society) style, AIP (American Institute of Physics) style, IEEE (Institute of Electrical and ElectronicsEngineers) style, Vancouver style, OSCOLA.

### 4.4. Academic integrity and plagiarism

Academic integrity is a set of ethical principles and rules defined by law that should be guided by participants in the educational process in lerning,

teaching and conducting scientific (creative) activities in order to ensure confidence in learning and / or scientific (creative) achievements.

Academic plagiarism is considered by the law of Ukraine "On Higher Education" [Effective from 28.09.2017] as a violation of academic integrity.

Academic plagiarism is the publication (in whole or in part) of scientific results obtained by others as the results of one's own research and / or reproduction of published texts by other authors without appropriate reference. Plagiarism is a serious violation of the academic standards and rules of conduct of both students and scholars.

In today's world, plagiarism is quite common in the academic world, as well as in the media, politics and other fields. In the general sense, plagiarism (from the Latin word "plagium" - theft) is the attribution of authorship to someone else's work of science, literature, art or to someone else's discovery, invention or innovative proposal, as well as use in their works of someone else's work without reference to the author.

The development and dissemination of various forms of plagiarism is influenced by both the lack of information skills and the lack of a clear understanding of intellectual borrowing standards in the academic world. However, in general, university students and faculty believe that they have sufficient information about plagiarism.

Unfortunately, understanding the concept of "plagiarism" and being aware of its negative consequences does not prevent the vast majority of students and some scholars from resorting to some form of plagiarism when writing their work. Today we can talk about the whole global culture of fraud, where participants not only tolerate plagiarism and other forms of fraud, but also consider them justified for their own goals and success.

The spread of various forms of academic fraud cannot be called a domestic problem alone. This is a global trend, the main forms of which are copying, plagiarism and illegitimate evaluation.

The following factors influence the level of academic fraud:

1. Low level of morality and culture of people who take to wrong doing.

2. Ignorance, misunderstanding that some actions are unacceptable. Many students do not even treat plagiarism seriously as a crime.

3. Confidence in impunity, tolerance of academic fraud cases.

4. Unclear formulation of requirements and instructions for student work, recurrence and irrelevance of topics of written works, misunderstanding by students of necessity and purpose of their writing.

5. Low level of professionalism, motivation and interest of teachers, decrease in the attention of the teaching staff to the quality of the work performed by students due to overload of classroom hours and additional workload.

6. The main means of influence is approval and indifference, or, conversely, condemnation by students of various forms of fraudulent behavior of their classmates.

To combat academic malpractice, one must change one's consciousness and not remain indifferent to the manifestation of malignity in the environment. After all, no form of control or sanction will be effective in a society that practices copy-past more often than quoting primary sources. The consequences of this problem are very deep, since corruption, fraud and their tolerance in public institutions, courts, and hospitals are often born out of fraud in universities: a diploma paper purchased, a borrowed paper, or falsified research results.

The ability to solve matters illegally obtained at university begins to be considered a norm and is carried forward to further life, which makes it impossible to eradicate the problem of corruption and fraud in our country.

In general, plagiarism in Ukraine implies (depending on each specific offense) civil, administrative and criminal liability. Of course, the majority of scientific works cannot be conducted without reviewing the literature and summarizing the results of studies by other authors. However, other people's opinions in one’s work must be clearly referred to the author and properly

arranged. It is necessary to clearly understand what is called citation and what is considered plagiarism.

The types of plagiarism include:

- ***republication*** (reprint) - reissue of the text (or a part of it) by another author (with or without source indication);

- ***replication*** - the process of copying data from one source to many others and vice versa, that is, a kind of "duplication" of information without the author's permission;

- ***literal plagiarism*** - rewriting the source text without significant changes and publishing it as your own;

- ***compilation*** (mosaic plagiarism) - compilation of own materials from several works of other authors and editing without permission - semantic, stylistic, grammatical editing and reduction of another's material;

- ***rewriting*** - adding to someone else's material without the author's permission additional information, with reworking of previously published material and replacing words and expressions, that is, rewriting another's information "in their own words";

- **combining your own and borrowed text without citing sources;**

- **lack of references to direct quotations;**

- ***mentioning the source without a reference*** (for example, mentioning the phrase Albert Einstein's German language teacher would say that from him "never going to be anything worthwhile" it is imperative to indicate the source from which the information was obtained);

- ***falsification*** - the fabrication or distortion of data (for example, statistical data or the results of experiments), with subsequent indication of them as their own work;

- other types of plagiarism.

At the same time, according to Art. 10 of the Law of Ukraine "On Copyright and Related Rights" cannot be covered by the concept of plagiarism (since they are not covered by copyright):

- well-known knowledge and facts, widespread and known ideas or definitions;

- idioms;

- paraphrase a phrase when translating from a dialect or another language, unless there is a well-known phrase or an accepted official translation;

- announcements of news of the day or current events that have the character of ordinary press information;

- works of folk art (folklore);

- official documents of political, legislative, and administrative nature (laws, decrees, court rulings, state standards, etc.) and their official translations, issued within the limits of their powers;

- state symbols of Ukraine, state awards, symbols and signs of state authorities, the Armed Forces of Ukraine and other military formations, symbols of territorial communities, symbols and signs of enterprises, institutions and organizations (after their official approval);

- banknotes;

- vehicle traffic schedules, broadcast schedules, telephone directories and other similar databases that do not meet the criteria of originality and are covered by the sui-generis law (a kind of law, special law);

- is also not a plagiarism the publication of an anonymous work under one`s own name, since in this case the anonymous work does not cover copyright.

Today, there are a large number of programs for checking the text of the work for originality.

Among the free programs you can select such as Advego Plagiatus, Anti-plagiarism, ContentWatch. Professional programs include: Turnitin, Crossref, RefWorks, Zotero, Mendeley, EndNote.

The originality of the text is a concept opposite to plagiarism. For example, if a plagiarism checker shows that the originality of a given text is 70%, it means that 30% of that text is non-original.

Most plagiarism programs, especially free ones, are basically text-checking programs for originality rather than correctness of citation. Correctly cited borrowing is recognized by such programs as plagiarism.

For example, common terms and definitions that have become a phrase such as the "Criminal Code of Ukraine", "United Nations", "World Trade Organization" will be referred to as a plagiarism by screening program. Therefore, any text can hardly be 100% original.

### 4.5. Publication of scientific article

Publication of an article in a scientific publication and a speech at a scientific conference with publication of the abstract of the report is a prerequisite for admission of the undergraduate to the defense of the master's thesis. For the future specialist, the scientist is very important to have a methodology for the preparation of scientific publications.

**A scientific article** is one of the types of scientific publications that describes the final or intermediate results of the conducted research, justifies the methods of their obtaining, and outlines the prospects for future developments.

The volume of a scientific article is usually between 5 and 24 pages.

***In content,*** scientific articles are divided into scientific, popular science, scientific-educational, scientific-methodical, and scientific-journalistic.

***According to the information provided***, the articles are overview, problematic and methodological. Review articles describe the status and prospects of research in a particular subject area, obtained from the analysis of primary sources.

Problem articles feature a problem that has not been thoroughly understood, such articles are published to discuss issues in the press.

Methodological articles provide a justification for the methodology for solving the problem.

***Purposeful scientific articles are:*** for a narrow circle of scientists, for specialists of a particular branch (specialty) or several branches (specialties), for the general public of scientists.

***According to the number of authors,*** scientific articles are individual or collective.

Scientific articles perform ***research*** (present scientific results), ***presentation*** (presenting a researcher in a scientific society), ***evaluative*** (containing an assessment of the state of scientific research on a particular problem), ***communicative*** (serve as a means of communication of researchers).

Requirements for the language of the scientific article are logic, clarity, brevity, accuracy of scientific terminology, reliability of source information, criticality in the selection of facts, proof of the content of the text, completeness (integrity of disclosure of one or more issues), logic and validity of the conclusions.

At the stage of intention (design) determine the motivation of writing an article (what the author expects from this event), the topic, purpose, idea, amount of information, produce a concept (vision of the author, the choice of arguments and language).

It is important to produce a considerable amount of material from various sources (monographs, scientific journals, including foreign ones).

Actually preparation of a scientific article covers the following stages:

1. Formulation of the working title of the article: the title should be concise and unambiguous, should concentrate the reader on the subject of research.

2. Determination of the boundaries of the topic and scope of scientific information presented in the scientific article.

3. Development of the indicative plan (content) of the article: introduction, main part, conclusions, prospects of the research.

4. Outline in the introduction of the content of the work: statement of the problem, clarification of its relevance and scientific and practical significance;

an analysis of recent research and publications in which the author has begun to address a particular problem; violation of issues not previously addressed to the article; formulation of the purpose and purpose of the article.

5. Determination of research methods, source basis, preparation of basic abstracts for the task.

6. Interpretation of terms used in the article.

7. Rationale in the main part of the obtained results. The text should be based on the principles of "from known to unknown", "from simple to complex".

8. Check consistency between title, purpose, objectives and conclusions.

9. Reflections on the prospects for further intelligence in this matter

10. Carrying out self-control of the performed work on the content, logical, linguistic-stylistic levels.

Check the text of the article for compliance with current spelling standards, scientific style requirements, design of quotes and references.

11. Registration of the list of used sources according to current standards.

### 4.6. Report at scientific conference

Another form of publicizing the results of a research paper is a presentation or presentation at a conference. This is the easiest way to get into a scientific society in a short time, with the right skills and the ability to prepare an interesting presentation.

**A scientific report (speech)** is a public message, a detailed statement of a particular scientific problem (topic, issue) under study.

Speaking at a scientific conference has several goals:

1) approbation of the basic ideas and results of research in the scientific community.

In fact, a speech at a scientific conference provides preliminary examination, verification of the value of the whole study or its individual parts. The discussion reveals the weaknesses and strengths of the study;

2) often a public appearance in front of a scientific society ensures that the author prioritizes the results obtained;

3) the speech at the scientific conference also sets out a communication goal that directs the scientist to transform the topic of his research for scientific discussion, which allows him to get not only an evaluation of results from colleagues, but also to discover new ideas and approaches during the discussion. In this case, the conference author uses the speech as a source of information.

But the main thing is that the speech at the conference is the most efficient means of introducing the results of scientific research into the information field of science.

There are several types of reports:

***1. Reporting speech***, which summarizes the state of affairs and the course of work over a period of time, highlights achievements and shortcomings. Reporting reports at seminars, symposia and conferences provide the presentation of research teams, schools, public scientific organizations.

2. ***Thematic report*** on a detailed presentation of a topic or problem. The author's thoughts and position play a significant role in it.

3. ***Information report***, which is to inform the present on the state of affairs in a particular field of activity. The purpose of this report is to submit information as objectively and comprehensively as possible without presenting the author's position. The structure of the text of the report is almost similar to the plan of a scientific article and may consist of an introduction, main and final parts. However, the method of preparing a report at a scientific conference or other scientific event is somewhat different than preparing an article.

There are two methods for writing a report. The first is that the researcher first prepares the abstract of his presentation, and on the basis of the abstracts writes a report, edits it and prepares for publication in a scientific collection in

the form of an article. The second, on the contrary, involves first the full writing of the report, and then in an abbreviated form - theses for preliminary acquaintance of the audience. The choice of the method of preparation of the report depends on the content of the material and the individual characteristics of the scientist.

The specifics of the oral presentation make a significant impact on the content and form of the report. Part of the report material is submitted on posters (slides, computer monitor, diagrams, charts, tables, etc.), so the report should comment on these materials and not repeat them. When preparing a report, it should be borne in mind that in 10 minutes a person can read or speak material printed on five pages of typewritten text at one and a half computer intervals in font 14.

In preparing the presentation (report) there are several circumstances to consider:

1) relevance of the topic of the presentation (report) to the topic discussed;

2) a clear distinction between scientific truth and discussion and unexplored issues;

3) its presentation is not written, but oral scientific language.

The most common disadvantages of presentations (reports) at scientific conferences are:

- inconsistency with the topic of discussion, which leads to a decrease in the interest of the listeners to the issues being taught;

- failure to comply with regulations that cause irritation to the audience;

- lack of clarity of presentation that causes loss of interest and dissatisfaction with the audience.

Also unpleasant in the oral report are the following points:

- abuse of foreign terminology and concepts that complicate the perception of the main idea;

- presence of parasite words ("here", "means", "so to speak", etc.);

- construction of complex sentences in which the number of words exceeds 14-15 (such phrases are not perceived, the content of grammatical construction is lost meaning);

- monotony of intonation, without emphasis on significant points of the report;

- excessive volume of voice (listeners do not perceive such language in 8-10 minutes);

The most common problem with the performance of novice scientists is fear. It is based on a whole set of objective and subjective reasons:

- fear of looking imperfect;

- giving too much importance to speech and possible mistakes;

- exaggeration of own defects;

- the ill-will of the audience;

- poor preparation or memories of past failures.

