NATIONAL UNIVERSITY LIFE AND ENVIRONMENTAL SCIENCES OF UKRAINE

Department of computer systems, networks and cybersecurity

Department of information and remote technologies

Tetyana Osipova
Olena Glazunova
Sergii Mamchenko
Dmytro Kasatkin
Olena Dubovyk

INFORMATION TECHNOLOGIES

Textbook

KYIV 2024

PRINT

UDC 004.05.94

Recommended for publication by the Academic Council of the National University of Life and Environmental Sciences of Ukraine (protocol No.__ dated November __, 2024)

Reviewers:

Viktoriia Khrutba, Doctor of Technical Sciences, Professor, Head of the Department of Ecology and Environmental Protection Technologies of National Transport University;

Olena Kryvoruchko, Doctor of Technical Sciences, Professor, Head of the Department of Software Engineering and Cyber Security, State University of Trade and Economics;

Mykhailo Shvidenko, Doctor of Economics, Professor, Head of the Department of Information Systems and Technologies, National University of Bioresources and Nature Management of Ukraine;

Svitlana Amelina, Ph.D., professor, head of the department of foreign philology and translation, National University of Bioresources and Nature Management of Ukraine.

Osypova T.Yu., Glazunova O.G., Mamchenko S.M., Kasatkin D.Yu., Rantjuk I.I., Dubovyk O.M.

The textbook "Information technologies" is designed for teaching the disciplines "Informatics and Systemology" and "IT in bio-engineering" and contains theoretical material that provides an opportunity to form an understanding of the relationship between information technologies, informatics, the systematicity of ecological and economic data, statistical data processing and their organization in the database system. A separate section is devoted to modern network and information and communication technologies. The presented theoretical material is supplemented with practical works using modern software methods: - K.: NUBiP of Ukraine, 2024. – 387 p.

CONTENT

INTRODUCTION

In Ukraine, there has recently been a rapid growth of ecological and economic organizations and social movements for the protection of the environment. In their work, they use experimental data, which must be skillfully and scientifically competently processed, systematized and visually displayed for society. It is for this reason that the discipline "Informatics" was introduced for students of higher educational institutions under the educational program of training of specialists of Bachelor's degree in specialties 101 - "Ecology", 051 - "Economics". Nowadays, life without computers is almost impossible. Computers are necessary at home, at work, in banking, in the film industry and many, many other places. Currently, it is impossible to even imagine life without computers. They opened a qualitatively new stage in the life and development of human civilization. However, the information contained on one computer is rather difficult, especially with large volumes of information, to be transferred to another computer for further work.

Until now, a standard program has been developed, several methodological instructions for performing laboratory work in the discipline have been issued, an educational and methodological complex has been prepared and electronic training courses have been introduced in the Elearn and Moodle system, and an educational practicum in informatics has been issued. The textbook is based on theoretical and practical material from the disciplines "Computer networks" for students of the Bachelor's degree.

The textbook consists of six sections containing: 1) use of the MS Office package (Osypova T.Yu.); 2) modern network and information and communication technologies (Mamchenko S.M.); 3) use of distance learning environment and Internet resources (Glazunova O.G.); 4) use of the Mathcad application (Osypova T.Yu.); 5) MS Access database management system (Mamchenko S.M.); 6) designing presentations in the MS Powerpoint processor (Kasatkin D.Yu.).

The textbook is addressed to students of the Bachelor's degree in the specialties 101 - "Ecology", 051 - "Economics" and may be useful for students of other non-technical specialties.

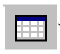
CHAPTER 1. USING THE MS OFFICE PACKAGE

1.1. Creation of tables in the word processor MS Word and carrying out calculations in them

Tables are used to present information containing numerical data in a form more convenient for analysis. The word processor Word has quite developed tools for quickly and conveniently creating tables of any configuration with wide possibilities of editing and formatting their content, as well as changing the structure of the table itself, performing simple calculations with numerical data.

Creating a table

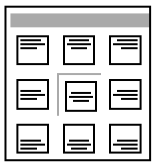
- **perform** actions: **Insert® Table⇒ Insert a table** ;
- in the dialog box that opens, in the **Number of columns field** set the required number of columns, and in **the Number of terms field** - the number of lines;
- press the **OK button** .

A table can also be created using the **Add table** button () on the standard toolbar, or by following the steps **: Insert ⇒Table® To draw the table** .

When a table is created by one of the above methods and the cursor is placed in one of the cells, two new tabs **Design** and **Layout** for working with tables automatically appear in the menu bar on the right.

Table formatting

- *Changing column width and row height:*
  - place the cursor on the vertical or horizontal dividing line of a column or row so that it takes the form ← ‖ → ;
  - when the left mouse button is pressed, the dividing line is moved.
- Merging *cells:*
  - select a range of cells for merging;
  - perform actions: **Layout** (work with tables)**⇒ Mergee cells** .
- *Column insertion (row, cells)* :
  - place the cursor in the cell near which the object should be inserted (column, row, cell);
  - perform actions: **Table ⇒Add** ;
  - in the cascading submenu that opens, select the desired object and its insertion option relative to the location of the cursor.
- *Horizontal and vertical alignment of information in a table cell*:



  - place the cursor in the desired cell;
  - press the right mouse button;
  - in the dialog box that opens, select the **Alignment in cell** item **,** go to the cascading submenu and choose one of the 9 options for aligning the contents of the cell;

  or :

  - perform actions **View⇒ Panels tools⇒ Tables and borders ;**

- buttons for 9 alignment options will appear on the toolbar;
- select a range of cells the contents of which must be aligned;
- choose one of the alignment options.

▪ *Changing the direction of writing text in a cell (horizontally, vertically):*
  - set the cursor in the cell;
  - perform actions: **Format⇒ Text direction ;**
  - in the dialog box that opens, in the **Orientation** field choose the text orientation option in the cell;
  - press the **OK** button .

▪ *Changing the thickness and type of the table line:*
  - set the cursor in the cell of the table;
  - perform actions: **Table ⇒ Table properties** ;
  - **or** call the context menu;
  - in the dialog box that opens, select the **Table** tab and press the **Borders and filling** button ;
  - in the next dialog box, on the **Border** tab in the **Type** zone , mark: **Grid -** to change the type and thickness of the grid, **All** - to change the type and thickness of all table lines, **Frame** - to change the formatting parameters of the table frame;
  - in the fields **Type** , **Color** , **Width,** select the desired one from the lists;
  - in the **Apply to field,** select: **table –** to format the lines of the entire table, **cell –** the lines of the cell in which the cursor is located, or the selected range of cells;
  - click the **OK** buttons in both dialog boxes.

▪ *Changing the background and color of the working field of the table:*
  - place the cursor in a cell of the table, or select a range of cells, the color of which must be changed;
  - perform actions: **Table⇒ Table properties** ;
  - in the dialog box that opens, select the **Table** tab and click the **Borders and fill** button ;
  - in the next dialog box, on the **Fill tab** , select a color from the palette;
  - In the **Apply to** field **,** select the desired one;
  - click the **OK** buttons in both dialog boxes.

Splitting and joining tables

The table can be divided horizontally into several. To do this, set the cursor in the selected place, perform the following actions: **Table ⇒ Split the table** . The table will be divided into two. The dividing line will pass above the cursor location. To combine the tables, they are placed one under the other and all punctuation marks between them are removed, including the paragraph end mark.

Conversion of text to table and table to text

When entering text that is planned to be converted into a table, the following rules apply:

- fragments of the text, which will be placed in separate columns of the table, are separated by certain punctuation marks: tabulation (Tab key), semicolon, paragraph or others;
- text fragments, which will be located in separate lines, are separated by the end of the paragraph mark (Enter).

Select the text intended for conversion into a table and perform the following actions:

- **Insert ⇒Table ⇒ Convert into a table ⇒Text into a table** ;
- in the **Convert to Table** dialog box enter the number of columns of the future table in the appropriate field, the number of rows may not be entered;
- in **the Auto Selection of width of columns** group of switches choose one of the proposed options;
- in the group of switches **Separator** note a tick mark used to separate text fragments intended for placement in separate columns;
- if there is no such sign among the proposed ones, choose the **Another** item and enter the desired character in the corresponding field;
- press the **OK** button .

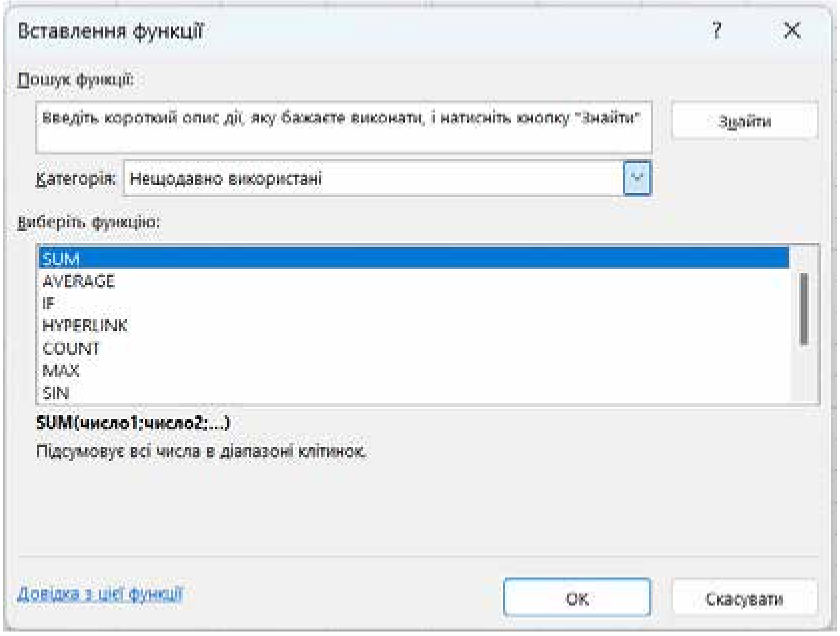
To convert the table into text, perform the following actions:

- separate the table;
- **Work with tables ⇒Layout ⇒ Convert to text** ;
- in the fields of the dialog box, similarly enter the parameters upon request.

Using formulas in a table

With the numerical information placed in the MS Word table, you can perform simple calculations, for example, adding, multiplying, dividing the numbers located in different cells of the table, by using VBA functions (Visual programming language Basic for applications). To perform calculations in a table cell, perform the following actions:

- set the cursor in the selected cell;
- **Work with tables ⇒Layout ⇒Formula;**
- in the dialog box that opens, one of the calculation formulas will be offered in the **Formula** field , depending on which cell was previously selected:
  - **=SUM(ABOVE)** – adding the numbers located above the selected cell (the cell with the formula is below the column with numbers);
  - **=SUM(LEFT)** – adding the numbers placed to the left of the selected cell (the cell with the formula is to the right of the row of numbers);
  - if there are empty cells in a row or column, they must be filled with zeros for calculations;
- if the proposed formula suits you, press the **OK** button ;
- if not, then it is removed from the **Formula** field , leaving only the = (equals) sign;



(Формула=formula, формат числа=number format, Вставить функцию=enter function, Вставить закладку=enter bookmark)

- enter the formula yourself, or select the menu (see fig.).

Addresses of cells with data are used when entering formulas. The cell address consists of the column designation and the row number. Columns are denoted by Latin letters (for example, A, B, C, D, etc.), rows by numbers (for example, 1, 2, 3, etc.). The address of the cell located at the intersection of column D and the second row will look like D2.

The following can be used in the formula:

- mathematical operators (for example, + (addition), – (subtraction), * (multiplication), / (division));
- VBA functions (for example, **SUM** - sum, **PRODUCT** - product, **MIN** - minimum value, **MAX** - maximum value, etc.);
- the required function is selected from the **Insert function list of the Formula** dialog box ;
- after entering the formula, press the **OK** button .

Examples of using functions :

=SUM(LEFT)/2 – the sum of the numbers located to the left of the selected cell, divided by two;

=MIN(LEFT) – the minimum number from those located to the left of the selected cell;

When the data presented in the table is changed, calculations according to the formulas are repeated. For this purpose:

- select the table, or the part of the table in which changes have taken place, using the mouse, or by performing the following actions: **Table⇒ Highlight⇒ Table** ;
- press the **F9 key** ;
- cell values calculated by formulas will be updated.

The main categories of functions, arguments, operators are given in table 1.1.

Table 1.1.

Categories of functions	
Statistical	
AVERAGE()	Average
COUNT()	Number of values
MAX()	Maximum
MIN()	Minimal
SUM()	Sum
Mathematical	
ABS()	Module
ROUND(x, y)	rounding
MOD(x, y)	
INT(x)	Integral
SIGN(x)	Whole part
PRODUCT()	Product
Logical	
IF(x,y,z)	If
AND(x,y)	AND
OR(x,y)	Or
NOT(x)	Denial
FALSE is a logical constant of 0	False statement
TRUE is a logical constant of 1	True
DEFINED(x)	Determines the value in a cell
Arguments (indicated in round brackets)	
RIGT	To the right of the cell
LEFT	Left
ABOVE	Above
BELOW	Lower
CELL ADDRESSES	A1, etc
constants	Numbers, text in double quotes
WORD functions	
signs of operations	
+	Addition
-	Subtraction
*	Multiplication
/	Division
%	Percentage
^	Exponentiation
=	Is equal to
<	Less
<=	Less or equal
>=	More or equal
< >	Not equal to

Practical work #1

The purpose of the work : to learn how to create, edit and format tables in the Word processor

Execution program

1. Download text editor Word.
2. Set page parameters: (left margin – 3 cm; right – 2.5 cm; top – 2.0 cm; bottom – 2.0 cm; page orientation – portrait).
3. Create a table. 1.2 given in the task, using the appropriate Word tools for this .
4. Copy table 1.2 and supplement it so that it looks like table 1.3, adding the missing elements and carrying out the appropriate formatting:
   - table header: Times New Roman , 14 pt, bold, alignment of text in the middle of the page;
   - table header: Times New Roman , 13 pt, bold, cell center alignment;
   - the content of the first column of the table: Arial , 13 pt, bold italics, center alignment.
   - information in cells: Times New Roman , 14 pt, ordinary, in the center;
   - type of lines for framing - according to table 1.3.: (double line 1.5 pt thick; single lines 0.75 pt thick; filling with the color of the table cap - 25% gray).
5. Align the width of the columns with numerical information and the height of the rows.
6. Calculate the average values and the sum using the formulas !
7. Split the table. 1.3. into two
8. Go to the next page.
9. Enter the text given in the task to be converted into a table, using the appropriate punctuation marks.
10. Convert the entered text into a table.
11. Enter the name of the performer, the name of the group and the date of the work in the header of the document.
12. Save the created document in your own folder.
13. Exit Word.

Tasks for practical work

Table 1.2

1.Валовий вміст мікроелементів у мулових відкладах очисних спор
мг/кг сухої речовини

Назва мікроелемента	Вміст мікроелементів, мг/кг сухої речовини		
	1	2	3
Cr	1710	2000	1251
Co	40	40	32,5
Ni	900	775	412
Cu	857	488	215
Zn	3201	3550	2287
Ga	5,1	11,4	8,9
As	3,1	0,4	0
Pb	117	158	173
Br	58,8	3,9	21,2
Rb	22,6	27,0	29,8
Sr	258	256	271
Bi	9,5	15,7	11,0
Th	5,1	7,0	11,2

(1. Content of trace elements in sludge deposits of cleaning spores mg/kg of dry matter

Microelement name

Content of trace elements, mg/kg of dry matter)

Table 1.3.

2.Результати досліджень вмісту мікроелементів у мулових відкладах очисних споруд, мг/кг сухої речовини

Назва мікроелемента	Вміст мікроелементів, мг/кг сухої речовини			
	1 повторність	2 повторність	3 повторність	Всередньому
Cr	1710	2000	1251	
Co	40	40	32,5	
Ni	900	775	412	
Cu	857	488	215	
Zn	3201	3550	2287	
Ga	5,1	11,4	8,9	
As	3,1	0,4	0	
Pb	117	158	173	
Br	58,8	3,9	21,2	
Rb	22,6	27,0	29,8	
Sr	258	256	271	
Bi	9,5	15,7	11,0	
Th	5,1	7,0	11,2	
Всього:				

(2. Results of research on the content of microelements in sludge deposits of sewage treatment plants, mg/kg of dry matter

Content of trace elements, mg/kg of dry matter

The name of the trace element

1 repetition

2 repetition

3 repetition

Average)

Text to be converted into a table.

3. Рівні радіаційного забруднення в Україні

Об'єкт Стронцій – 90, nKi/кг, л Цезій – 137, nKi/кг, л
Сіно природних угідь 247±53,7 543±121,5
Сіно сіяних трав 209±41,8 269±109,3
Солома 127±37,7 118±85,2
Трава природних угідь 164±67,8 253±91,5
Силос 91±47,6 87±44,4
Картопля 13,5±2,08 17,1±2,13
Буряк кормовий 31,6±11,8 46,4±20,17
Комбікорм 38,2±6,32 51,6±7,73
Молоко 5,7±1,07 26,2±13,21
М'ясо великої рогатої худоби 15,3±1,52 136,3±47,32
Кістки великої рогатої худоби 1084±231,36 363±127,73

(3. Levels of radiation pollution in Ukraine

Object Strontium - 90, nKi/kg, l

Cesium 137, Ki/kg, l

Hay of natural lands 247±53.7

543±121.5

Hay of sown herbs

209±41.8

269±109.3

Straw 127±37.7

118±85.2

Grass of natural lands

164±67.8

253±91.5

Silage 91±47.6 87±44.4

Potatoes 13.5±2.08 17.1±2.13

Fodder beetroot

31.6±11.8

46.4±20.17

Combined feed 38.2±6.32 51.6±7.73

Milk 5.7±1.07 26.2±13.21

Cattle meat

15.3±1.52 136.3±47.32

Bovine bones 1084±231.36

363±127.73)

Self-test questions

1. How to insert a table into a text document?
2. What are the ways to create a table of the desired configuration?
3. How to change row height and column width?
4. How to give the same width or height to a group of cells?
5. How to move the cursor through the cells of the table?
6. How to change the direction of writing text in a cell?
7. How to change the type and thickness of the table line?
8. How to change the color of the working area of a cell, table?
9. What are the options for aligning information in cells and how to implement them?
10. How to combine and split cells in a table?
11. How to insert and remove additional rows, columns and cells?
12. How to convert text to table and table to text?
13. How to split a table into two and how to merge two tables into one?
14. How to enter a formula into the table?
15. What VBA functions are offered for performing calculations?
16. How to renew calculations by formulas?