The worst is the fear of criticism from colleagues, opponents, the scientific community.

However, one should not be afraid of criticism. It should be understood that criticism is a way of spiritual activity focused on a holistic evaluation of the phenomenon by identifying its contradictions, strengths and weaknesses. The constructive-critical approach comes not from the reality we want to see, but from the one that exists, with its pros and cons, advantages and disadvantages. Constructive, free criticism is an important condition for the realization of the principle of objectivity of scientific knowledge.

Conference abstracts are usually published in a specially published collection. Requirements for the presentation of the abstract of the report and the date of their submission can be found in the conference organizing committee. Usually, their size is 1-2 pages in A4 or A5 format. A copy of the published scientific article and the abstract of the report is sewn into the master's thesis in applications.

# 5. BASICS OF INTELLECTUAL PROPERTY

Intellectual property (IP) is the right to the results of intellectual, creative activity in scientific, artistic, industrial and other fields of activity. IP is the object of civil legal relations with respect to the right of everyone to own, use and dispose of the results of his intellectual creative activity, which can be used by other persons only in agreement with creators, except in cases provided by law.

## 5.1. Intellectual property rights

A feature of IP law is its dual nature - economic and spiritual. The IP right contains:

- personal non-property right of the creator to the created product of intellectual labor;

- the property right to that product (that is, the ownership of the material embodiment).

Personal non-property (or moral) right belongs only to the creator, that is, to the individual. These include:

- the right to recognize a person as the creator (author, performer, inventor, etc.) of an IP law object;

- the right to prevent any encroachment on the right of the IP, which can damage the honor and reputation of the creator of the IP law object.

- other IP personal non-property rights established by law with respect to a specific IP law object.

Personal non- property rights are inalienable to the author, that is, they are not alienated or transferred. They belong to the author regardless of his property rights and are retained by the author in case of transfer of his property rights to another person.

Non-property right operates without restriction in time.

Property rights include:

- the right to use IP law object;

- the exclusive right to authorize the use of IP law object;

- the exclusive right to prevent the misuse of IP law object, including prohibiting such use;

- other property rights established by law with respect to a specific IP law object.

The property right may belong to the creator (author) or other physical person or legal entity, that is the person or the enterprise. Property rights may be the subject of a collateral agreement, be transferred in whole or in part to another person under the contract.

Property law has temporal and territorial limitations. For example, the right to an invention is valid for 20 years and only in the territory of the patent office country.

Intellectual property rights are inviolable. No one shall be deprived of, or restricted in the exercise of, IP except in the cases provided for by law.

IP law and property right are independent of each other. The transfer of rights on an IP law object does not imply the transfer of ownership of the thing and vice versa.

Violation of intellectual property rights is possible:

- in the form of actions (infringement of intellectual property rights);

- in the form of inaction (non-recognition of intellectual property rights by the bodies through which, in cases established by law, the results of intellectual, creative activity should be legitimized);

- in mixed form (non-recognition of intellectual property rights with subsequent illegal use by the same subject of the results of other people's intellectual, creative activity).

The infringement of intellectual property rights shall also be recognized for the import into the customs territory of Ukraine of products (goods) in which the objects of intellectual property rights protected in the territory of Ukraine are used, without the permission of the subject of intellectual property rights, with

violation of this right, regardless of whether they have been protected or whether these objects are protected in their countries of origin.

The infringer of intellectual property rights may be a physical person or legal entity.

The material consequence of infringement of intellectual property rights is the appearance of counterfeit goods, i.e. products (goods) produced with the use of the object of intellectual property rights and implemented within Ukraine with violation of the right to them. Counterfeit products are also considered to be products that are made lawfully, but are distributed in violation of intellectual property rights.

The general principles for the protection of intellectual property rights against infringements are set out in the Civil Code of Ukraine, which states that such a right is inviolable. It belongs to its owner as a natural right, so that no one can be deprived of intellectual property rights or restricted in its exercise, except as provided by law. In accordance with these principles, which in turn are based on the provisions of the Constitution, the protection of intellectual property rights is exercised by the court.

IP law institutes are determined by the type of creative activity. In 1967, a Convention was signed in Stockholm to establish the World IP Organization (WIPO). The Convention provides a list of activities that are assigned to IP.

IP rights include:

- the right to industrial property;
- the right to non-traditional IP objects.
- copyright and related rights.

Industrial property refers directly to the results of creative activity used in industry, agriculture, and trade.

The term "industrial property" does not cover movable or immovable property involved in manufacturing (equipment, structures, transportation, etc.). The concept of industrial property is defined by the Paris Convention for the Protection of Industrial Property.

Copyright and related rights govern the relationships that arise in connection with the creation and use of literary, musical and artistic works, scientific works, and the like.

Copyright is referred to in English as "copyright," because historically, in the first place, it was understood that only the author or his successor could authorize copies of a work.

Related are rights to objects such as artistic performances, phonograms, etc. The combination of these two groups of legal relations is explained by their close interdependence and the same laws governing the respective relations.

### 5.2. Industrial property

The objects of industrial property are divided into the objects of patent law and the means of individualization of participants of civil turnover, goods and services. Patent objects include: inventions, utility models and industrial designs - those protected by patents.

According to the Law of Ukraine "On Protection of Inventions and Utility Models", the object of the utility model may be the same as the object of the invention, that is, the product, method and use of a previously known product or method for a new purpose.

However, only devices are patented as utility models, and use the same features as utility devices to characterize the utility model. Utility models differ from inventions, mainly in two aspects: first, the utility model does not require an inventive level; secondly, the maximum period of protection provided by law is less than the term of protection of inventions.

Means of individualization of the participants of the civil turnover, goods and services include: trade marks (signs for goods and services), geographical indications and company names.

Invention (utility model) is the result of human intellectual activity in any field of technology.

Objects of the invention (utility model):

- products (device, substance, strain of microorganism, cell culture of plants and animals, etc.);

- process (method);

- new application of a known product or process.

Devices include designs and products – machines, mechanisms, devices, vehicles, tools, and more.

The utility model is a new and industrially applicable constructive device.

Substances include individual chemical compounds (characterized by qualitative and quantitative composition of atoms, the relationship between atoms and their mutual arrangement in a molecule is expressed by a chemical formula or crystal lattice), high molecular weight compounds and objects of genetic engineering, compositions, compounds, solutions, nuclear transformation products. For substances of indeterminate composition or indeterminate structure (for example, an individual chemical compound with indeterminate structure is an antibiotic), indications of a method of preparation are indicated.

Individual strains include strains of microscopic fungi, yeast, microscopic algae, lichens, invertebrates, non-cellular structures of viruses and phages, DNA-carrying strains (RNA). Hybrid somatic cultures and cells and cells carrying DNA (RNA) are also patented. Human genes, materials, or substances that exist in nature are not patented.

Methods of the invention include the processes of performing actions on a material object by means of material objects, that is, actions on raw materials, work pieces, and the like.

Traditionally, these are different methods of machining, chemical technology, production and transfer of energy, images, etc., various impacts on plants, animals and other objects of wildlife in order to improve their consumption properties, increase yields.

Method is the main subject of patent law in the medical field: methods of treatment, diagnostics, prevention, prognosis, research, production of a medicinal

product, etc. Almost always all of these methods involve experimental or clinical studies that confirm the feasibility of use.

A patent granted in a method also extends to a product obtained in that way.

A new application of a known product or process involves 3 specific features of a particular product or method:

- the purpose for which the product or method was applied;
- new purpose;
- positive differences in the use of a product or method for a new purpose.

Legal protection is granted to an invention (utility model) that does not contravene public order, the principles of humanity and morality and meets the conditions of patentability.

The right to use the invention is transferred to other interested parties under license. A license is an agreement whereby a person who holds an exclusive right to an invention (the licensor) allows the other person (the licensee) to use the object of that right for an agreed fee and to some extent. The license agreement is a type of commercial agreement, a special form of an agreement for the purchase and sale of IP object, in particular, technology transfer. Lump sum payments – is payment to the licensor of a fixed amount in the agreement prior to the mass release of the product, one-off or in installments. Royalties are payments that the licensee pays to the licensor throughout the life of the agreement. The licensor's share of the licensee's profit is determined by the deductions from each unit of the product manufactured under the license. Combined royalties combine one-off payments and periodic deductions. Commercial technology transfer may be under a commercial concession or under a commercial intermediation agreement for the distribution of goods and services. Patent ownership (that is, all exclusive rights) can be transferred to any physical person or legal entity under the sale, service, exchange, gift, etc. The transfer of the exclusive rights to a patented entity may be a person's contribution to the statutory fund of the joint venture as reflected in the joint venture

agreement. Patent assignment agreements are required to be registered with national patent offices.

***An industrial design*** is the result of a person's creative activity in the field of artistic design, namely: form, drawing or coloring, or a combination thereof, which determine the appearance of an industrial product and are intended to meet aesthetic and ergonomic needs. This is a legal protection of the results of the creative work of designers.

Using only artistic (such as color-changing) or design (e.g., resizing) tools is not enough, and the complementarity of these tools is a prerequisite. Therefore, the main feature of an industrial design is a design decision, that is, the definition of the appearance of products that meet human needs, can be perceived visually and able to maintain their appearance. Design objects are industrial products (production equipment, home appliances, furniture, tableware, clothing, etc.), elements and systems of the environment in the workplace, in the city, in the premises, in visual information, etc.

Industrial objects cannot be proposals that are contrary to the public interest, to the principles of humanity and morality, both for their intended purpose (such as torture tools) or for exterior design (for example, pornographic or offensive images or inscriptions).

Not recognized as patentable industrial designs:

- products whose appearance is due to their technical function (e.g. screws, except decorative ones);

- objects of architecture (except for small architectural forms), industrial hydro technical and other stationary structures. Small architectural forms include the appearance of kiosks, transport stops, telephone booths and more. Architectural objects are copyrighted;

- printed matter - books, newspapers, prospectuses, booklets protected by copyright;

- non-permanent objects, i.e. liquid, gaseous, loose and similar substances.

Industrial designs may be:

- three-dimensional structures, such as the appearance of the machine, furniture, etc.;

- plane compositions based on elements that have no volume: for example, the appearance of a scarf or carpet, drawings;

- combined, for example, the appearance of the information board, clock face, construction tile;

- single object, for example a separate product (single), or part of the product, if it has a complete composition, functionally standalone, can be used with other products (for example, headlights with different models of cars, pens, etc.)

- multi-object, for example, a set of products that make up the whole: all components perform different functions, differ from one another, but aimed at performing the same task as a whole.

They also protect the variants of products: the artistic designs of the same product, which have different essential features with the same aesthetic and ergonomic features of the product. For example, several cars that differ in the shape of the handles, headlights, trim: several chairs, different in texture and color of the upholstery.

Industrial designs must meet certain requirements.

The basic requirement for an industrial design is that it should be new and original, that is, it has individual characteristics due to the creative contribution of the author in shaping the appearance of the industrial product.

An industrial design shall be recognized as new if the set of its essential features has not become publicly available in the world by the date of application or, if priority is previously claimed. In addition, the content of all applications previously received by the Office shall be taken into account in the process of establishing the novelty of an industrial design, with the exception of those deemed to have been withdrawn at that date, and the possibility of contesting such decisions shall be exhausted.

## 5.3. Means of individualization of participants of the civil turnover, goods and services

Objects of IP, as a means of individualizing participants in civilian turnover, goods and services (or commercial designations) include:

- commercial (corporate) name;
- trademark or sign of goods and services;
- geographical indication of origin of goods.

The security document concerning trademarks and geographical indications of origin is a certificate issued by the state.

***Commercial (corporate) name.*** Here it is fundamental to distinguish such concepts as the official name of the legal entity and the commercial (corporate) name of that entity.

Thus, the official name of a legal entity is a name that individualizes a legal entity in the aggregate of its rights and responsibilities as an independent legal entity. Such name is for the legal entity the same as for the physical person his name, i.e. personal (moral) right, which cannot be the subject of turnover.

Commercial (corporate) name is the name used by a physical person or legal entity to identify an enterprise that he or she uses to identify his or her business (commercial) relationship.

Therefore, the company name, as an object of industrial property, can be transferred, i.e. to be the subject of turnover, but only together with the integral property complex or the part that it designates.

The commercial name is protected from its first use without mandatory registration, but can be entered in the register. The Law “On State Registration of Legal Entities and Individual Entrepreneurs” stores the most complete information about commercial names.

***Trademark (sign for goods and services)*** – any designation or any combination of designations that can be used to distinguish goods (services) produced (provided) by different persons. The trademark object is words, letters,

numbers, pictorial elements, color combinations.The trade mark is certified by a certificate.

R or ® or Reg TM - means registration as a mark for goods and services. Also used are abbreviations M (Mark), TM (Trade Mark) MR (Mark Registered), SM (service mark), words Trademark, Registered Trademark (Registered UK mark), "Mark Registered" and sometimes the letter L (from English Logo).

Relations that arise in connection with the acquisition and exercise of ownership of marks for goods and services in Ukraine are governed by the Law of Ukraine "On Protection of Rights to Marks for Goods and Services".

The ownership of the sign is certified by a certificate. The Certificate of Ukraine for the mark for goods and services is an official security document, issued on behalf of the state by an authorized body.

Certificate of Ukraine for a mark for goods and services gives its owner the right to use the mark, as well as the exclusive right to prohibit other persons from using the registered mark without his consent, the exclusive right to dispose of the right to the mark.

The rights arising from the certificate shall be valid from the date of application.

Any physical person or legal entity, association of persons or their successors has the right to obtain the certificate.

The amount of legal protection provided is determined by the image of the sign and the list of goods and services entered in the State Register of Certificates of Ukraine for signs for goods and services, and certified by a certificate with the copy of the sign entered in the Register and the list of goods and services.

The period of validity of the certificate is 10 years from the date of application and is extended at the request of the holder of the certificate every 10 years, subject to payment of the fee in accordance with the procedure established. The procedure for extending the period of validity of the certificate

is established by the Regulation on the State Register of Certificates of Ukraine for Signs for Goods and Services.

Upon termination of the certificate, no one other than the former owner is entitled to re-register the mark within three years.

Geographical indications in accordance with the Law "On Protection of Rights to Indicate the Origin of Goods" include:

- a simple indication of the origin of goods.

- qualified indication of origin of goods.

A simple indication of the origin of goods is any verbal or pictorial (graphic) designation that directly or indirectly indicates the geographical origin of the goods. No registration, protection is provided on the basis of its use.

Qualified indication of the place of origin of a product is the name of a geographical place used to refer to a product originating from that geographical place and having certain features (qualities, properties, reputation, etc.) solely or principally due to the natural conditions of that place and / or human factors. It covers geographical indication of origin (GIO) and name of place of origin (NMP) of the product.

GIO is the geographical name of a particular region, which indicates the specific qualities of the product but does not oblige the product to be manufactured in that locality. For example, works of arts and crafts that are caused by technology that originated in a particular place and people who use it, but the production of this product may be concentrated in a completely different place.

The NMP provides certain product features that can only be provided in a particular locality (i.e. compliance with technology and availability of people who own it - conditions are necessary but not sufficient). Most often it concerns agricultural and natural products (wines, mineral water of a particular kind).

The geographical indication must also meet certain requirements:

- protection is provided only to a qualified indication of the origin of the goods;

- applies only to goods and does not apply to services;

- the indication contains the name of the place of origin of the product or the place where the raw material is produced or processed.

Objectively, there are special conditions and factors that cause special properties and qualities.

- production (extraction) and processing of the goods designated by this name or at least the main component is carried out within the specified geographical place (in the first case it is NMP, and in the second – GIO).

For the warning marking of the qualified indication of the origin of the goods the abbreviation GIO or NMP is used.

Instead of marking or in addition to it - the text "Registered geographical indication of origin of goods in Ukraine" or "Registered name of origin of goods in Ukraine".

Registration of a geographical indication is indefinite, provided that the characteristics of the goods marked with this indication are retained. The Certificate of Right of Use is valid for 10 years, renewable every 10 years.

The holder of the certificate of use of the qualified indication of origin of the goods is also entitled to use the registered indication of origin, to prohibit such use by persons who are not entitled to it and to demand the cessation of these violations and compensation for material and non- material damage. These rights are not exclusive (monopolistic) because they belong to a range of entities: the registration of rights to use a qualified indication of the origin of goods does not restrict the rights of others to register their rights to use it.

### 5.4. Non-traditional intellectual property objects

***Legal protection of integrated circuit topography.*** IC topography (ICT)– is fixed on the material carrier spatial-geometric placement of the set of elements of the integrated circuit and connections between them. The state protects the ICT by registering it with a certificate. The amount of legal protection is

determined by the image of the ICT on the material carrier. Security does not cover ideas, methods, systems, technologies, encoded information that can be embodied in the ICT. Conservation condition of topography of IC: originality.

***Legal protection of trade secrets.*** Trade secret is information of a technical, organizational, commercial, industrial or other nature, except for those that cannot be kept confidential by law.

This information is confidential in the sense that it is unknown and not easily accessible to third parties, and the person controlling it is taking steps to maintain its secrecy.

That is, a trade secret must meet the criteria:

- submitted in the form of information;
- secrecy of information;
- commercial value;
- the provision of adequate protection by the person lawfully controlling this information.

Only under these conditions the entrepreneur has the right to judicial protection of his interests.

In the concept of commercial secrecy combine conditionally:

- business information;
- professional secrecy;
- trade secrets;
- undisclosed information - know-how;
- confidential information.

Trade secrets must be part of the enterprise management and security system. The security system is directly related to marketing, patenting, information security. Particularly important is the security system for exporting enterprises.

The employee's duty of secrecy is set out in the employment contract. In many countries, a non-disclosure agreement is signed by the employee: an

obligation not to disclose known information either during the work of the company or for a specified period after dismissal.

***Know-how.*** One of the components of a trade secret that usually relates to industrial property. It means technical knowledge, experience, production secrets that are necessary to solve a production problem and belong to confidential information, that is, they are valuable only because they are unknown to third parties.

Possible objects of know-how:

- patentable but not claimed industrial property or claimed but not yet officially published;

- inventions are patentable but not deliberately claimed, for example, because of the inability to legally detect patent infringement rights (methods of diagnosis and treatment, measurement of physical and chemical quantities without communication with devices);

- non-patentable inventions (algorithms, computer programs, ways of organizing production and marketing planning of goods, managing production and marketing of goods, accounting methods);

- information of textual and graphic technical documentation (drawings, formulation of materials, technological processes, technological maps, instructions, business plans, R&D reports, etc.).

***Legal protection of scientific discoveries.*** Discovery is the establishment of previously unknown, but objectively existing patterns, properties, and phenomena of the material world that bring about a fundamental change in the level of scientific knowledge. Discoveries in this sense are not geographical, archeological, paleontological discoveries, as well as the discovery of mineral deposits and discoveries in the social sciences. The right to discovery is certified by a diploma. The author of the discovery has personal non-property rights:

- the right of authorship - the right to be considered as the discoverer of certain knowledge;

- right to name - the right to give the discovery author`s name or custom name.

***Legal protection of rationalization proposals.*** A rationalization proposal is a proposal that contains a technological (technical) or organizational solution defined by legal entity (company, production plant, factory) in any field of its activity.

A proposal object is a material object or process. Criteria for defining a rationalization proposal:

- technical or organizational solution;

- local novelty (unknown at a particular enterprise);

- utility.

The author receives a certificate on a rationalization proposal that is valid indefinitely within the company that issued it.

***Legal protection of breeding achievements.*** The breeding achievements are the results of scientific and practical activity on the creation of varieties and hybrids of plants and breeds of animals with specified characteristics.

A plant variety is a separate group of plants (clone, lineage, first generation hybrid, population) that:

- can be distinguished in the group of plants related to each other by common features and properties (within the botanical taxon);

- has at least one difference from a known group of plants, which is characterized by heredity;

- suitable for reproduction of plants of the variety in unaltered form.

An animal breed is a group of animals (lineage, family, breed) created as a result of creative activity that has persistent genetic traits passed on to their offspring.

Property rights to breeding achievements (plant variety and animal breed) shall be certified by a patent for a plant variety, animal breed whose term of validity is 30 years; for trees, grapes - 35 years (from January 1 of the year following the year of registration of rights).

## 6. PATENT APPLICATION FOR INVENTION (UTILITY MODEL)

The author of a proposal having features of an invention or utility model may become a subject of patent rights only if the application is duly qualified by a competent state body, which in Ukraine is Ukrpatent - State Enterprise "Ukrainian Institute of Industrial Property" - authorized state institution for review and examination of applications.

In order to do this, the author of the proposal must give it an objective form that would make it possible for others to perceive and be capable of reproducing. The proposal must be embodied in a drawing, a prototype or simply described so that its nature is clear and accessible to others and is usable.

### 6.1. Procedure for obtaining a patent for an invention (utility model)

The right to qualify a creative proposal as an invention or utility model belongs to Ukrpatent. Only after Ukrpatent recognizes the proposal by an invention, utility model or industrial design, decides to enter it in the relevant State Register and grant a patent to the author, does it officially recognize the author of his creation who obtain certain rights and privileges established by the current legislation of Ukraine. Only then can the author, as well as others, disclose the substance of the proposal through publication, oral reports, and otherwise.

Intellectual property rights for inventions and utility models requires a number of formalities. This is, first and foremost, the submission of a properly filed application to the Office.

Requirements for the composition and registration of the application materials, submission of the application are determined by the Law of Ukraine *"On Protection of Rights to Inventions and Utility Models"* and *"Rules for Drafting and Submission of the Application for Invention and Utility Model"*.

The next stage is the examination of the applications when they are provided.

The last stage is the entry in the special State Register of objects that meet the conditions of patentability. After state registration a law enforcement document - patent is issued. Ukraine now has a single form of legal protection for inventions, utility models and industrial designs - a patent.

A patent is a technical and legal document certifying the recognition of the claimed proposal by the invention, utility model or design, their authorship, priority and ownership of the objects.

The right to apply for the invention or the utility model has first and foremost the author. He or she may (but is not obliged) to file an application with the Intellectual Property Representative (patent attorney) or another trustee. Foreign nationals and legal entities with permanent residence outside Ukraine submit applications only through intellectual property representatives.

An employer is entitled to apply if the invention, utility model was created in connection with the performance of a job directed by the employer.

Successors of both authors and employers also have the right to apply. The application is in Ukrainian and must relate to only one result of technical creativity (requirement of uniqueness of the invention). No two inventions, utility models or industrial designs may be combined in one application.

The application is sent to the Ukrainian Industrial Property Institute (Ukrpatent). The patent application is submitted in the prescribed form. In this application form containing a request for a patent of Office Ukraine, it is necessary to indicate which of the two objects of industrial property the applicant requests to grant a patent - for "invention" or "utility model". In the case of a request for a patent for an invention, it should be noted what the patent applicant wishes to obtain - a patent with a validity of 20 years, issued after the substantive examination or a patent with a validity of six years, which is issued under the responsibility of the applicant without essential examination. The

patent application must state the name of the applicant (s), his address, as well as the author(s) of the application.

***Composition of the application.*** The application must include:

- an application for the grant of a patent of Ukraine for an invention or utility model;
- description of the invention (utility model);
- the invention (utility model) claims;
- drawings (if referenced in the description);
- abstract.

***Paperwork.*** The application documents, namely: patent application, description and invention (utility models) claims, drawings and abstract are submitted in three copies. Documents are issued in Ukrainian.

All documents of the invention (utility model) application should be designed so that they can be stored for a long time and directly reproduced in unlimited copies.

The application documents are printed on 210 × 297 mm white paper (A4 format, portrait orientation). Each application document begins on a separate sheet, with the second and subsequent sheets numbered in Arabic numerals.

All documents are printed in black. The description text, the claims and the abstract are printed at 2 intervals or at 1.5 intervals with a computer font of at least 2.1 mm in height.

Latin names, Latin and Greek letters, graphic symbols, mathematical and chemical formulae may be written in ink or paste ink in black.

The bibliographic data of the sources of information in the application documents shall be provided so that this source of information can be found.

***Graphic images.*** Graphic images (drawings, diagrams) are executed according to the rules of the drawing, on dense, white, smooth paper with black clear lines and brush strokes, which are not wiped, without coloring.

The scale and clarity of the images are chosen such that when playing with a linear reduction in size to 2/3, it is possible to recognize all the details.

The height of the numbers and letters must be at least 3.2 mm. Numbers and letters must be clear, the thickness of their lines must match the thickness of the image lines. Numbers and letters should not be enclosed in brackets or quotation marks.

The drawings use predominantly rectangular (orthogonal) projections (in different views and sections), in some cases the use of an axonometric projection is also allowed.

Each element in the drawing is made in proportion to all other elements, except when a clear image of the element requires different proportions. The dimensions in the drawings do not indicate, they are given, if necessary, in the description. The drawings are performed without any inscriptions, except for the necessary words, such as "water", "steam", "open", "closed", "section by AA".

Separate figures are placed in such a way that the sheets are as full as possible and the drawings can be read with the vertical position of the longer sides of the sheet.

If the figures, placed on two or more sheets, are parts of a single drawing, then they are placed so that this drawing can be arranged without missing any of the figures shown on different sheets.

Multiple shapes can be placed on a single drawing sheet, with a clear distinction between them.

The figure elements are denoted by Arabic numerals according to the references to them in the description of the invention (utility model). The same elements in several figures are denoted by the same numbers. Designations not mentioned in the description of the invention, the drawings are not applied and vice versa. If graphical representations are presented in the form of a diagram, standardized conventions are used in its execution.