How to format data in a table?

1.2. Calculation by means of MS WORD

Using fields for calculations in MS Word

When working in the word processor MS Word, there is often a need to type and calculate simple formulas. At the same time, you can abandon the use of MS Equation and use the insertion of fields of the Eq type . In this case, the user writes the code corresponding to the required formula in the text.

Suppose we need to display the formula I = U / R not in a row, but as a fraction. To do this, press **Ctrl** + **F9** - two curly brackets will appear on a gray background, inside which you need to enter the code: eq I = \ f (U; R). If you press **F9** at the moment when the cursor is inside the field, the field will be updated and its value will be displayed - we will see the expression as a fraction.

{eq I=\f(U;R) } $I=\frac{U}{R}$

Fig. 1. The code and the result of its execution

If desired, you can turn this field into an MS Equation object by double-clicking on it with the left mouse button. To switch the field back to code display, press **Shift** + **F9** when the cursor is on the field or it is highlighted, or right-click on the field and select "Codes / field values". The code can be edited and the fonts of symbols in it can be changed both in the usual way and through styles. The key combination **Alt** + **F9** switches the display mode of field codes / values in the entire document.

Types of formulas that can be specified using the Eq fields can be viewed by selecting the " **Field** " item in the " **Insert** " menu. In the left half of the window, select the " **Formulas** " category, and in the right - the " Eq " field, then click on the " **Parameters** " button, and we will see a list of possible keys for this field. Highlighting each of them, you can read a brief description of the keys at the bottom of this window.

We will list only the most used keys:

• \ f (x; y) - fraction , this key was used in our example;

• \ r (n; x) - the sign of the root , the degree of the root is written before the semicolon, after - the expression itself;

• \ i (a; b; f) - integral , the first parameter - the lower limit, the second - the upper limit, the third - the integral expression;

• \ b () - brackets , the size of which corresponds to the size of the expression enclosed within them;

• \ s (a; b) - places each subsequent parameter below the previous one, for example, if you want to write the variable U squared, and also with the subscript i, then write the code in the field: eq U \ s (2; i).

With the help of the "=" field, Word can perform simple mathematical calculations. Press Ctrl + F9 and enter the expression code in the field, for example: = (10 + 16 ^ 0.5) * 2. When pressed, the field will be updated and we will see the 28 in the result.

In technical reports (for example, in course projects), calculations must be made in the form of:

U = 50 V

R = 10 Ohms

$$I=\frac{U}{R}=\frac{50}{10}=5(A)$$

For this, Word provides for the creation of so-called bookmarks (variables).

These bookmarks can be assigned to any fragments of text or numbers and then used in fields (almost like in a programming language). To do this, type the first two lines of the example. Now select the number 50 and press **Ctrl** + **Shift** + **F5** - the bookmark editing window will appear (it can also be called via the " **Insert** " -> " **Bookmark** " menu). In the upper field " **Bookmark Name** ", give the number the name U_1 (you cannot give names of the U1 type to numbers, because in the calculated fields Word perceives these names as references to table cells) and click the " **Add** " button. Next, select the number 10 and give it the same name R_1. Then go to a new line in the text and type:

{ eq I = \ f (U; R) = \ f ({U_1}; {R_1}) = {= U_1 / R_1}} (A)

Curly brackets are not entered manually, but mean the insertion of fields when pressing Ctrl + F9. If everything is entered correctly, after updating the fields (select the entire line and press F9), the third step of our example will be in two layers.

{ eq I=\f(U;R)=\f({U_1};{R_1})}

$$I=\frac{U}{R}=\frac{50}{10}=5$$

Figure 2. The code and the result of its execution

If the result of the calculation needs to be presented with several significant figures after the decimal point, then you can use the numeric format key. For example, by adding \ # 0.0 after = U_1 / R_1, we get 5.0.

For ease of use, you can set the switch in the "Bookmarks" option in the " **Service** " -> " **Options** " menu on the "View" tab **,** then the numbers 50 and 10 to which the bookmarks are assigned are displayed in square brackets (the brackets are not displayed when printing). If you change these numbers now, the new calculation result will be displayed after updating the fields. For convenience, variable values can be highlighted in dark blue. Then you can immediately see where you need to enter data, and when printing on a black and white printer, the dark blue color is almost indistinguishable from black.

{ eq I=\f(U;R)=\f({U_1};{R_1})={=U_1/R_1}}

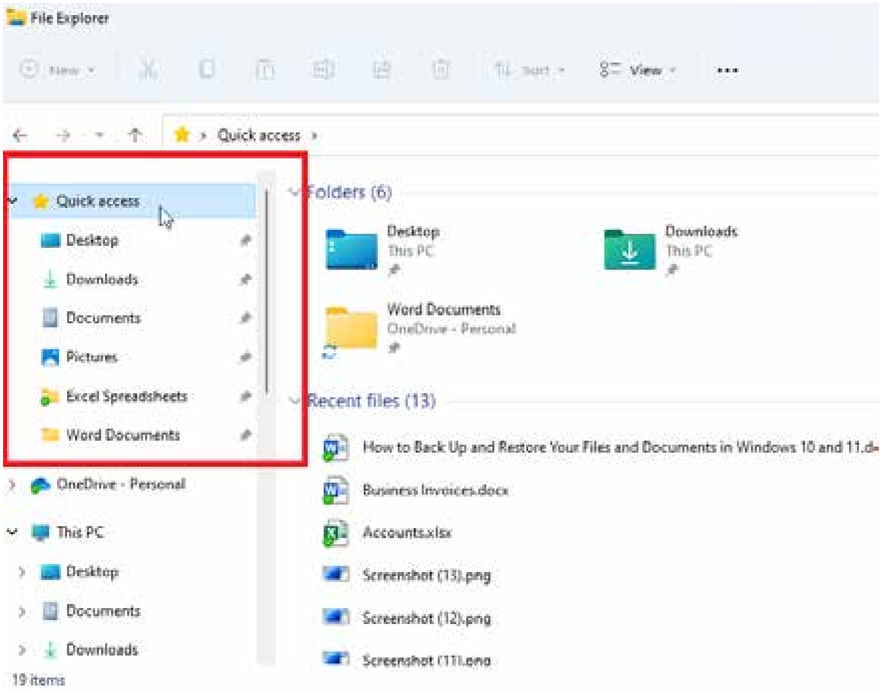
50105(A)

Figure. 3. The code and the result of its execution.

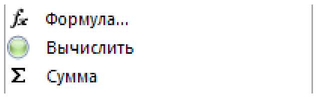
Setting up the toolbar for calculations using MS Word

In Word, you can calculate the value of an expression without using fields. But first you need to add a special command to the toolbar. In Word 2016, we do the following:

Select in the **File** menu



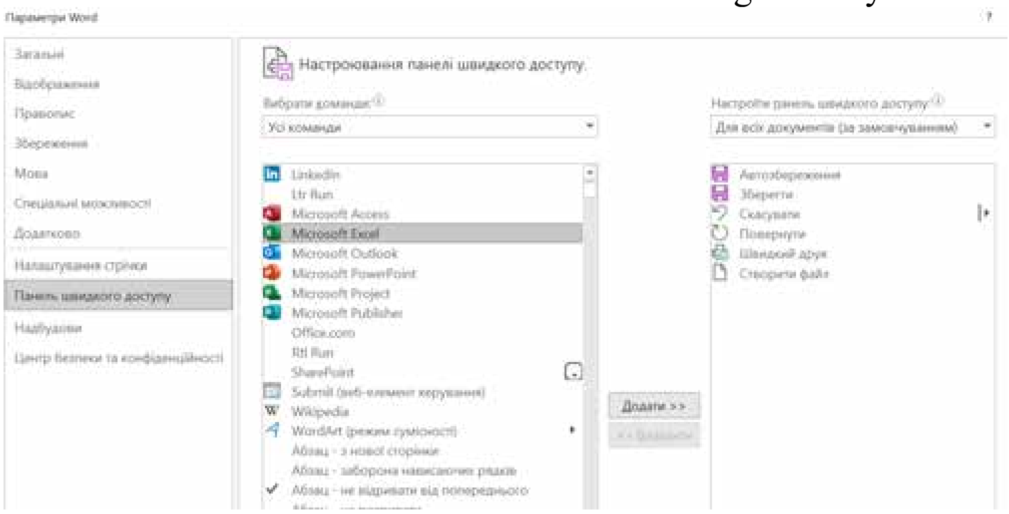
(Панель швидкого доступу=Quick Access panel, команди не на стрічці= commands not on tape, обчислити=calculate, додати=add)

Word Settings→Options→Select commands from→All commands Select commands in the corresponding window  .

Before clicking the **Add** button , it is possible (not necessary) to create a group on one of the tabs, for which the corresponding button serves. The group can be renamed (for example, Calculations).

Now that the group is created, you can add your favorite teams. At the end, press **OK** , and the corresponding commands will appear on the quick access panel.

In Word 2003, you need to open **Service** > **Settings** > the **Commands** tab**,** find the **All commands** item in the **Categories** list (on the left) . A full list of Word commands will appear on the right. Any of them can be dragged to the menu or to the toolbar. You need to select **ToolsCalculate** and drag it to any toolbar.



(Команди=commands)

The button is not active yet.

In order to apply it. We write an algebraic expression:

3.02 * (6.32 + 5.21) / 2.85 =

We highlight it (the = sign does not need to be highlighted!), and click on the added button - the result is placed in the clipboard. To see the result, place the cursor after the = sign and press the **Insert** button or **CTRL** + **V.**

3.02 * (6.32 + 5.21) / 2.85 = 12.2178

To raise a number to a power , you need to use the symbol ^ (**Shift** + **6** in the English keyboard layout). For example, 5 to the third power:

5 ^ 3 = 125

Four arithmetic operations (+, -, /, *), parentheses, exponentiation, and percentage calculations can be used in formulas. All letters are ignored, so you can use notation like "5000 hryvnias", "$125" in the formula. For example, 600 hryvnias * 5% = 30.

As you know, calculations in MS Word can also be done in tables using **Formulas** . If there is a need to use formulas in tables quite often, then for convenience it is suggested to add the Formula button to the toolbar and the most used **Summation** operation (**Σ** (**AutoSum**)).

(Команды=commands, Таблицы=tables, Автосумма=AutoSum, Все команды=All commands)

Practical work #2

The purpose of the work: to master skills of performing calculations in an MS Word document

<u>Execution program</u>

1. Download MS Office Word word processor.
2. Customize the calculation toolbar. For this purpose, add commands **Σ (Autosum or Sum),** ***fx*** **(Formula), Calculation (Calculate or ToolsCalculate)**
3. Calculate the values of the given expressions using the **Calculate or ToolsCalculate** tool **.** Moreover, ordinary fractions should be entered in parentheses, and the numerator should be separated from the denominator by parentheses.

1. $$\frac{0{,}5+\frac{1}{4}+\frac{1}{6}+0{,}125}{\frac{1}{3}+0{,}4+\frac{14}{15}}+\frac{(3{,}75-0{,}625)\cdot\frac{48}{125}}{12{,}8\cdot 0{,}25}.$$

2. $$\frac{0{,}725+0{,}6+\frac{7}{40}+\frac{11}{20}}{0{,}128\cdot 6\frac{1}{4}-0{,}0345:\frac{3}{25}}\cdot 0{,}25.$$

4. Find 78% of 6,000 hryvnias, 37% of $5,000. Raise the following expressions to the power of $\sqrt[5]{185}$; $56{,}7^2$; $13{,}8^3$; 17^3.

5. Make calculations in table 1.4. using the appropriate commands on the toolbar

Table 1.4

No. z/p	Product name	Number of sown areas, ha	Productivity without the contribution of fertilizers, cwt/ha	The pFig of one centner, hryvnias
1	Winter wheat	200	22	126
2	Spring wheat	150	19	110
3	Barley	80	18	80
4	Oat	70	19	79
5	Rye	55	29	90
6	Buckwheat	40	34	145
7	Millet	35	70	85
8	Pea	30	95	95
9	Corn	70	190	85
10	Potato	144	370	60
11	Beet	155	390	55
Everything				
On average				

6. Follow the example given in the task with the calculation of I through U and R. Change the parameters of current strength I and voltage U to 13A and 5V. Enter all the necessary parameters in the corresponding fields and calculate the resistance R, if $R = \frac{U}{I}$.
7. Save the document in its own folder.
8. Shut down the computer.

Self-test questions.

1. How do I set up my own dashboard for calculations?
2. What field codes are used for calculations in Word.

1.3. Entering formulas into a text document

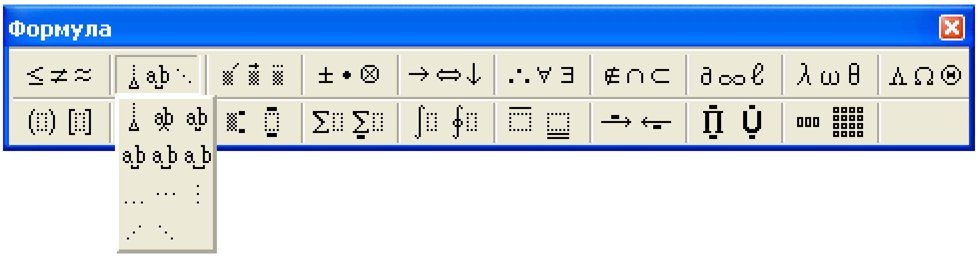
To write mathematical expressions in text documents that cannot be written using superscripts, subscripts and other text tools, use the formula editor **Microsoft Equation 3.0** .

Loading the formula editor

- perform actions: **Insert⇒ Object ⇒Microsoft Equation 3.0** ;
- press the **OK** button ;
- **or** click on the $\sqrt{\alpha}$ button on the toolbar.

Record formulas

- the formula is recorded in a special area that appears on the workspace after loading the formula processor together with the special **Formula** panel ;



- before writing symbols with indices, under the sign of the root, sum, integral, in the form of a fraction, etc., first enter the appropriate template from **the Formula panel** , and then fill it in;
- Cyrillic and Latin characters are entered from the keyboard; Greek alphabet, mathematical and special symbols - from the **Formula** panel by selecting them with the mouse pointer;
- the position of the blinking cursor in the template zones indicates the current location of the symbol;
- movement through the zones of the template or according to the formula is carried out with the cursor control keys or with the help of the mouse;
- writing a symbol of a mathematical operation will refer to the symbol framed by the cursor at the time of writing;
- the transition to a new line in the formula is carried out using the **Enter** key ;
- indentation between symbols within the formula zone is carried out with the **space** key while holding down the **Ctrl** key **,** or using the **Spaces and ellipsis** panel from the **Formula** toolbar ;
- to write a new formula, leave the area of the previous formula and load the formula editor again.

Editing formulas

- *Contents of the formula:*
  - highlight the formula by clicking on it once;
  - enter the formula area by double-clicking on it so that a blinking cursor appears in the middle of the formula;
  - place the cursor in the place of the formula where you need to edit;
  - to remove symbols or signs, use the **Delete** or **Backspace** keys ;

  or:
  - right-click on the highlighted area of the formula;
  - in the context menu that opens, select the items **Object ⇒Formula ⇒Open** ;
  - the content of the previously highlighted area of the formula will open in a special window with improved conditions for editing;
  - after editing the formula, close the window.
- *Size formula:*

- leave the formula zone by clicking with the mouse outside its borders on a free place;
- select the formula by clicking once with the mouse so that a frame with eight markers in the shape of black squares appears around it;
- place the cursor on one of the markers so that it takes the shape of a double-sided arrow (↔) and, with the left mouse button pressed, change the size of the formula to the desired one.

▪ *The size of the symbol in the formula:*
- enter the formula area;
- highlight the character whose size needs to be changed;
- in the **Size** menu select the type of character size you want.

Use of "fields" for date entry and autonumbering of formulas

To enter the date , which will be automatically updated each time the document is opened, perform the following actions:

- **Insert⇒ Date and time** ;
- in the **Date formats** field choose the desired format;
- press the **OK** button ;
- when clicking with the mouse on the date entered in this way, it will be highlighted with a gray rectangle .

To autonumber formulas, perform the following actions:

▪ place the cursor to the right of the formula, which must be numbered;
▪ **Links ⇒Insert name** ;
▪ in the **Name** dialog box , in the **Parameters** group , in the **signature** field , select **Formula** from the list ;
▪ while in the **Name** field the inscription **Formula 1** will appear ;
▪ if necessary check the **Exclude signature from names** box , after which the word **Formula** will disappear in the inscription **Formula 1** and only the number will remain;
▪ press the **OK** button ;
▪ as a result, the inscription **Formula 1** will appear to the right of the formula (if the signature was not excluded from the name), and the number will be in a gray frame;
▪ in the inscription, you can change everything except what is highlighted in gray (located in the field);
▪ if necessary, remove the inscription **Formula** , and put the remaining number in round brackets, set the appropriate formatting parameters, mostly formatting parameters of the main text or formula.

To update formula numbers, highlight the text fragment where the changes occurred and press the **F9** button .

To work in the formula editor, it is possible to use both the **Formula panel** and the keyboard. The table shows the main key combinations for effective work in the formula editor.