If the diagram is represented in the form of rectangles as graphic designations of the elements, then in addition to the digital designation directly in the rectangle, if possible, enter the name of the element. If the graphic dimensions of the element do not allow this, the name of the element can be

indicated on the line (if necessary, in the form of an inscription under that element).

The schematics of one type allow the image of individual elements of circuits of another type (for example, on the electrical circuit, the elements of kinematic, hydraulic circuits, etc. are allowed).

Each graphic image is numbered consecutively in Arabic numerals (Fig. 1, Fig. 2, etc.) regardless of the type of this image (drawings, diagrams, etc.) and the numbering of the sheets according to the order of their presentation in the text of the description. If the description of the invention explains only one graphic image, it is not numbered.

***Chemical formulae.*** The application documents may use chemical formulae.

Structural formulae of chemical compounds are provided (as in the drawing) with the numbering of each structural formula as a separate figure and references to the corresponding designations.

Conventional element symbols should be used when writing structural chemical formulae, and the links between elements and radicals should be clearly indicated.

***Mathematical formulae and symbols*.** In the description, claims and abstracts of the invention (utility model) mathematical expressions (formulae) and symbols can be used. The mathematical expression representation form is not regulated.

All letters in mathematical formulae must be deciphered. In this case, deciphering the letter designations is presented in the order they are used in the formula.

To mark the intervals between quantities, use the sign "–" (from … to …), in other cases it is necessary to write the words "from" and "to".

When expressing values in percent, the percent sign (%) should be put after the number. If there are several quantities, the percentage sign is placed before their list and separated from them by a colon.

Mathematical notation ">", "<", "=" and others are used only in mathematical formulae, and in the text should be written in words (greater, less, equal, etc.).

Explanation of the mathematical formula should be written in a column and with semicolon after each line.

### 6.2. General requirements for the contents of the application documents

The application is written in Ukrainian. If the description and the invention (utility model) claims are stated in another language, in order to save the filing date, their translation must be received by Ukrpatent within two months from the filing date of the application.

Application materials should not contain expressions, drawings, photographs and any other material contrary to public order and morality, disparaging statements about inventions (utility models) and results of activities of others, as well as information and materials that are obviously not relevant or are not required to recognize the application documents as complying with the requirements of the Rules.

In the claims, description, abstract and explanatory materials to the description, as a rule, standardized terms and abbreviations, and in their absence - commonly used in scientific and technical literature.

When using terms and notations that are not common, it is necessary to explain their meaning when first used in the text.

All symbols should be explained.

In the description, the claims and the abstract it is necessary to preserve the uniformity of terminology, i.e. the same features in the mentioned documents should be called the same. The requirement of uniformity of terminology also applies to the symbols and dimensions of the physical units used in the application materials.

The name of the invention may optionally include Latin alphabets and numbers. The use of symbols of other alphabets, special characters in the name is not allowed.

The units of measurement of physical quantities are predominantly used in units of the current International System of Units.

***Patent application.*** An application for the grant of a patent (declarative patent) of Ukraine for an invention or a declarative patent for a utility model must be submitted in Ukrainian using the form set out in Annex 1 to the Rules. If the information cannot be completely filled up by the lack of space in the appropriate columns, then it is listed on an additional sheet in the same form, indicated in the relevant column of the application.

The columns with codes (21), (22), located at the top of the application, are not filled in by the applicant, they are intended to indicate the details of the application after its submission to the Office.

If the applicant intends to pursue a patent in a foreign country, the mark in the appropriate box of the application must be marked "X".

Columns with codes (86) and (87) are filled in if an international application containing the indication of Ukraine is accepted for consideration under the national procedure.

The code (86) indicates the registration number and filing date of the international application established by the receiving agency. The code number (87) indicates the number and date of the international publication of the international application.

In the box containing the request to grant the patent of Ukraine, it is necessary to indicate what kind of patent the applicant is applying for, having marked "X" in the corresponding box.

According to the code (71) for the physical person (s) indicate full name, place of residence; for the legal entity (legal entities) indicate the full name (according to the constituent documents), location.

If the applicant is an inventor or several inventors all inventors, their place of residence is indicated on the reverse of the application in the code bar (72).

For a foreign person, transliteration (transfer of transcription marks of a certain language by the letters of the Ukrainian alphabet) is carried out with the full name or the name of the specified person. Following the Ukrainian indication, the same information is given in parentheses in the original language. The applicant's place of residence or location (if applicable) shall be given in the original language and shall indicate the country code.

For applicants - legal entities of Ukraine, enter the code according to the Unified State Register of Enterprises and Organizations of Ukraine.

If there are several applicants, this information is provided for each individual.

Code (54) gives the full name of the invention (group of inventions) or utility model, which must coincide with the name given in the description.

The code (98) indicates the address for correspondence between the applicant and Ukrpatent, the full name or the name of the addressee. Correspondence can be carried out at any convenient address for the applicant in the territory of Ukraine.

If there is a telephone, fax or other means of communication, they are indicated.

If the applicant uses the services of a representative or another authorized representative, code (74) indicates the full name and registration number of the representative or the full name of the other authorized representative.

If the applicant wishes to expedite the publication of the application, an X must be marked in the appropriate box.

The section of the application "List of Documents to be Attached" is filled in by means of "X" in the respective cells, indicating the number of copies and sheets of each document. In the box "other documents", if any in the application materials, the name of the document must be indicated.

If the right to file an application and to obtain a patent has been transferred by the inventor or employer to the assignee, in the column "Grounds for the emergence of the right to file the application and to obtain the patent" indicate the corresponding basis with the symbol "X". If the applicant (s) is the sole inventor or several inventors, then this box is not filled.

The code (72) provides information about the inventor (s): full name and place of residence. For a foreign inventor, transliteration (transfer of transcription marks of a particular language by the letters of the Ukrainian alphabet) is carried out in full and in brackets, the same data in the language of the original, If the inventors are the applicants, they put the signatures in the right column.

If the inventor (s) do not wish to be mentioned in the publication of the application and / or patent information, then the entry in the relevant application column shall be signed by the inventor (s) who does not want to be mentioned.

Filling in the last column of the application "Signature (s) of the applicant (s)" is mandatory, except when all applicants are several and their signatures are affixed to the code (72).

If the applicant is a legal entity, the application shall be signed by the person having the authority. The signature consists of the full name of the position of the person who signs the application, personal signature, initials, surname and is affixed with a seal.

If the applicant has commissioned a case on the application to a representative or other authorized person, then the authorized person may sign his / her name instead of the applicant. The date of signature is also indicated in this column. If any information is given on an additional sheet, then it should be signed in the same order.

***Description of the invention (utility model).*** The description should disclose the essence of the invention (utility model) clearly and completely.

The description must be stated in the order specified in the Rules.

Description structure:

1. The description begins with an indication of the heading index of the current edition of the International Patent Classification to which the invention (utility model) belongs, the name of the invention and contains the following sections:

- the field of technology to which the invention (utility model) relates;
- the essence of the invention (utility model);
- the prior art;
- a list of figures of the drawing (if they are referenced in the description);
- information confirming the feasibility of the invention (utility model).

For better understanding and more concise description, a different sequence of sections or parts thereof is permitted, if the nature of the invention so requires.

Replacing a section of the description in whole or in part by a reference to an information source containing the necessary information is not permitted, even if it is a description of a previously filed application or a description of a security document.

2. The name of the invention (utility model) must correspond to the essence of the invention (utility model) and, as a rule, characterize its purpose.

The name of the invention (utility model) should be given in the singular.

The exceptions are:

- names that are not used in the singular;
- the names of the inventions, which are chemical compounds covered by the general structural formula.

The name of a group of inventions, which are objects, one of which is intended to be obtained (manufactured), made or used by another, must contain the full name of one invention and abbreviated name of the other.

The name of a group of inventions, which are objects, one of which is intended for use in another, must contain the full names of the inventions that belong to the group.

The name of a group of inventions, which are variants, must contain the name of one object of the group, with the words "variants" in parentheses.

3. Field of the invention to which the invention (utility model) relates. This section identifies the field of technology to which the invention (utility model) relates and, where appropriate, the scope of the invention (utility model). If there are several such industries, then those that have the advantage are indicated.

4. The prior art. The section describes a prior art known to the applicant that can be considered useful in understanding the invention (utility model) and its relationship with the prior art.

In particular, it can be data about known to the applicant analogues of the invention (utility model) with selection among them the analogue closest to the set of features of the invention (utility model).

An analogue of the invention (utility model) is a means of the same purpose known from sources that have become publicly available before the date of application to the Office, or, if claimed priority, before the priority date, and is characterized by a set of features similar to the essential features of the invention (utility model).

If there are several analogues, the last to be described is the closest analogue.

In describing each of the analogs, the bibliographic data of the source of information where it is disclosed shall be given, indicating their features which coincide with the essential features of the claimed invention (utility model) and the reasons known to the applicant that hinder the expected technical result.

In order to identify and substantiate the reasons that hinder the use of the closest analogue to obtain the expected technical result, it is necessary to analyze the technical properties of the analogue due to the set of features inherent in it, the nature of detection of these properties when using it and to show their insufficiency to achieve the expected technical result.

***The structure of the claim.*** The utility claims may be single or multiple and may include one or more items, respectively.

A single formula invention (utility model) claim is used to characterize a single invention (utility model) by a set of essential features that do not have development or refinement for particular cases of its implementation or use.

The multi-link claim is used to characterize a single invention (utility model) with the development and / or refinement of a set of its features with respect to certain embodiments and uses of the invention (utility model) or to characterize a group of inventions.

A multi-link formula characterizing one invention (utility model) has one independent clause and a subsequent dependent clause (s). The multi-formula characterizing a group of inventions has several independent items, each characterizing one of the inventions of the group. In this case, each of the inventions of the group can be characterized by the involvement of dependent items subordinate to the corresponding independent item.

When compiling a multi-link formula, the following rules are followed:

- independent clauses, as a rule, should not contain references to other clauses of the formula, but such references are allowed, if they make it possible to state this independent clause without repeating in it the full content of other clauses;

- the dependent clauses of the formula are grouped together with the independent clause to which they are subordinated, including when dependent clauses of the same content are involved to characterize the various inventions of the group;

- the multi-link claims are numbered in Arabic numerals starting with 1 (in the order in which they are presented).

***Preparation of the claims.*** An item of the invention (utility model) generally consists of a restrictive part that includes features of the invention that are similar to those of the closest analogue, including a generic term

characterizing the purpose of the object, and a distinctive part that includes features that distinguish the invention from the closest analogue.

The limiting and distinguishing parts of a formula are separated from each other by the expression "which is different in that ...".

Without dividing the limiting and distinguishing parts, in particular, claims are made, which characterize:

- an individual compound;
- strain of microorganism, cell culture of plants and animals;
- use of a previously known product or method for a new purpose;
- an invention that has no analogues.

The formula (or each item of the multi-link formula) is set out in one sentence. An independent claim should only relate to one invention (utility utility).

In the independent claim (or in each independent claim that characterizes the group of inventions) a set of features sufficient to achieve the technical result is included. This set of features determines the amount of legal protection.

When drawing up an independent formula clause, it should be borne in mind that a set of features sufficient to achieve the technical result must be conveyed by a certain set of features inherent in the object.

A dependent clause of the invention (utility model) includes features that develop or refine a set of features specified in an independent claim, including by developing or refining certain features, and are only required in certain embodiments of the invention (utility model) or its use.

The limiting part of the dependent clause of the formula includes a generic term that reflects the purpose of the invention (utility model), as a rule, abbreviated compared to that described in the independent clause, and contains references to the independent clause and / or dependent clause (s), which it applies to.

The subordination of dependent clauses to an independent clause can be direct and indirect, that is, with reference to one or more dependent clauses.

The direct subordination of a dependent clause is used when only the features indicated in the independent clause of the formula are required to characterize the invention in the particular case of its implementation or use along with the features of this clause.

In a dependent clause of the formula characterizing a single object, in all cases, the term "Device according to claim 1" means the full meaning of the first clause of the formula, namely the totality of all, without exception, the features contained in its limiting and distinguishing parts.

If the dependent clause is formulated in such a way that there is a substitution or removal of the feature of the independent clause of the formula to which it is subordinate, then the dependent clause cannot be recognized as characterizing one invention in conjunction with that independent clause.

The claims are signed by the applicant in the same manner as the patent application.

***Drawings.*** Graphic images (drawings, diagrams, etc.) are drawn on a separate sheet (separate sheets). In the upper right corner of each sheet the name of the invention (utility model) is indicated.

Photographs may be provided in addition to other graphics to explain the nature of the invention (utility model). In exceptional cases, photographs can be presented as a basic type of illustrative material, for example to illustrate the steps of surgery.

The format of the photos should be in such a way that it does not exceed the size of the margins of the application document sheets. Small-size photos should be pasted on a pre-determined sheet of paper in accordance with the sheet quality requirements.