Table 1.5

Superscript characters	
Dash from above	CTRL+SHIFT+HYPHEN
Tilda	CTRL+SHIFT+~
Arrow (vector)	CTRL+ALT+HYPHEN
One stroke	CTRL+ALT+'
Two strokes	CTRL+SHIFT+"
Single point	CTRL+ALT+.
Blank spaces	
Tabulation	CTRL+TAB.
Zero space	SHIFT+SPACE
Space 1 pt	CTRL+ALT+SPACE
Short space (one sixth of a long space)	CTRL+SPACE
Middle space (one third of a long space)	CTRL+SHIFT+SPACE
Fractions and indices	
Fraction	CTRL+F
Slashed fraction	CTRL+/
Superscript	CTRL+H
Subscript	CTRL+L
Superscripts and subscripts	CTRL+J
Integral	CTRL+I
The square root of a number	CTRL+R
() Round brackets	CTRL+9 or CTRL+0
{} Curly brackets	CTRL+SHIFT+{, CTRL+SHIFT+}
[] Square brackets	CTRL+[, CTRL+]
Greek letters	
Entering Greek letters	Ctrl+G followed by a Latin letter

- $\theta - q \quad \omega - w \quad \varepsilon - e \quad \rho - r \quad \tau - t \quad \psi - y \quad \upsilon - u \quad \iota - i \quad o - o \quad \pi - p$
- $\alpha - a \quad \sigma - s \quad \delta - d \quad \phi - f \quad \gamma - g \quad \eta - h \quad \varphi - j \quad \kappa - k \quad \lambda - l$
- $\zeta - z \quad \xi - x \quad \chi - c \quad \varpi - v \quad \beta - b \quad \nu - n \quad \mu - m$

Practical work No. 3

The purpose of the work: to master skills of performing calculations in an MS Word document

Execution program

1. Download word processor.
2. Set the margins of the document: (left – 2.5; right – 1.5; top – 2.0; bottom – 2.0).
3. Set the work execution date, which will change automatically at each session of working with the document.
4. Enter the text document with formulas specified in the task, adhering to the established formatting options.
5. Insert autonumbering of formulas.
6. Give formula numbers formatting options for the main text.
7. Move the text fragment with formula (3) to the beginning of the text.
8. Update the numbering of formulas.
9. Save the created document in your own folder.

10.Exit Word.

Tasks for practical work

[Дата]

1. Середня концентрація речовини у проточному водоймищі:

$$C_{ср} = C_{пр} - (C_{пр} - C_o) \cdot \exp(-(\frac{Q_{вит}}{W} + k) \cdot T_{умов}), \qquad (1)$$

де $C_{пр} = \dfrac{Q_{ст} \cdot C_{ст}}{Q_{ст} + kW}$; $Q_{ст}$ – сумарна витрата стічних вод, які надходять до водоймища, м^3/рік; W –об'єм водоймища, м^3; Т – тривалість прогнозу, рік; k – величина коефіцієнта консервативності речовини, 1/рік; C_o – вихідна концентрація речовини, г/ м^3; $Q_{вит}$– витрата води, що витікає з водоймища, м^3/рік; $T_{умов}$ – умовний час водообміну, рік.

2. Рівняння для чисельності молодих (N_1) і старих (N_2) клітин у мікробній популяції:

$$\begin{cases} \dfrac{dN_1}{dt} = \dfrac{2}{T_2} \cdot N_2 - \dfrac{1}{T_1} \cdot N_1 - D \cdot N_1 \\ \dfrac{dN_2}{dT} = \dfrac{1}{T_1} \cdot N_1 - \dfrac{1}{T_2} \cdot N_2 - D \cdot N_2 \end{cases}, \qquad (2)$$

де T_1 – середній час визрівання молодої клітини; T_2 – середній час перебування старої клітини в репродуктивному періоді; D – швидкість потоку.

3. Матрична модель вікової структури популяції:

$$X(t_0) = \begin{Vmatrix} x_1(t_0) \\ x_2(t_0) \\ \vdots \\ x_n(t_0) \end{Vmatrix} \qquad X(t_1) = \begin{Vmatrix} x_1(t_1) \\ x_2(t_2) \\ \vdots \\ x_n(t_1) \end{Vmatrix} = \begin{Vmatrix} \sum_{i=k}^{k+p} \alpha_i \cdot x_i(t_0) \\ \beta_1 \cdot x_1(t_0) \\ \vdots \\ \beta_{n-1} \cdot x_{n-1}(t_0) \end{Vmatrix}, \qquad (3)$$

де $X(t_0)$ - вектор, який характеризує популяцію в початковий момент часу; $X(t_1)$ - вектор, що характеризує популяцію в наступний момент часу; α - коефіцієнт народжуваності; β - коефіцієнт виживання.

(In the following text, which will be a translation of the figure above, all formulas will be replaced with '*formula*'

[Date]

1. The average concentration of a substance in a flowing reservoir:
****formula****

where *formula* total flow of wastewater entering the reservoir, m³/year; and the

volume of the reservoir, m³; T- duration of the forecast, year; k value of the coefficient of conservatism of the substance, 1/year; C - initial concentration of the substance, g/m³; O - amount of water flowing out of the reservoir,

m³/year; T - conditional time of water exchange, year.

2. The equation for the number of young (No. 1) and old (No. 2) cells in the microbial population:

****formula****

where T1 is the average maturation time of a young cell; T2 - the average time an old cell stays in the reproductive period; D - flow rate.

3. Matrix model of the age structure of the population:

****formula****

where X(to) is a vector that characterizes the population at the initial moment of time;

X(4) is a vector characterizing the population at the next moment in time; and

birth rate; in the survival rate.)

Self-test questions

1. How to download formula editor?
2. What is the order of writing the formula?
3. How to change the size of the formula area?
4. How to format the content of the formula?
5. How to change the size of symbols in a formula?
6. How to insert autonumbering of formulas?
7. How to set a date that will change every time the document is opened?
8. How to update formula numbering?

1.4. Creation of graphic objects in the Word processor

The word processor Word allows you to design a text document with graphic objects (flow charts, graphs, diagrams, photos, etc.) by directly creating them or importing them from other applications, files or the library of the processor itself.

Creation of graphic objects

- perform actions: **Insert⇒ figures** ;

- in the menu that opens, select the type of graphic object that is planned to be created;
- move the cursor to the working field (the cursor will take the shape of +) and while holding the left mouse button, move it, creating a graphic object of the required size;
- to create absolutely correct shapes, such as vertical or horizontal lines, a circle, a square, etc., perform the specified actions with the **Shift** key pressed .

Entering text

To enter text inside a graphic object :

- separate the object - autofigure ;
- click on it with the right mouse button;
- in the context menu that opens, select the **Add text** item**,** after which a cursor will appear in the middle of the autoshape ;
- enter text.

To create text labels anywhere in the working area of a complex graphic object :

- choose a rectangle;
- draw a rectangle at the place where the text inscription is created and write the text inside it;
- select the received shape with text, call up the context menu, open the list of possible options and choose **None (** the outer borders of the text area will not be visible);
- the text area can be freely moved around the working field.

To create artistic or vertically placed text inscriptions :

- in the **Insert menu** , select **WordArt** ( );
- in the dialog box that opens, select the recording style and click on the **OK button** ;
- in the next dialog box, enter the text and set its formatting parameters;
- click on the **OK** button .

Formatting of created graphic objects

Moving the object on the working field

- select a graphic object (click on it once so that rectangular markers appear around it);
- bring the cursor to the object so that it takes the shape of a cross;
- move while holding the left mouse button;
- for smooth movement use the key combination (**Ctrl + ←↑→↓)** .

Changing the orientation of the object in space

- select a graphic object, the **Format** tab for working with drawing tools automatically appears;
- on the **Format** tab , select the **Return/ Reflect** sub-item , go to the submenu and select the appropriate action.

Changing the type and line thickness of a graphic object

- single out the graphic object;
- on the **Format** tab , click the **Shape Contour** button ( ) and in the expanded menu, select the option to change the type and thickness of the lines; or the **Stroke Type** button ( )– to change the solid line to another of the proposed options.

Changing the color background of a graphic object

- select the graphic object;
- on the **Format** tab**,** next to the **Shape fill** button ( ), open the list of possible color gamut options and select the desired one;
- to create a background in the form of a combination of two colors with a smooth transition from one to the other, choose the **Filling options** option ;
- in the dialog box that opens, on the **Gradient** tab in the **Color** and **Hatch Type** zones select options.

Setting the overlapping order of graphic objects

When creating a complex graphic image that consists of many shapes and text zones, the order in which they overlap each other is important, because the shape or text zone that is in the upper layer can cover part of the object that is below it. The last created shape is automatically placed higher relative to the already created ones. To change the overlapping order of objects, perform the following actions:

- separate a graphic object that is planned to be placed above or below another;
- on the **Format** tab in the **Sorting** item select the **Move forward (Move back)** sub-item ;
- go to the cascading submenu and select the item **To background , To** foreground or **another** .

Combining several graphic objects into one

Combining provides the possibility of working with an object that is created from many separate elements, as with a single whole. In particular, copy, change the overall size, prevent the object from breaking between pages, etc. For this:

- on the **Format** tab , click the **Selection area** button on the **Ordering** panel ;
- **Selection** panel appears to the right of the created picture , which lists all the graphic objects in the picture;
- while holding the **CTRL** key, select all objects one by one;
- on the **Format** tab in the **Sorting** zone select the **Group** item ;
- grouped objects will form a single object.

Disconnecting grouped objects

- select a grouped object by clicking on it;
- on the **Format** tab in the **Sorting** zone select the sub-item **Ungroup**;
- the ungrouped object will consist of separate objects, which makes it possible to format them separately.

Practical work #4

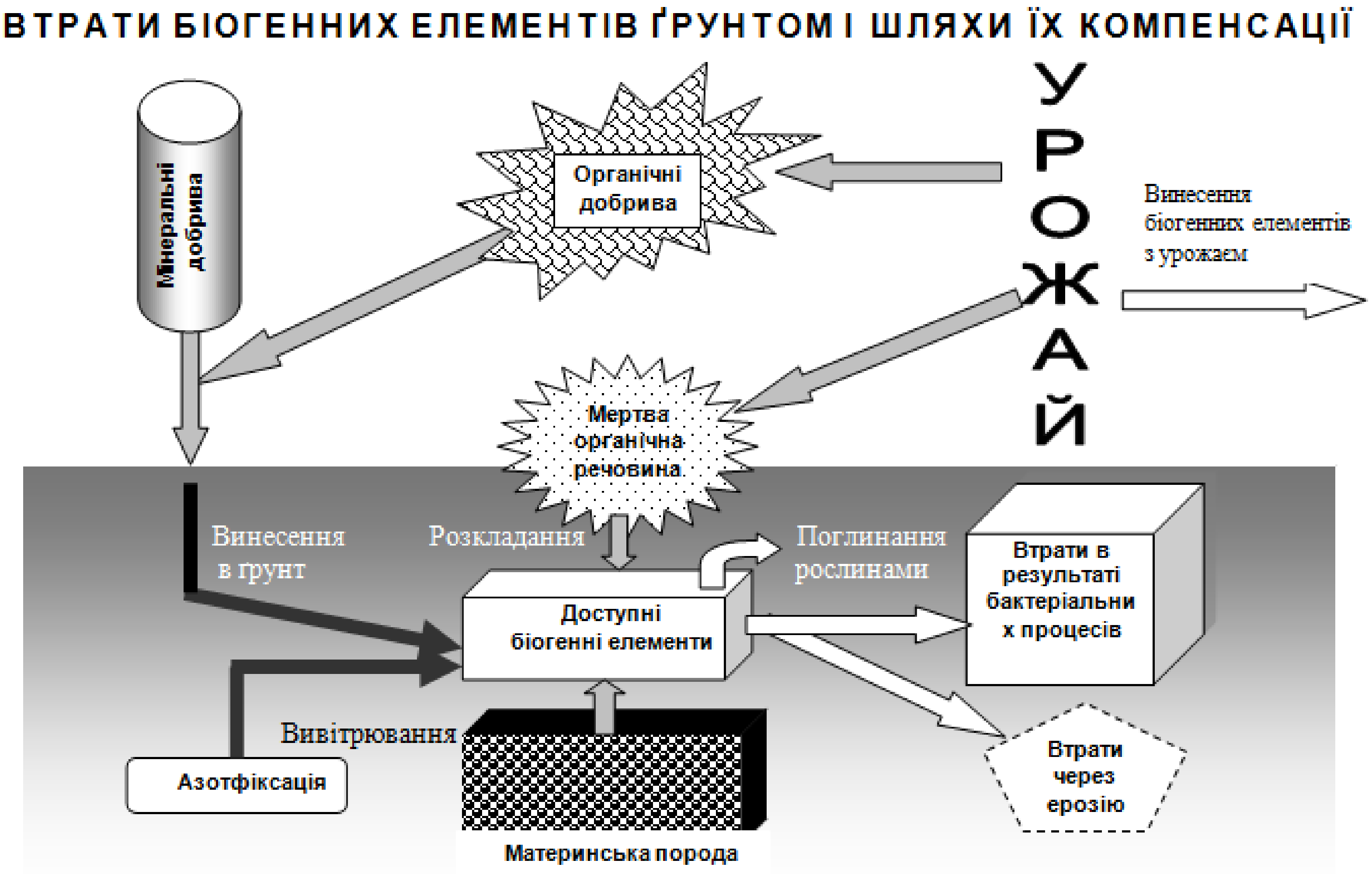
The purpose of the work : to learn how to create and format graphic objects in the Word processor

Execution program

1. Download word processor.
2. Set page orientation to landscape.
3. Create the structural diagram given in the task according to the following requirements:
   - the name of the structure scheme: Arial , 16 pt, semi-bold, all caps, sparse 2 pt, center alignment;
   - text inside auto figures: Arial , 12 pt, bold ;
   - fill the objects and set the formatting parameters of individual elements according to fig. 3;
   - group all elements into one object.
4. Save the created document in your own folder.
5. Exit Word.

Tasks for practical work

It is shown in fig.



(Втрати біогенних елементів ґрунтом і шляхи їх компенсації -

<u>Self-test questions</u>

1. How to create a graphic object?
2. How to move the created graphic object?
3. How to write text inside a graphic object?
4. How to change text direction?
5. How to format the text inside the object?
6. How to make the outer borders of the text area invisible?
7. How to change the overlapping order of objects?
8. How to change the formatting parameters of the external lines of the object?
9. How to insert a WordArt object ?
10. How to change the size and orientation in space of a graphic object? How to group graphic objects?

1.5. Creating, editing and formatting spreadsheets

The Excel spreadsheet is a powerful software tool for effective processing of data presented in tabular form: performing various calculations, constructing graphic dependencies , creating databases, modeling, forecasting and optimizing processes, finding the roots of equations, etc.

The structure of the table processor window is in many respects similar to the structure of the windows of other Windows applications. The Excel window displays a title bar, a menu bar, by default two toolbars, **Standard** and **Formatting** , a formula bar, an address bar, a workspace, a status bar, and scroll bars.

When you load Excel, a new document called **Workbook 1 is automatically created,** which can have up to 255 sheets. Each sheet of the workbook is presented in the form of a table consisting of 256 (2^8) columns and 65536 (2^{16}) rows. Column headings are usually marked with letters of the Latin alphabet, and row headings with numbers.

A rectangle is located at the intersection of each column and row, which is called *a <u>cell</u>* . A cell clicked with the left mouse button is considered active, it is highlighted by a bold black frame. Each cell has its own address (name), which is determined by the title of the corresponding column and the row number (for example, the cell formed by the intersection of column F and row 2 has the address F2). In Excel, in addition to the addresses of individual cells, the addresses of cell ranges that include part of a column (D2:D8), part of a row (C3:C12), or a block of cells (B3:E6) can be specified. At the same time, the symbol " **:** " separates the address of the first cell (upper left) from the range and the last cell (lower right).

Start Microsoft Excel

- load the Windows operating system;
- perform actions: **Start⇒ Programs ⇒Microsoft Excel** ;
- **or** : click with the mouse on the image of the icon or the shortcut of the application, if they are located on the desktop;
- **or** : **Start⇒ Create an Office document⇒ New book** .

Creating a table

The working field of an Excel sheet has the form of a table consisting of columns of the same width and rows of the same height, at the intersection of which there is a cell. The user, as a rule, creates a table structure depending on personal needs: gives a certain look to the table header by combining cells, changes the width of the columns and the height of the rows.

Merging cells

The merging of cells is used to form the structure of the table, not to increase the width or height of the cells.

The procedure of combining cells involves creating one cell from a certain number of cells. For this purpose:

- select the cells that are planned to be merged (drag the cursor along the cells with the left mouse button pressed);
- click on the button **Combine and place in the center** () on the formatting panel;
- **or** perform a sequence of actions: **Format⇒ cells ⇒ Alignment ⇒ Association cells** ;
- in case of erroneous merging of cells, perform a similar sequence of actions and remove (disable) the **Merge option cells**

Changing the height of rows and width of columns

The height of the rows and the width of the columns depends on the content of the cells formed by their intersection, the requirements for the appearance of the table and the personal preferences of the user. Most often, the size of the cell is changed using the mouse. For this purpose:

- set the cursor between the column names - to change the column width, or between the row numbers - to change the row height, so that it takes the form ◄┼► ;
- when the left mouse button is pressed, the borders of rows and columns are moved, setting the required height and width.

Changing the width and height of a group of cells

To give a group of cells the same size, other than the default, the previous method is not very efficient and not accurate enough. For this purpose:

- *single out a group of columns* , the width of which is planned to be changed to the same value;
- perform actions: **Format⇒ Column ⇒Width** ;
- in the dialog box that opens, enter the width value from the keyboard (one unit corresponds to the width of one character of size 10);
- press the **OK button** ;
- *single out a group of lines* , the height of which is planned to be changed to the same value;
- perform actions: **Format⇒ The line⇒ Height** ;
- in the dialog box, enter the line height value in the appropriate field from the keyboard (the number 12.75 corresponds to the height of a character of size 10, 25 - corresponding to the height of a character of size 20);
- press the **OK button** .

Inserting a cell (row, column)

- select a cell next to which you need to insert an empty cell (row, column);
- perform actions: **Insert ⇒Cells (Rows, Columns);**
- when inserting an empty cell, mark the direction of movement of filled cells in the dialog box that will open when performing the specified actions;
- the column is automatically inserted to the left of the active cell, the row is inserted from above.

Create notes

Notes are used to provide additional information about the contents of cells. For this purpose:

- select the desired cell;
- call up the context menu and select the **Add note item** ;
- in the rectangular area that appears, enter the text of the note and click with the mouse outside it (the entered text will disappear, and a red triangle will appear in the upper right corner of the selected cell);
- when the mouse cursor is placed on a cell with a note, a rectangular area with the text of the note appears;
- changing the text of a note or removing it is carried out using the corresponding items in the context menu.

Data types in cells and their input

Information entered into the cells can be of different types (formats): text, number, date and time, formula.