***Abstract.*** The abstract is a summary of the content of the description of the invention (utility model), which includes the name of the invention (utility model), the characteristic of the field of technology of the invention (utility model), and (or) its scope (s), if it is not clear from the name , characterization

of the essence of the invention (utility model) indicating the technical result to be achieved.

The essence of the invention (utility model) in the abstract is characterized by a free statement of the formula, preferably one in which all the essential features of each independent item are retained.

The abstract is for informational purposes only. It cannot be taken into account for any other purpose, in particular to interpret the claims (utility models) and to determine the prior art.

The essay is abstract in such a way that it can serve as an effective search tool in the relevant field of technology. The recommended abstract text volume is up to 1000 characters. The text of the abstract should be set out in separate short sentences and avoid complex stylistic references.

Mathematical and chemical formulae, as well as drawings, can be included in the abstract if it is impossible to make the abstract without them. The drawings given in the abstract should be made on a separate sheet and added to the abstract.

The abstract may also contain some additional information, such as a reference to the number of independent and dependent claims, graphs and tables.

Inventions and utility models must meet certain requirements for inventive level, novelty, prior art, industrial applicability.

***Inventive level.*** The patent for the invention should have an inventive level. The legislation of Ukraine considers that an invention has an inventive level, unless it is obvious to a specialist, that is, it does not follow explicitly from the prior art. In assessing the inventive step, the content of applications submitted but not yet published shall not be taken into account. This requirement does not apply to utility models.

***Novelty.*** An invention (utility model) is recognized as new one if it is not part of the prior art. Objects that are part of the prior art should be considered only separately to determine the novelty of the invention. The prior art includes all information that has become publicly available in the world before the date

of submission of the application to the Office or, if a priority is claimed, before the date of its priority.

When checking the inventive level, information from the prior art of the effect of the set of features of the claimed invention on the achievement of the specified technical result is established. If such information is not established, the invention is recognized as being in accordance with the condition of the inventive level.

***Industrial suitability.*** An invention or utility model is recognized as being commercially viable if it can be used in industry, agriculture, medicine or in other fields of economic activity. The branch of industry is indicated for use in which the invention is intended, to confirm the possibility of its implementation by means described in the application or known by the date of priority to obtain the specified technical result.

### 6.3. Example of application for utility model and invention

IPC[7]: A 43 D65 / 00

MULTIPLE SHOOTING MOLDING MACHINE

The utility model relates to the shoe industry, namely the design of a shoe molding machine.

The machine is known for the manufacture of rubber textile shoes [Altzitzer V.S., Krasovsky V.D., Meerson V.D. Production of shoes from polymeric materials / ed. V.A. Berestnev. - L.: Chemistry, 1987. – 232p., P.93], which consists of a rotary support with matrices attached to it in a circle and two injection devices. This machine allows obtaining melt polymers for molding sole of only one or two colors, which prevents the expansion of the range of shoes that are produced.

Also the machine is known for casting a multi-colored sole of the shoe [USSR patent No. 1556528, IPC A 43 D65 / 00, Bul. No. 13, 1990], containing a rotary support with molds and injection devices attached thereto, with nozzles

for injecting melt polymers of different colors. This machine does not allow the manufacture of soles of more than four colors.

In addition, the sequential injection of melt polymers of different colors into one mold, the temperature of one of the polymers is lower than the initial melt temperature, which leads to low bond strength [Lapshin V.V. Fundamentals of thermoplastics casting under pressure. - M.: Chemistry, 1974. - 274 p., P.189].

The object of the utility model is to create a machine for molding multicolored soles of the shoe, which by changing the relative position and number of elements would ensure the expansion of the range and increase the strength of multicolor soles.

This object is achieved by the fact that in the machine for molding multicolor soles, containing a rotary support with molds and injection devices with nozzles for injection of melt polymers of different colors, in accordance with the utility model, injection devices are installed with the possibility of simultaneous injection from nozzles in one mold.

This arrangement of molding devices will allow manufacturing soles with the number of colors equal to the number of injection devices, as well as simultaneously inject melts of polymers of different colors into one mold, which will increase the strength of connection between the layers of polymers of different colors by increasing the adhesion due to the fact that the melts will have an equally high temperature.

A multicolor sole molding machine, for example, with five injection devices, is presented in Figure 6.1.

The multicolor sole casting machine has a plurality of molds 1 through 24 secured around the rotary support 25 as well as injection devices 26 through 30 with nozzles 31 through 35. The casting devices 26 through 30 are mounted opposite the support 25 with the possibility of simultaneous injection of melt polymers of different colors from nozzles 31 to 35 in one mold from 1 to 24.

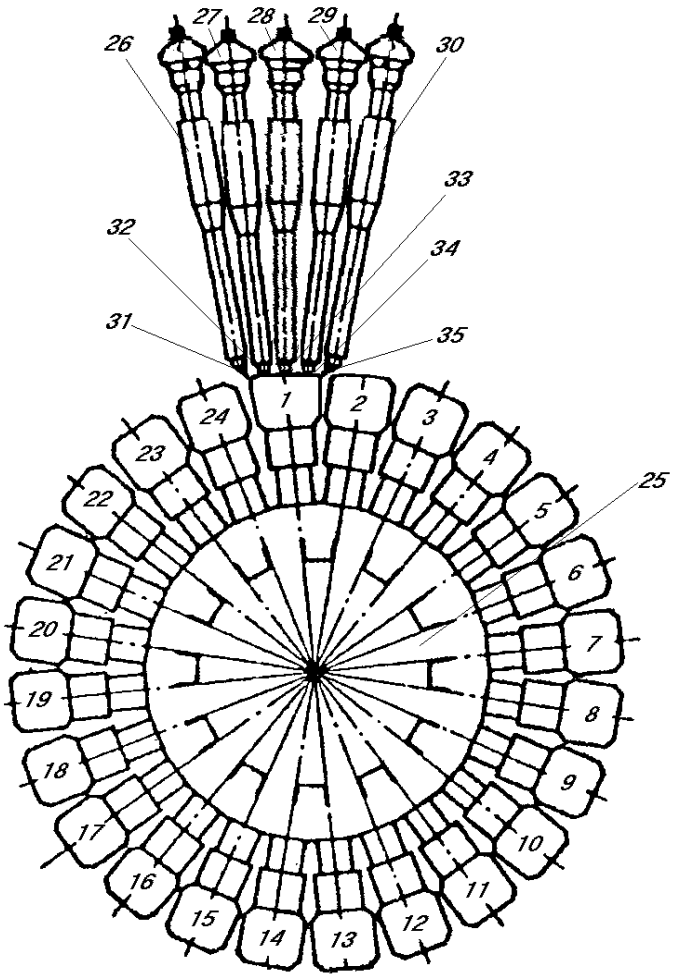



Fig. 6.1. Machine for multicolor shoe sole casting

The machine works as follows. In the mold 1 melts of different colors simultaneously are injected from the nozzles from 31 to 35 of injection devices 26 to 30, after which the support 25 rotates to the next position and the injection into the next matrix 2 begins. After cooling and curing the polymer, the multi-colored sole is removed from the mold.

UTILITY MODEL CLAIMS (FORMULA)

A multicolor shoe sole molding machine containing a rotary support with molds and injection devices with nozzles for injection of melt polymers of different colors, which is different in that the injection devices are installed with the possibility of simultaneous injection from the nozzles in one mold.

# 7. APPLICATION FOR GOODS AND SERVICES SIGN

***A sign for goods and services*** is a designation that distinguishes the goods and services of one person from the same or related goods and services of others. This term is enshrined in the Law of Ukraine "On Protection of Rights to Marks for Goods and Services".

## 7.1. The concept of a sign for goods and services

In everyday life, as a definition for trademarks can be found other names: logo, emblem, brand, trademark, slogan. Let's find out what these names mean.

***Trade mark*** (TM) in fact, is the same as a sign for goods and services, as a mark is makes it possible to distinguish the goods of one legal entity or physical person from the similar product of other legal entities or physical persons.

A trademark is a unique graphic element that is usually located next to the company name. It can also be used individually without a name.

***Logo*** - a specially designed, individually stylized form of company name, often in the original design image.

***A service mark*** is a trademark used in relation to services and not to goods.

***Slogans*** - short phrases that emphasize certain qualities of the product and the characteristics of the product or the enterprise as a whole.

***Brand*** - commonly known or well-known name that already has a reputation among consumers and has won a certain segment of the market.

***The object of the sign may be*** any designation or any combination of designations. Such designation may include words, proper names, letters, numbers, pictorial elements, colors, and color combinations, and any combination of such designations.

***Types of signs for goods and services.*** The law provides for the use of the following types of signs for goods and services:

***Verbal*** (words and abbreviations, for example, Coca-Cola, Microsoft, Kyivstar, Slavutich) are characters in the form of combinations of letters, words, or phrases.

The basic requirement for this type of sign is easy pronunciation in different languages. They are most popular because they are easy to remember and easy to advertise. These can be both existing (Nova Poshta, Puzata Khata) and artificially created words (Ukrsibbank, Roshen).

There are two varieties of word marks subject to protection: in the first case, the word itself is protected, in the second case it is a word mark made in a special style, that is, the font, the character of the letters, their relative size, background and other visual informative elements.

Verbal trademarks may include logos and slogans. For example, Nokia has registered the "Connecting People" slogan as a trademark. Examples of verbal trademarks are given in Fig. 7.1.


Fig. 7.1. Verbal trademarks

***Imagery*** (the composition of lines, spots, shapes on a plane) is a designation in the form of graphic compositions of any shape on a plane. The name itself indicates that they are embodied in the drawing, picture etc. In this case, both existing objects and abstract images and other symbols can be used. For the sake of efficiency, the pictorial sign should not be complicated and overloaded with details, but on the contrary, it should be simple and noticeable to ensure the success of advertising, the ability to use images on different materials.

An example of an iconic trademark is the crocodile of the French fashion brand Lacoste, the "swoosh" (whistling, high-speed movement) of the Nike sportswear brand, the three-star star of the Mercedes brand, Apple's stylized apple (Fig. 7.2).

Fig. 7.2. Iconic trademarks

***Volumetric*** characters are signs in the form of figures or their compositions in three dimensions - length, height and width.

Typically, volumetric trademarks are the product itself or its packaging (bottles, vials, tubes, boxes). However, volumetric signs should not simply repeat the appearance of a known object, but should be new and original, for example, a Coca-Cola branded bottle, a flower vase bottle (Raul Mason wine), a bottle of Salvador Dali perfume, a bottle in the form of apples (Nina Ricci), chocolate in the form of egg, frost, animal figures and more (Fig. 7.3).


Fig. 7.3. Volumetric trademarks

As the mark must distinguish a particular product from a number of other goods, the shape of the product should not be determined solely by its functional purpose.

***Combined*** characters are various combinations of words and images. For example, a combination of the Reebok text trademark and a pictorial sign  , a Mitsubishi inscription and a three-diamond graphic image  .

***Non-traditional*** are light, sound, aromatic and other signs for goods and services.

***Sound*** trademarks can be represented by fragments of music or short original sounds. Recently, this type of trademark is being used more and more often.

Often, sound trademarks are called "jingles". Jingle is a short, concise musical phrase with vocal singing that may contain a brand name or slogan. Examples of sound trademarks are call stations ("Europe Plus", "Gala Radio"), radio programs, tunes and screensavers of popular TV shows and more. World-famous examples of sound brands can be called the ringtone of Nokia mobile phones - Nokia Tune (musical phrase from the composition of Grande Valse by Francesco Tarreg), the sound that accompanies the beginning of the movie of the 20th Century Fox, the sound of a roaring lion by Metro-Goldwyn -Mayer Pictures.

***Aromatic*** trademarks are represented by odors, usually not specific to certain goods. Such trademarks are extremely rare not only in Ukraine but in the whole world.

They are practically unregistered, as it is difficult to submit them for registration, as well as to inform consumers that this fragrance is a trademark. The first company to be licensed for aromatic brand was the Dutch company Senta, which registered the trademark "scent of fresh mowed grass" for tennis balls. In the UK, floral fragrance for car tires and the smell of bitter beer for darts are reported; in the US, the smell of plumeria (tropical wood) for threads,

sewing and embroidery, as well as lavender and vanilla scents for stationery; in Australia - the smell of eucalyptus for golf supplies and more. However, at one time, in the United Kingdom, the registration of the fragrance brand for the famous Chanel No. 5 perfume was refused on the grounds that the smell should distinguish some products from others, and the perfume, that is, the odor carrier, in this case is a commodity in itself. Thus, the trademark indicates the type of goods.

The main problem with the use of non-traditional signs for goods and services is the peculiarities of their registration and protection in different countries. According to the Regulation on the State Register of Certificates of Ukraine for Marks for Goods and Services, the following types of trademarks can be registered in Ukraine: verbal, pictorial, volumetric, holographic, color-signs, sound and light signs.

In Ukraine, as in the US and Europe, the law does not explicitly indicate that a fragrant sign may be registered, but at the same time there is no direct prohibition of such registration.

The rules for drawing up, filing and examining the application for the issue of a certificate of Ukraine for a sign for goods and services stipulate that the said signs are registered by the patent office if there is a technical possibility of entering them in the register and promulgating information regarding their registration. Thus, if a sign is claimed as a sound sign, then such marking is given in the form of a phonogram, the type of sound (a piece of music or a part of it, noises of any origin, etc.) is indicated, and in the case of the use of a piece of music, its description is given in the form of record. If a sign is claimed as a light sign, then it is given in the form of a video, providing a description of the light symbols (signals), their sequence, the duration of the glow and other features.

If a trademark is registered in an international register, the following may be affixed to it: ®, ©, ™ or other marks.

The ® and © symbols can be seen, for example, on the famous World Wildlife Fund sign (Fig. 7.4).


Fig. 7.4. World Wildlife Fund sign

The letter R, placed in a circle, indicates that the trademark is appropriately registered and has legal protection under the applicable Patent Law. The letter C, enclosed in a circle, is an International Copyright Notice indicating the exclusive rights to that object (work, image, etc.) of a particular person or organization.

Other warning mark symbols are a combination of TM (trademark), SM (service mark), or the phrase "Marca registrada", "Trademark", "Registered Trademark", "Marque deposee", "trademark", etc.

Such symbols indicate that the manufacturer is the proprietor of his product or service, all rights reserved, and forgery is punishable by law.

The registered mark for goods and services relates to intangible assets and is an important element of marketing.

***Functions of signs for goods and services.*** A sign for goods and services (trademark) is a link between the manufacturer of a product or service and their consumer. It draws the buyer's attention to the products they are branded, allowing the consumer to select the product he needs from a specific manufacturer.

Trademarks (signs) perform basically four functions:

***1. Accentuate a product or service to others in circulation.*** This helps the trademark owner to sell the product or provide services, and to the buyer in choosing the right product or service among similar ones.

***2. Indicate the origin of the product or service.*** In this case, the source of origin does not mean a geographical area, not the name and location of its owner, namely the affiliation of a product or service to a certain manufacturer, brand, operator, etc.

***3. Indicate certain quality of goods and services.*** Trademark owners generally maintain their reputation by claiming that goods and services with these trademarks meet a certain level of quality standard. However, the consumer may not know the name of the company that manufactures the product, that is, different trademarks may characterize different products manufactured by one company. For example, in our market, not every consumer knows the name of Unilever, but everyone knows the brands it offers: Dove, Rexona, AX, Timotei, Sunsilk, CLEAR, Domestos, CIF, Lipton, Knorr, Calve and more than 400 other trademarks.

***4. Promote a specific product or service.*** This feature is one of the main features of trademarks. Trademarks are in fact advertising means. The function of advertising is a psychological effect on the consumer, which is carried out by placing a sign in the press, radio and television. Once a brand has gained a good reputation, it is much easier for a product to expand into new markets and thus stimulate exports.

An effective trademark system helps protect consumers from unfair trade and competition (for example, the use of misleading or similar trademarks).

Trademarks are also needed for government bodies responsible for checking the quality of goods and services. They help identify products and services that do not meet the requirements of the law as a result of complaints or laboratory tests. Trademark registration is a useful source of statistical and economic information for government agencies.

Therefore, the whole country should be interested in an effective legal system that ensures the protection of trademarks and their use for the benefit of producers and consumers.

***Conditions for granting legal protection of a mark for goods and services.*** Legal protection shall be granted to a mark which does not contravene public order, the principles of humanity and morality and to which grounds for refusal of granting legal protection do not apply.

Legal protection cannot be obtained for designations that depict or imitate:

- national emblems, flags and other national symbols (emblems);
- official names of the states;
- emblems, abbreviated or full names of international intergovernmental organizations;
- official control, warranty marks, seals;
- awards and other honors.

Such designations may be included in the mark as non-protected elements, if the consent is received of the appropriate competent authority of the State whose symbolism is used as an element of the mark or of the competent authority of the owner (in particular international intergovernmental organizations).

May not be registered as signs markings that are identical or similar in such a way as to be confused:

- with signs previously registered or applied for in Ukraine in the name of another person for the same or related goods and services;
- with the marks of others, if these marks are protected without registration on the basis of international treaties to which Ukraine is a party;
- with company names that are known in Ukraine and belong to other persons who have been entitled to them before the date of submission of applications for the same or related goods and services;

- with qualified indications of origin of goods (including alcohols and alcoholic beverages), which are protected in accordance with the Law of Ukraine "On Protection of Rights to Indicate the Origin of Goods". Such designations may only be non-protected elements, marks of persons entitled to use the specified indications;

- with conformity marks (certification marks) registered in due course.

Not registered as signs symbols that reproduce:

- industrial designs, the rights of which belong in Ukraine to other persons;

- the names of works of science, literature and art known in Ukraine or quotations and characters, works of art and fragments thereof without the consent of the copyright owners or their successors;

- surnames, names, aliases and their derivatives, portraits and facsimiles of persons known in Ukraine without their consent.

### 7.2. Registration of a sign for goods and services

***Registration and application for registration of a mark for goods and services.*** Requirements for the application are established the Law of Ukraine "On Protection of Rights to Marks for Goods and Services" and issued on its basis by the Rules for drawing up, submission and consideration of the application for the issue of a certificate for a mark for goods and services.

The application is submitted to the State Enterprise “Ukrainian Institute of Intellectual Property” (Ukrpatent) directly by the person wishing to obtain the certificate, or upon the request of the applicant through an intellectual property representative (patent attorney), registered in accordance with the Regulations on patent representative in the case attorneys), , or other authorized person.

Foreign persons and stateless persons who reside outside Ukraine apply only through patent attorneys, unless otherwise provided by international agreements. If the applicants include at least one physical person who has a

permanent residence in the territory of Ukraine, or a legal entity that is located in the territory of Ukraine, the application may be filed without the involvement of a patent attorney, provided the address for correspondence in Ukraine is provided.

The application must be in Ukrainian, refer to one character and include:

- an application for the registration of a sign, which contains information about the applicant and his address;

- an image of the sign claimed;

- the list of goods and services for which the applicant seeks registration of a sign, grouped by the International Classification of Goods and Services for the Registration of Marks.

If the applicant requests color protection or a combination of colors as a distinguishing feature of his sign, he must:

- state this and indicate the color or color combination in the application;

- submit color images of the sign in the application.

The application fee shall be paid within the time limits in accordance with the Procedure for payment of fees for actions related to protection of intellectual property rights.

The fee for submitting an application for a sign for goods and services is determined in accordance with the Procedure based on the content of the application materials received by Ukrpatent at the date of its submission.

***Examination of the application.*** Examination of the application is carried out in accordance with the Law of Ukraine "On Protection of Rights to Marks for Goods and Services" and the Rules and consists of formal examination and qualification examination (examination in essence).

After conducting a formal examination, during which the application is checked for compliance with the formal requirements of the Law and the date of its submission is established, a qualification examination of the application is conducted, during which the compliance of the declared designation with the conditions of granting legal protection is checked.

The final results of the examination of an application which is not withdrawn or deemed not to be such shall be reflected in the substantiated opinion of the examination on the application that enters into force after its approval.

On the basis of such a conclusion, the decision is made on the registration of a sign for all the goods and services specified in the application, or on the refusal of registration of the sign for all the goods and services specified in the application, or on the registration of a sign in respect of the goods and services specified in the application and refusal of registration of the sign for the rest of the goods and services specified in the application. The decision on the application is sent to the applicant.

On the basis of the decision on the registration of the sign for goods and services and in the presence of a document on payment of the state duty for the issue of the certificate and the fee for its publication, the information on the issue of the certificate, determined in due course, shall be published in the official bulletin "Industrial Property". These duties and taxes are payable upon receipt of the decision on registration of the sign by the applicant.

Simultaneously with the publication of information on the issuance of a certificate, state registration of the mark is conducted, for which the relevant information is entered in the State Register of Certificates of Ukraine for signs for goods and services.

### 7.3. Example of application for goods and services sign

The designation refers to combined signs, consisting of verbal and pictorial elements.

The image is a stylized picture of the sun in the form of a circle, surrounded by six triangles.


To the right and bottom of the image is the inscription "SOLAR", made in capital letters, the font Ar Destine.

The color scheme of the sign is black and white.

List of goods classified according to the International Classification of Goods and Services:

Class 9. Scientific, research, nautical, surveying, photographic, cinematographic, audiovisual, optical, weighing, measuring, signaling, detecting, analyzing, surveying, life-saving and teaching apparatus and instruments; apparatus and instruments for transmitting, switching, converting, accumulating, regulating or controlling the distribution or use of electricity; apparatus and instruments for recording, transmission, reproduction of sound, images or data; recorded and downloaded media files, computer software, pure digital or analog media for recording and storing data; mechanisms for accepting payment for coin-operated apparatus; cash registers, counting devices; computers and computer peripherals; diving suits, diving masks, earplugs for divers, nose clips for divers and swimmers, diving gloves, snorkeling apparatus; fire extinguishers.

| **Product name** | **Base number** |
|---|---|
| solar panels | 090557 |
| solar panels for generating electricity | 090733 |

# 8. COPYRIGHT AND RELATED RIGHTS

The Ukrainian legislation on copyright and related rights is based the law on "Copyright and Related Rights". Certain provisions on the protection and protection of copyright and related rights are contained in the laws of Ukraine "On Cinematography", "On Television and Radio Broadcasting", "On Publishing", "On the Distribution of Copies of Audiovisual Works, Phonograms, Video programs, Computer Programs, Databases", "On the peculiarities of state regulation of activity of economic entities related to production, export, import of disks for laser reading systems", "On advertising", etc.

## 8.1. Copyright essence

Copyrights objects include works in the fields of science, literature and the arts, namely:

- literary works of fiction, non-fiction, scientific, technical or other nature (books, brochures, articles, etc.);
- speeches, lectures, sermons and other oral works;
- computer programs;
- databases;
- musical works with text and without text;
- dramatic, musical-dramatic works, pantomimes, choreographic and other works created for stage performance and their productions;
- audiovisual works;
- works of fine arts;
- works of architecture, town planning and landscape art;
- photographic works, including works performed in ways similar to photography;

- works of fine arts, including works of decorative art, weaving, ceramics, carvings, foundry of glass, jewelry, etc., if they are not protected by the laws of Ukraine on the legal protection of industrial property objects;

- illustrations, maps, plans, drawings, sketches, plastic works relating to geography, geology, topography, engineering, architecture and other fields of activity;

- the stage performances of the works referred to in paragraph 1 of this list and the processing of folklore suitable for the stage performance;

- derivative works;

- collections of works, collections of treatments of folklore, encyclopedias and anthologies, collections of ordinary data, other composite works, provided that they are the result of creative work for the selection, coordination or ordering of content without infringing the copyright of the works included in them as constituent parts;

- texts of translations for dubbing, sounding, subtitling in Ukrainian and other languages of foreign audiovisual works;

- other works.

***Copyright and grounds for protection.*** Copyright objects are works without completing any formalities about them and regardless of their completeness, purpose, value, volume, manner or form of their expression and purpose (education, information, advertising, propaganda, entertainment, etc.). Protection extends to both published and non-published works.

A work cannot be published if it violates the human rights to the secrecy of personal and family life, damages public order, health and morals of the population.

Protection applies to works that are material (for example, unprinted but recorded), but in some cases this condition is not obligatory (for example, speeches, lectures, sermons), but in this case it is difficult to prove authorship.

Part of the work that can be used on its own, including the original title, is also protected.

Criteria for the protection of works (for the protection of rights in court):

- novelty (sometimes originality, can insure protection of similar works), that is, the work is not plagiarized. Novelty can relate to both content and form.

- expression in material form. It is treated in accordance with national laws.

Not considered as objects of and not protected by Copyright are:

- news of the daily or current events (press information);

- works of folk art (folklore), but protected are processing of folklore - derivative works;

- official documents of political, legislative, administrative nature (laws, decrees, state standards) and their official translations;

- state symbols of Ukraine, state awards, symbols and signs of state authorities and military formations, enterprises, institutions, organizations, territorial communities;

- banknotes;

- schedules of transport traffic, schedules of television and radio programs, telephone directories, databases that do not meet the criterion of originality and are covered by sui-generis (a kind of special right).

But drafts of official symbols and signs, in particular monetary ones, are considered as protected works before their official approval.

Photos obtained with the help of non-human technical devices (satellite, meteorological) are not protected because they are not the subject of creative work, that is, not the subject of copyright. But photos are the property of the organizations that took the pictures.