To enter any type of data into a table cell, perform the following sequence of actions:

- activate the cell for entering data;

- enter data (number, text, formula) using the keyboard;
- confirm input:
  - press a key enter
  - **or** click the mouse on another empty cell.

Text

Most often, filling in tables begins with text entry. Text when entered is displayed in a pre-activated cell and is automatically aligned to the left edge. If the length of the text label exceeds the size of the cell, the rest of it is written to the right of the active cell. However, in fact, all information is only in the cell activated at the beginning of text input. If you click with the mouse outside the cell with the entered text, only its part, limited by the size of the cell, will be displayed on the screen, and the rest of the text will be invisible. To place the text within one cell both physically and visually, perform the following sequence of actions: **Format ⇒Cells⇒ Alignment ⇒ Moves by words** . As a result, fragments of text, limited by the width of the column, will be located under each other.

Numbers

Any number is entered into the activated cell and is automatically aligned to the lower right edge. If necessary, the location of the numbers in the cell is changed. Numerical data can be entered in various forms and formats: as an integer (124); decimal fraction (14.426) with accuracy up to 30 decimal places; ordinary fraction ($1\ ^{1}/_{5}$); monetary format (1.20 hryvnias, $5). If the number has more than 12 digits, Excel automatically converts it into a floating point format, i.e. the number 0.000000000137 entered in the cell after changing the active cell will become 1.37E - 10. When writing a decimal fraction, the whole part of the decimal is separated by a *comma!* To write a number in a certain format, perform the following sequence of actions: **Cell ⇒Format ⇒Number** and select the desired format.

Date, time

One form of numerical information in an Excel cell can be a date or time. Dates are most often entered in the form 14.3, 14.03.05, 14 Mar 05, etc. When entering a date, days, months and years are separated *by a dot* , which automatically converts the number into a date format (this is often the cause of an error when writing a decimal fraction). The time is recorded similarly. The appearance of the date and time record can be changed in a wide range by performing the following actions: **Format ⇒Cells ⇒Number ⇒Date** .

Autofill cells

auto-completion tool in its asset , which significantly speeds up the input of numerical and textual data that changes within a certain interval or according to a certain law. An example of such data can be serial numbers

(1,2,3 ...), dates (1.02.05, 2.02.05 ...), days of the week (Monday, Tuesday, ...), months of the year (January, February ...) and other lists.

Filling adjacent cells with numerical data using the autofill function can be done in different ways.

Dragging the autofill marker

- the initial value is written in the selected cell;
- activate the adjacent cell and record the next value;
- the difference between the second and first entered values will determine the step size (when entering dates with a change step of 1 day, this action is skipped);
- select the cells that contain the initial and next value of the list;
- place the mouse pointer in the lower right corner of the selected cells on *the autofill marker* (□) so that it takes the form of a black cross (□);
- when the left mouse button is pressed, the cursor is dragged through a range of cells;
- as a result, the selected range will be filled with data that differ from each other by a given step;
- when dragging the marker down or to the right, the data will increase, up or to the left, −it will decrease.

Progression

If the list to be created consists of numbers, each of which differs from the previous one by some constant value, or a certain number of times, then you can fill a range of cells using the arithmetic or geometric progression tool. For this purpose:

- enter the first value of the list in the selected cell, confirm the entry by pressing the Enter key ;
- activate the cell with the entered value;
- perform actions: **Main⇒ fill in ⇒Progression ;**
- in the dialog box of the same name that opens, in the **Location group** mark **by columns** or **by terms** ;
- enter the step size (difference between two adjacent values) in the **Step field;**
- in the **Type zone,** mark **arithmetic** or **geometric** ;
- in the **Limit field value** indicate the maximum value of the list;
- press the **OK button** .

To autofill cells, standard Excel autofill lists are also used, or personal ones can be created.

Formatting cell contents

Regardless of the type of information entered into the cells of the table, a wide range of formatting tools can be applied to it. In order to reduce the time required to carry out the same type of formatting operations (setting the type and size of the font, number format, alignment in a cell, etc.), it is advisable to carry out similar operations with a group of cells. For this purpose:

- select a cell or a range of cells to which formatting should be applied;
- perform a sequence of actions: **Format⇒ cells** ;
- in the dialog box that opens, **for:**
  - *data format changes:*
    - perform actions: **Number⇒ Numerical formats** and select the desired number format;
  - *changes to the alignment of information in the cell:*
    - select the **Alignment tab** ;
    - in the **Alignment zone, in the horizontal and** vertical **fields,** select the alignment option from the lists;
    - in **the Orientation zone,** move the word **inscription** to an angle of 90 ^{o} for the vertical location of the information in the cell, or at any other angle of inclination, indicating the required value on the numerical pointer;
    - in the **Display area** note the item **transferred by words** for the location of information in the cell not in one line, but with the possibility of its transfer to subsequent lines;
    - mark the point **of unification cells** to merge previously selected cells into one;
  - *font changes and index entries:*
    - select the **Font tab** ;
    - in the **Font** , **Pattern** , **Size fields** , select the type, pattern, and size of the letters from the lists;
    - in the **Modification zone** mark the appropriate point for writing the superscript or subscript next to the symbol;
  - *changes to the format of table lines:*
    - select the **Border tab** ;
    - in the **All zone** , mark the table boundaries to which formatting will be applied;
    - **line type** in the fields and **color** choose the type and color of the table lines from the lists;
  - *changing the background color of the cells:*
    - select the **View tab** ;
    - in the **Color zone** note the color of the background of the cell, which will be displayed in the **Sample area ;**
- after setting the formatting parameters, press the **OK button** .

Practical work #5

The purpose of the work : master the skills of working in the Excel spreadsheet environment, learn how to create, format and edit tables

Execution program

Download the Excel spreadsheet.

Create and fill in the table given in the task. 1.6 according to the following requirements:

- the name of the table (Arial , 14 pt, bold);
- cap (Times New Roman , 12 pt, bold, center alignment) ;
- digital information of cells (Arial , 12 pt, center alignment);
- fill in the numbers in order using the autofill marker ;
- dates to be filled using a progression;
- the concentration of ketamine before cleaning with the help of progression;
- the names of the columns "before cleaning", "after cleaning" for chemical oxygen consumption should be filled using the auto-fill marker ;
- fill in the value of the installation performance using the autofill marker ;
- set the same column width and row height;
- the general frame of the table is double.

In the cell containing the name of the table, make a note in which to place information about the performer of the laboratory work.

Give the cells with the dates of the measurements the date format of the type "March 14".

On the cell with the name "HCK" set the note "Chemical oxygen consumption".

1. Save the created document in your own folder.
2. Exit Excel.

Tasks for practical work

Performance indicators of the bioreactor when purifying water from ketamine by an association of gram-negative bacteria

Table 1.6

Item no .	Date of measurements	The concentration of ketamine , mg/dm ^{3}		CCC, mg/dm ^{3}		Productivity of the installation, dm ^{3} /day
		before cleaning	after cleaning	before cleaning	after cleaning	

1.	01.05.06	100	5	120	80	6
2.	19.05.06	200	7	280	115	6
3.	06.06.06	300	12	610	150	6
4.	24.06.06	400	15	860	240	6
5.	12.07.06	500	18.5	1056	320	6

Self-test questions

1. How to download MS Excel?
2. What is common and different in the structure of the window of the word processor Word and the processor of electronic spreadsheets Excel?
3. What is an Excel document?
4. What does a workbook sheet consist of?
5. How to create a table of the desired configuration?
6. How to merge cells and what is the use of merging cells?
7. How to change column width and row height?
8. How to set the width or height of the same size for a group of cells?
9. How to set table boundaries?
10. How to insert an empty cell, column and row?
11. What types of data can be entered in the cell and what are the features of their recording?
12. How to change data format?
13. What is the cell format and how to set it?
14. How to align the location of the information in the cell?
15. How to change the orientation of placing information in a cell?
16. How to place a fragment of text in a cell, the size of which exceeds the width of the cell?
17. What means of automating the entry of table information does Excel provide?
18. How to set a note on a cell?
19. How to edit, format and remove the content of a note?

1.6. Calculations in spreadsheets

Calculations in Excel are carried out thanks to the presence of a powerful formula machine, which provides the ability to process data with entering the results of calculations directly into a table. Formulas are usually used to perform operations on data located in different cells of a worksheet, on different sheets, or in different books. A formula in Excel is a sequence of characters beginning with the sign “=” (equal), which can include constant values (constants or references to cells with constants); references to cells containing variables; names; functions; operators the formulas use the following operators: addition "+", subtraction " –", multiplication "*", division "/", raising to the power "^", as well as relative, absolute and mixed references to cell addresses. Examples of formulas can be the following entries:

=A8 –B8; =C3+D3*$E$1; =F6/G6; = SUM(A5:A12).

The result of these actions is recorded in the cell containing the formula after it is entered and the Enter key is pressed .

If the cell with the formula is made active again, the formula can be seen and edited in the formula bar.