***Subjects of copyright.*** The author of the work - the primary subject of copyright, in the absence of evidence of another - an individual, who is listed as the author on the original or a copy of the work (presumption of authorship), even if the work is published under a pseudonym (provided that it identifies the author) . Both Ukrainian and foreign nationals may be subject to copyright. Foreign national authors enjoy the protection of copyright law in Ukraine, if the

works created by them are in some objective form in the territory of Ukraine, and if not - in accordance with the international treaties of Ukraine and the common copyright conventions (Geneva, Bern). The authors may be co-authors if the work is created by the joint creative work of two or more persons.

***Heirs.*** Only property rights are inherited, copyright is not inherited. (Exception: The personal non-property right "to counteract any misrepresentation, distortion or other alteration of the work or any other encroachment on the work that may damage the author's honor and reputation" may also be transferred to the heirs.)

Successors are persons who have acquired copyright by law or contract, including legal entities (theaters, publishers, etc.) who are engaged in the use of works.

Collective management organizations, which are not independent entities of copyright, but act on behalf of and on the basis of a contract with the author, manage the property rights of authors on a collective basis, in particular collecting remuneration for the use of works.

### 8.2. Special copyright cases

***Co-authored works.*** Copyright is owned by all contributors, regardless of whether the work is one whole or consists of separate parts. Relations between co-authors are determined by the agreement between them, in particular the part of the remuneration.

If the work is one whole, neither of the contributors can without good reason refuse others permission to use or change the work.

If the work consists of separate parts, everyone has the right to use their part at their own discretion, unless otherwise agreed by the joint agreement. The author of each piece retains its copyright (for example, an audiovisual work, authored by artists of different genres - director, screenwriter, songwriter, composer, artist, production operator).

Co-authorship is the copyright of the interview (interviewee and taker). Interviewing is permitted only with the consent of the person who gave it.

In the absence of a co-authorship agreement, the remuneration for the use of the work is due to all co-authors in equal parts.

***Composite works*** are collections, anthologies, collections of folklore treatments, etc., provided that they are the result of creative work in selecting, organizing content without violating the protection of the rights of the works that belong to them. Authors have the right to use their works regardless of their composition. The compiler has the copyright to select and arrange the works.

***Collective works*** are encyclopedias, encyclopedic reference books, periodicals, scientific papers, newspapers, magazines, etc. Persons organizing the creation of such works are not recognized by the authors, but they have the exclusive rights to use such works as a whole, and the authors - to use their parts.

The difference between a collective and a composite work: when using a collective work, one contract must be concluded with all authors, and when using a composite work, there must be a separate contract for each work that belongs to it.

***Official works*** can be created in conjunction with an employment contract and an order. In both cases it is assumed that:

- non-property rights belong to the author;

- individual personal non-property rights may belong to the legal or physical person in which the author works or to the customer;

- property rights belong to the employee who created the object (author) and the employer jointly, unless otherwise stipulated by contract (contract) or law. These agreements between author and employer set the amount and procedure for payment of royalties for the creation and use of the work.

There is a distinction between active commercial use of a product of creative activity - direct sale of material medium (books, videocassettes, etc.) or public display (motion picture, etc.) and passive - issuance of licenses for the use of parts of works in commercial circulation. This kind of passive use is the use of

well-known characters as brands, set expressions, separate frames of cartoon films, clothing elements of characters, original things and more.

***Characters.*** The rights to the character belong to the author of the first work where it appeared. For example, in many cases, cartoon characters or feature films are created by the authors of a book or screenplay to whom the character is entitled. Subsequent use thereof is an adaptation or other alteration that gives copyright protection, but subject to the rights of the original author.

The Law "On Copyright and Related Rights" provides for the use of part of the work, including the original title, independently. In this case, they are also considered as a work and protected by copyright. The form of expression of a work is protected, not theories, principles, concepts, etc., even if they are described and illustrated in the work.

The graphic character has a certain physical form, and literary exists in the imagination of the reader. There was even the idea of protecting a form of expression of a piece of work as an image that arises in the human imagination by conducting an examination to reveal the degree of similarity between a given character and others who can imitate it.

In Ukraine, a graphic or drawn character is protected by copyright as a work of fine art, as a work of applied art, as an illustration, etc. (non-exhaustive list).

Only the form of expression is protected. For example, if a cartoon is used, then each individual character and his or her statements are protected as part of the script.

***Advertising.*** One of the copyright objects may be a promotional message if it is expressed in its original form and is the result of creative activity. (If this is an informational message, such as the benefits of a product, copyright is not protected). The originality and uniqueness testify to the creative character.

Advertising is one of the types of works or containing works protected by copyright law. Example:

- literary works (original advertisements, scripts of commercials, etc.);

- musical works (the musical series accompanying all advertising messages about a certain product);

- audiovisual works (promotional videos);

- works of painting, sculpture, graphics (outdoor advertising, form and packaging design);

- photos (photos of the product in print advertising, etc.).

This list is not exhaustive. The copyright agreement provides for the possibility of anonymous use, that is, without the name of the author, otherwise there will be a violation of one of the non-property rights of the author.

The copyright holder is usually the advertiser. He owns the property rights to use the advertisement in any form and by any means. However, this requires that the author of the advertisement (for audiovisual works is a director, scriptwriter, music author, artist, etc.) be an employee of the advertiser with the relevant official duties or contract with the author.

***Photos.*** Ukrainian law provides for the protection of photographs by copyright. However, the law does not define the term "photography", which causes ambiguous decisions, for example, in court as to whether to consider a photograph an image recorded on a microfilm or a slide film, that is, whether legal protection applies to such images. There are several definitions of the term "photography".

A photographic work is an image of real objects that is obtained on surfaces that are sensitive to light or other radiation. According to WIPO still images taken on surfaces that are sensitive to light or other radiation, regardless of the technical process of the image (chemical, electronic, or other), should be considered as photographs.

Slides and apertures are also essentially photographic works because they contain discreet information and still images - unlike audiovisual works.

If a photojournalist takes a photo on his own initiative, he owns all the copyright to it.

If a photojournalist is an employee of a newspaper, magazine, etc., then his photograph can be considered as an official work in the case of certain conditions:

- the journalist is a hired employee (employment contract) and not a freelance employee or independent worker who renders his services under a civil contract;

- the work was created by a journalist just as a hired employee - as a job, and for publication in a newspaper, magazine, etc.;

- the amount of royalties for each use of the work is obligatory stipulated in the contract between the author and the employer;

- The employer has the right to use the work created by the journalist only during the period when the author has a working relationship with him.

***Works of architecture.*** A work of architecture is a work of art in the field of constructing buildings and landscapes (drawings, sketches, models, erected buildings and structures, parks, plans of settlements, etc.).

According to the law of Ukraine "On architectural activity", objects of copyright for works of architecture are objects of architecture or town-planning (works of architecture) at all stages of their design and construction.

Co-authors of a work of architecture are the persons whose creativity is the architectural design of separate independent sections of the project (interiors of premises, individual houses or structures of architectural complexes, landscaping, etc.).

Co-authors may not be persons who provide technical, advisory or organizational assistance to the author or organize the design and construction and control over the execution of these works (reconstruction, restoration, overhaul).

To the authors of the work of architecture belong to all property and property rights defined by the law "On Copyright and Related Rights".

Special non-property rights of the author of the architectural work - unhindered photographing of his own work of architecture and designation of the object of his own name.

The property rights of the author of the architectural work may relate not only to the project of the object, but also to the working documentation created therefrom and extend to the constructed object of architecture.

The author of the custom-made architecture project has the exclusive right to:

- participation in its further implementation, unless otherwise provided by the terms of the contract with the customer (copyright supervision);

- modification of an object of architecture in case of change of its functional purpose or reconstruction;

- royalties for creating an architectural work and using it.

The use of an architectural project for implementation is one-off, unless otherwise provided by the contract for the creation of the project. Re-use of the project and its working documentation is possible only with the consent of the author with the payment of the royalties.

The author's property rights for the project and the built-in architectural object are retained by the author if the owner or user of the object changes.

It is possible to use images of architectural works permanently in a place open for free visit, unless the image of the work is the main object of reproduction for commercial purposes.

***Cartographic works.*** Cartographic works are all kinds of maps, atlases, plans, regardless of their form and type of information carrier: aerospace maps, their derivative products; digital maps and diagrams (digital terrain models), their software; cartographic content of globes; advertising cartographic products; sketches of illustrations relating to geography, topography, cartography, etc.

The objects of copyright in the creation of cartographic works are:

- development of a project of a cartographic work or series of interrelated works - form of the work, purpose, content, method of cartographic image, method of transfer of information, etc.;

- development of the author's original work - thematic content, system of symbols, decoration, translation, etc .;

- development of new geoinformation technologies, software complexes for creation of processing and storage of digital cartographic information;

- development of new technologies when creating globes, relief maps, and plans.

By copyrights are also protected works of cartographic subjects: methods of creation or updating of cartographic works; creation of new catalogs, directories of cartographic information; publications and scientific developments on the subject.

***Museum exhibits.*** Copyright also applies to art exhibits in museums. Larger museums most often exhibit works that have expired copyright which are not the property rights to material media - sculptures, canvases, etc., but copyright property to the result of creativity. In this case, no one has the exclusive right to authorize or prohibit the reproduction and distribution of the relevant picture.

If the term of copyright is not expired, the museum retains the material medium, unless otherwise stipulated in the contract.

But the museum has the right to prohibit access to exhibits that, as tangible property, belong in his person to the state. The museum should also, as a person authorized by the state, take care of the preservation of the exhibits and, for example, prohibit photography when it harms the work of art (use of a magnesium flash). The entrance to the museum is a material reflection of the services provided - access to the exhibits.

The production of artistic, printed, souvenir and other duplicated products and consumer goods from the image of museum exhibits, museum buildings and

the use of their names and symbols is carried out only with the permission of the museum management.

If the reproduction (photograph) of the exhibit already exists, then the rights of the author of this copy and its reproduction shall continue to apply. But certain conditions are necessary: reproduction (copy) was creative and proving the fact that it was this copy (reproduction) that was used for further reproduction. Museum permission is not required for such reproduction and distribution.

***Exercise of copyright.*** The term "copyright for a work" includes all the rights granted to the author: both personal property and non-property ones.

Personal non-property rights:

- to require author`s name to be given in connection with the use of the work;

- to ban author`s name if he or she wishes to remain anonymous;

- choose a nickname and ask for its use instead of the author's real name;

- ensuring the integrity of the work (counteract the distortion or any encroachment on the work, which can damage the honor and reputation of the author);

- accompaniment of the work with illustrations, prefaces, sayings, comments, etc. - only with the consent of the author.

The right to maintain the integrity of the work is that changes are made in relation to the production process in different areas of creative activity (audiovisual works, computer programs, the concept of appearance of everyday objects, etc.).

It must be distinguished from the right to change, which is part of the property rights and is a way of use (adaptation, translation, etc.).

The author has the right at any time to prohibit the use of his works, if it harms his honor and reputation.

In the case of the death of the author, the integrity of the work is protected by a person authorized by the author, in the absence of such authorized integrity of the work is protected by heirs or other interested persons.

If a work goes into the public domain, any changes to it can be made freely, but provided that it is a modified version (for example, a motion picture based on a famous work).

Non-property rights also include:

- inalienability of rights;

- the right of publication.

Personal non- property rights cannot be transferred (alienated) to other persons.

Property rights to the work:

- the right to use the work;

- the exclusive right to authorize the use of the work;

- the right to prevent the misuse, including to prohibit it, that is, the right to prevent the unauthorized copying, sale, execution, demonstration, or creation of derivative versions of copyright work by other persons.

The use of the work is:

- publishing;

- reproduction by any means and in any form;

- translation;

- processing, adaptation, arrangement, etc .;

- inclusion in the collections, databases, anthologies, encyclopedias, etc .;

- public performance;

- sale, lease or rental, etc .;

- import of its copies, copies of its translations, alterations, etc.

A work is considered to be published if it is in any way communicated to an indefinite number of persons, including published, publicly performed, publicly shown, transmitted by radio or television, displayed in publicly available electronic information systems.

If the work is released, the author cannot prohibit its private or free display in the family (i.e., non-commercial use).

Legislation in most countries allows the possibility to refuse to publish (the right to revoke) or to withdraw a work from circulation. The views of the author outweigh the principle of binding force of contracts and respect for the rights acquired by third parties. In Ukraine, such actions are not foreseen.

If the material object in which the work is embodied (works of fine art: sculptures, paintings, etc.) is owned by another person, it cannot prevent the author from registering the copyright because the owner is entitled to the material medium as an object of property right, and the author for the artistic content of the work. The author has additional rights if his work became the property of a third party:

- right of access - the opportunity to reproduce their works;

- right to follow - the right in case of resale of a work for remuneration from the seller in the form of a certain percentage of the resale price (in Ukraine it is 5%).

The owner of the original work of fine art or architecture is not allowed to destroy this object without first offering the author for a price that does not exceed the cost of materials or allows the author to make a copy of the work, and for the architectural construction - a photograph.

This list is not exhaustive, including the exclusive rights of authors to use works of architecture, urban planning, landscape art and the right to participate in the practical implementation of projects of these works.

Property rights may be transferred in whole or in part to any other person under the copyright agreement.

The right of the author to receive just compensation for any use of the work created by him may not be subject to transfer or refusal. This right does not concern property rights, it is not alienated.

A copyrighted person (author or person to whom a property right to a work has been legally transferred) can claim his or her copyright with a copyright mark (regardless of whether the registration is present).

The use of a copyright mark does not imply a requirement to complete the formalities as a condition of protection. Copyright protection is granted automatically both to works with or without the mark.

Copyright mark contains:

- latin letter "C", surrounded by a circle - ©;
- the name of the copyright holder;
- year of the first publication of the work.

***Copyright registration procedure.*** Registration of copyright is not obligatory, but the author or the owner of property rights for the work may register their copyright in the relevant state registers at any time during the term of copyright protection. The fact of registration may be used to the benefit of the author in situations where there is a dispute about the authorship.

***Copyright compensation.*** The author can get his reward:

- under the agreement that specifies this remuneration after being discussed by counterparties;
- thanks to the actions of the collective management organization;

*Copyright agreement.* Copyright agreements are:

- the transfer (alienation) of property rights;
- transfer of exclusive or non-exclusive right to use works;
- agreement of order;

Under the agreement on the transfer of the rights to use the work, the copyright subject authorizes the use of the work in any known manner or in some specific way to a third party. Use of the work is allowed solely on the basis of the copyright agreement, except in cases provided by law.

The transfer of the exclusive right implies the transfer of the right to use the work in a certain way and within the established limits to only one person, who has the right to allow or prohibit such use of the work to other persons.

An agreement for the transfer of a non-exclusive right to use a work to another person gives him or her the right to use the work in a certain way and within the stipulated limits, provided that the person who transfers the non-exclusive right retains the right to use the work and transfer the non-exclusive right of use to others (for example, permission to exercise theatrical production of the play is provided by the playwright of several theaters).

Copyright agreements are made in writing. Exception: An agreement to publish a work in periodicals (newspapers, magazines, etc.) may be made orally.

The contract must specify which rights to use the work are transferred and whether these rights are exclusive.

Property rights not specified in the contract as transferred shall be retained by the copyright subject. Unless otherwise stated, the transferred rights are not considered exclusive.

The contract states the essential conditions:

- contract term;
- the way of using the work;
- the territory covered by the transferred right;
- amount and procedure of payment of royalties;

Other conditions may apply at the request of either party.

The royalties are determined by:

- as a percentage of the income from the use of the work;
- in the form of a fixed amount (lump sum payment);
- otherwise.

***Copyright restrictions.*** The law allows in some cases the freedom to use the work without the author's consent or to reproduce copies of the work to libraries or archives, for study and for personal purposes.

The law allows the work to be used freely without the consent of the author, but with the obligatory indication of the author's name and source of borrowing in case:

- use of quotations, including in the form of press reviews, the inclusion of excerpts from speeches and works in phonograms, video programs, broadcast programs;

- as illustrations in publications, broadcasts or educational programs;

- reproduction in the press (reprint) or public performance of articles published in newspapers or magazines on current economic, political, religious and social issues or works of the same nature, unless specifically prohibited by the author (no note: reprint without permission is prohibited);

- reproduction in the catalogs of works exhibited at publicly available exhibitions, in collections, etc .;

- publication of published works in relief and dot font for the blind;

- public performance of musical works during official and religious ceremonies, as well as funerals;

Without the consent of the author it is allowed:

- reproduction of copies of the work by libraries and archives

- reprographic reproduction of educational institutions for classroom or as illustrations for training;

- reproduction solely for personal or ordinary family purposes (with the exception of architectural structures, computer programs, reprographic reproduction of books, musical texts, works of art).

***Copyright term.*** Copyright takes effect from the day the work is created. The protection provided by law is valid for the life of the author and for 70 years after his death.

Exceptions:

- for works published anonymously or under a pseudonym that does not cause doubts about the author's identity - 70 years after the publication of the work;

- for works created in co-authorship - during the life of the co-authors and 70 years after the death of the last co-author;

- for the works of posthumously rehabilitated authors - 70 years after rehabilitation;

- for a works published for the first time in 30 years after the death of the author - 70 years after the date of lawful publication;

- if a work is published for the first time after the term of copyright protection expires, then the person who made the publication shall enjoy the rights equivalent to the property rights of the author for 25 years from the date of the first publication.

Copyright expiration is January 1 of the year following the year in which the stated legal facts took place. Personal non-property rights are protected indefinitely.

Only property rights are inherited, but the heirs have the right to oppose the change of the work and encroachment on the work, which can damage the honor and reputations of the author. After the expiration of the copyright, the works are transferred to the public domain, that is, they can be freely used by any person without payment of remuneration, provided that the non-property rights of the author are respected.

### 8.3. Related rights

***Objects of related rights are:***

- performance (literary, dramatic, musical, musical-dramatic, choreographic, folklore and other works);

- phonograms (video programs);

- broadcasts (programs) of broadcasting organizations.

***Occurrence and exercise of related rights***. Related rights arise from the fact of the origin of a work, the production of a video or phonogram, the publication of a broadcast organization. A person with related rights may use a special sign, established by law, on all copies of phonograms and video programs, or their packaging, to notify their rights.

- latin letter "P", surrounded by a circle;

- name of the person to whom the related right belongs;

- indication of the year of the first publication of the phonogram (videogram).

In the absence of evidence to the contrary, the performer, producer of the phonogram or videogram shall be the persons whose names are stated on the phonogram, videogram or their packaging.

Personal non-property rights.

Artists have the rights to:

- require recognition as a performer;

- require that the name or nickname be noted or communicated in connection with each appearance, recording, performance;

- demand the proper quality of the recording of performance and to counteract any distortion, substantial alteration which could damage author`s honor and reputation.

Producers of phonograms (video programs) have the rights to:

- indicate their name (title) on each recording medium or packaging, along with the authors, artists and titles of the works;

- require mentioning when using phonograms (video programs).

Broadcasting organizations have the rights to:

- require mentioning of their name in connection with recording, reproduction, distribution of the broadcast and public re-announcement by another broadcasting organizations.

The law covers all aspects related to music, from performing on stage to producing CDs, karaoke, cell phones. That is, a piece of music is protected not only in form but also in essence, all ideas of a piece of music are protected. The fact that a music idea is being misused can be easily verified.

Restriction of property rights of performers, producers of phonograms and video programs, and broadcasting organizations. The law permits the free use of

related rights objects, their fixation, reproduction and communication to the public under the following conditions:

- reproduction of these objects for the purpose of study or research without export permission from Ukraine;

- retention by the subjects of related rights of the right to fair remuneration, taking into account the number of copies reproduced;

- observance of the personal non-property rights of the subjects of related rights.

Only home reproduction is allowed for the personal use of the works and performances recorded in the phonograms and video programs. Payment to owners of copyright and / or related rights for this reproduction is made in the form of deductions of 5% of the cost of the equipment and tangible media, with the use of which reproduction for personal purposes can be made. The exceptions are equipment and material intended for professional use, exported from Ukraine or imported into the customs territory for no commercial purpose.

The amount of the deductions is determined by the Cabinet of Ministers, and they are listed by manufacturers and importers of equipment and material media (tape recorders, camcorders, flash cards, blank CDs) by the designated Collective Management Organizations for payment to the entities of copyright and related rights.

For public use, the pay is: 1% of the proceeds of the activity in which the related rights objects are used, or 2.5% of the total cost of the said use in the absence of income (e.g., street events).

For public announcement by broadcasting and relaying performances and phonograms recorded for commercial purposes in broadcasts of terrestrial and satellite broadcasting and television - 2% of the proceeds from the activity through which the use of object is carried out and Internet - 5% of revenues. They shall provide written information about the phonograms used and the performances recorded therein for the distribution of the remuneration.

Allocation of remuneration between entities: 50% for performers, 50% for phonogram and video producers. It is distributed equally: 50% between Ukrainian and foreign performers.

Cable broadcasting organization is a television and radio organization that broadcasts publicly broadcast radio and television programs and programs (both its own and others'). A minimum rate of remuneration for the use of works of science, literature and art - 5% of the revenue generated from the type of activity in which the public announcement (cable television, radio, via the Internet) occurs. This royalty (royalty) is calculated and paid depending on the length of the public announcement (may be reduced in some cases).

According to the national legislation of Ukraine, the rights of performers, producers of phonograms and video programs and broadcasting organizations shall be protected for 50 years from the date of the first recording of the performance, publication of the phonogram or public announcement of the broadcast.

The term of protection expires on January 1 of the year following that in which the intended term of protection expires.

Ways to manage property rights:

- personally;

- through his attorney;

- through the organization of collective management.

Powers to manage property rights are obtained on the basis of agreements concluded in writing.

Protection of copyright and related rights. Infringements of copyright and / or related rights are:

- any actions that violate the property and non-property rights of the copyright and / or related entities;

- piracy - publication, reproduction, importation into the customs territory of Ukraine and exportation, distribution of counterfeit copies of works (including computer programs and databases);

- plagiarism - the publication, in whole or in part, of someone else's work under the name of a person who is not its author. Plagiarism is a violation of both non-property rights (the right to be considered as the author) and property (use of the work without permission and payment of remuneration);

- any actions for conscious circumvention of technical means of protection of copyright or related rights.

Subjects of copyright and related rights have the right to:

- demand recognition and renewal of their rights and prohibit actions that violate or create such a threat;

- file claims for damages, including loss of profit, and non-property damage;

- require the termination of preparatory actions for infringement of copyright and related rights, including customs procedures;

- to demand from violators information about persons involved in the production and distribution of counterfeit products and channels of its distribution.

The court has the right to make a decision on compensation for non-property and property damages, on recovery from the offender of the income received as a result of the violation, on payment of compensation (from 10 to 50,000 minimum wages), on prohibition of publishing works, performances, production of phonograms, termination of their distribution, confiscation of counterfeit copies and equipment and materials intended for their production with a possible transfer to the plaintiff, publication in the press of information on violations and court decisions, etc.

The court may impose on the offender an additional fine of 10% of the amount awarded in favor of the plaintiff. The amount of the fine is transferred to the State Budget of Ukraine.

***Copyright and Related Rights in the Information Society.*** The development of computer networks significantly changes the conditions for the transmission of information and, accordingly, the conditions for reproduction,

distribution and management of intellectual property. The use of classical legislation is often impossible, and special legislation is not available at the international and national levels.

Any presentation of information on the Internet is a creative work. Even objects that are not copyright protected, such as any statutory government documents, are transformed and become objects of intellectual work.

From a copyright perspective, translating a work into digital form is a reproduction of the work or its transformation. Legislation in most countries (and in Ukraine as well) stipulates that reproduction of works without the consent of the authors and without payment of royalties is a violation of copyright, except when such use is made solely for personal purposes. Personal use is a one-time conversion, translation, processing, arranging or other reproduction solely for the purpose of personal use, in cases such as: personal research, education or entertainment.

Typically, sites that host copyright items indicate the conditions under which these works may be used by third parties.

*Educational edition*

*Zlotenko* Borys
*Kulik* Tetyana

# METHODOLOGY OF MODERN SCIENTIFIC RESEARCH WITH THE BASICS OF INTELLECTUAL PROPERTY

Textbook

Навчальний посібник присвячений висвітленню загальних методів сучасних наукових досліджень, методології математичного планування та аналізу експерименту, етапів підготовки магістерської роботи. Розглянуто основи інтелектуальної власності. Наведено приклади оформлення заявки на винахід (корисну модель) та знаку для товарів та послуг. Зміст навчального посібника відповідає програмі дисципліни «Методологія сучасних наукових досліджень з основами інтелектуальної власності». Посібник рекомендований для студентів другого (магістерського) рівня освіти.

*Навчальне видання*

*Злотенко* Борис
*Кулік* Тетяна

# МЕТОДОЛОГІЯ СУЧАСНИХ НАУКОВИХ ДОСЛІДЖЕНЬ З ОСНОВАМИ ІНТЕЛЕКТУАЛЬНОЇ ВЛАСНОСТІ

Навчальний посібник

Рекомендовано Вченою радою Київського національного
університету технологій та дизайну
для студентів другого (магістерського) рівня вищої освіти
усіх спеціальностей

Редактор *Т. Кулік*
Відповідальний за поліграфічне виконання *А. Пугач*

Підп. до друку 19.02.2021 р. Формат 60х84 1/16.
Ум. друк. арк. 9,06. Облік. вид. арк. 7,09. Наклад 20 пр. Зам. 1571.

Видавець і виготовлювач Київський національний університет технологій та дизайну.
вул. Немировича-Данченка, 2, м. Київ-11, 01011.

Свідоцтво про внесення суб'єкта видавничої справи до державного реєстру видавців, виготовників і розповсюджувачів видавничої продукції ДК № 993 від 24.07.2002.