Record formulas

- activate the cell in which the formula must be written;
- enter the "=" sign (without quotation marks) from the keyboard;
- switch the keyboard to the Latin (English) layout;
- write down the required formula in the form of a sequence: addresses of cells with data on which calculations must be made; mathematical symbols; numbers; built-in functions, etc., depending on the calculation algorithm (*numerical data in the form of decimal fractions must be written <u>after a comma</u> !*);
- press the Enter key ;
- the result of calculations will be displayed in the selected cell.

If the cell is activated again, the formula used for the calculation will be displayed in the formula bar.

To ensure the execution of mathematical operations in the formula in a certain order, appropriate pairs of parentheses are used. For example, if you need to find the average between the values of four cells with the addresses F4, C5, F6, D9, then the formula will look like this:

= (F4+C5+F6+D9)/4.

Using references to cell addresses in formulas

Formulas in Excel can contain a reference to a cell address (for example, A5), the addresses of a range of cells (for example, A5;B5;G5), or the address of a range of cells (for example, D5:D10). In order to save time and eliminate errors when entering links to cell addresses or their ranges, use the mouse. To do this, in the process of writing the formula, it is enough to click on a cell, or select a range of cells whose coordinates are present in the formula, and the desired address will appear at the location of the cursor in the formula. If the values of the cells referenced in the formula change, the calculation result of the formula will also change automatically.

Formulas use *relative* (type A1), *absolute* (type $A$1) and *mixed* (type $A1, A$1) references to cell addresses.

In relative links (type A1), the address of the cell to which the link was made is automatically updated when the formula is spread from one cell to another. That is, if the distribution of the formula is carried out from cell A1 in the vertical direction, then the address of the cell in the formula to which the reference is made will change as follows: A2, A3, A4, ... If - in the horizontal, then: B1, C1, D1, ... In addition to relative references, Excel uses absolute references (such as $A$1). The $ symbol fixes the reference, leaving it unchanged when spreading the formula to other cells. If you need to fix only a row or only a column in the formula, then use mixed links, for example, A$1 or $A1. In this case, the $ symbol fixes part of the link and leaves it unchanged when spreading the formula only vertically or horizontally.

Thus, by entering one formula, you can expand it to fill a rectangular range of cells with data.

Move, copy and distribute formulas

The procedure for entering formulas is a relatively time-consuming process. To speed up the process of filling the table with the results of calculations, the once entered formula is distributed, moved or copied to the cells in which similar calculations are performed.

Distribution of the formula to a range of cells (part of a column or row) is carried out if you need to perform similar actions with the data contained in a certain range of cells. When spreading in the formula, the relative references to the cell addresses change.

To distribute the formula, perform the following actions:

- select the cell with the formula;
- bring the mouse pointer to the lower right corner of the cell (autofill marker) so that it takes the form of a black cross;
- while the left mouse button is held, the cursor is moved to the last cell of the range in which the result of the calculation according to a similar formula should be obtained, after which the key is released.

When moving a formula to a new table location, the references in this formula do not change. The cell in which the formula was previously becomes free. To move the formula, perform the following actions:

- select the cell with the formula;
- bring the mouse pointer to the border of the cell so that the pointer image changes from a white cross to a black one;
- while the left mouse button is held, the contents of the cell are moved to the desired place in the table, after which the key is released.

When moving several formulas that are located in adjacent cells and can be separated into a block, the mouse pointer is raised to the border of the block and the specified actions are performed.

To copy the formula :

- select the cell with the formula;
- perform the sequence of actions specified in the previous section to move the formula, while holding down the **CTRL** key .

To highlight the formulas directly in the cells of the table, and not the results of calculations based on the formulas, perform the following actions: **Service⇒ Parameters ⇒View ⇒Formula** . To hide the formula display mode, perform the specified sequence of actions again.

Conditional formatting of table cells

When analyzing large arrays of numerical data presented in tabular form, as well as to track their changes depending on changes in input data, conditional formatting of certain table cells (usually cells with final or intermediate results) is used. Conditional formatting consists in setting conditions for changing the appearance of a cell (color, background, font type, etc.) depending on the value located in it (entered or obtained as a result of calculations using a formula).

For example, you can set parameters for conditional formatting of cells according to which: the numbers in the cells, where the average value of the levels of bird disease by district is determined, will change color to red if the average value exceeds the permissible level, if not , then the font color will remain black. Basically, conditional formatting is used to focus the user's attention on numbers that deviate from the norm or need attention.

To set conditional formatting:

- select a range of cells, the values of which are planned to be set to conditional formatting;
- perform actions: **Home ⇒Conditional formatting** ;
- in the dialog box that opens, in the **Cells Selection Rules** area , select a condition from the list (*between, more or equal to,* etc.), according to which formatting will be performed, and indicate the limits of numerical values to which conditional formatting will be applied according to the first condition;
- press the **Format** button ;
- in the dialog box that opens, on the **Font** tab , set the font parameters, or on the **View** tab , select the fill color of the cell, which it will acquire when the formatting condition is met;
- if it is necessary to format cells according to several conditions, again refer to the menu of conditional formatting of cells and configure the parameters of formatting according to additional conditions similarly as many times as the conditions need to be displayed.

Practical work #6

The purpose of the work: to master the skills of writing formulas, copying and distributing them, and performing calculations based on them

Execution program

1. Load the Excel spreadsheet editor.
2. Create and fill in the table given in the task. 1.7 according to the following requirements:
   - table name: Arial , 12 pt, bold;
   - table header: Times New Roman , 12 pt, bold, center alignment;
   - in the first column: Times New Roman , 12 pt, bold, alignment on left margin;
   - numerical information in cells - Times New Roman , 12 pt, center alignment.
3. The values in the cells of the table, surrounded by a dash-dotted line, are obtained by calculations:
   - $Д_{заг} = ((ГДК - Ф) * 3000) / 1000$,

     where $Д_{заг}$ is the permissible entry of harmful impurities into the soil, g/ha;

     $ГДК$ – the maximum allowable concentration of this impurity in the soil, g/t of dry matter of the soil;

     $Ф$ – background (analytically found) content of this impurity in the fertilized soil, g/t of dry soil matter;

     3000 is the approximate average mass of the arable soil layer, t/ha.
   - $Д_{сер} = \frac{Д_{заг}}{T * C_x}$,

     where $Д_{сер}$ is the average dose of possible fertilization in the soil, t/ha per year based on the dry matter of the sediment;

     C_x – the content of a controlled admixture in this fertilizer, g/t of dry matter of OMD;

     T - the maximum period of application of PES or composites based on it on one and the same site, years.
   - $Д_{макс} = 5 Д_{сер}$,

     where $Д_{макс}$ is the one-time maximum dose of the specified fertilizer when it is applied to the soil once every 3-5 years.
4. Formulas for calculations are entered in the upper cells of the corresponding columns, using relative and absolute references to the addresses of cells with values, and spread them to ranges of cells that require similar calculations.

5. Conditionally format the column containing , $Д_{макс}$ according to the following conditions:
   – cells with values less than or equal to 50 are painted green;
   – cells whose values are between 50 and 300 are yellow;
   – cells whose values are greater than or equal to 300 are red.
6. Compare the obtained results with those given in the table.
7. Save the created document in your own folder.
8. Exit Excel.

Tasks for practical work

Table 1.7

Experimental and calculated normative indicators limiting the use of OMD for fertilizing agricultural lands

substance (admixture)	Average content in the studied soils, g/t (F)	Soil GDK, g/t (GDC)	The average content in the obtained OMD, C_x, g/t	$D_{general}$, kg/ha	D_{sir}, t/ha	$D_{max.}$, t/ha
Nitrates (KO_3)	21.2	130	1220	326.4	5.35	26.75
Chlorides (Si)	34.2	100	116.5	197.4	33.89	169.44
The sum of water-soluble salts (åи)	840	3000	13183	6480	9.83	49.15
$Cr_{general}$	63.9	100	327.8	108.3	6.61	33.04
No	52.4	100	255.1	142.8	11,20	55.98
Cu	42.9	100	634.5	171.3	5.40	27.00
Zn	161.4	300	1133	415.8	7.34	36.70
CD	0.25	3	36	8.25	4.58	22.92
Pb	31.9	100	97.8	204.3	41.78	208.90
As	1.8	20	12.7	54.6	85.98	429.92
Sn	10	50	39.6	120	60,61	303.03
Hg	1,2	2.1	0.8	2.7	67.50	337.50
$Sr._{staff}$	95.2	600	1835.4	1514.4	16.50	82.51
Mn	588.3	1500	577.3	2735.1	94.75	473.77
The maximum period of application of PES or composites based on it on one and the same land plot, years (T)						50.00

Self-test questions

1. What is called an Excel formula and how do you start entering it?

2. How can you see and edit a formula entered in a cell?
3. How to enable the formula display mode in cells and what is it used for?
4. How do formulas use references to addresses of cells with data and what are they?
5. How to spread the formula to a range of cells?
6. How do you copy and move formulas? How do references to cell addresses in formulas change?
7. How to give conditional formatting to cells? What is it used for?
8. How many conditions can be specified for conditional formatting?

1.7. Calculation of functional dependencies and construction of their graphs

The calculation of functional dependencies in MS Excel includes the following stages: entering the values of the argument (arguments); entering a formula that reflects a given functional dependency, using absolute and/or relative references to cell addresses with argument/argument values; spreading the formula to the range of cells corresponding to the range of cells with the argument/argument values. The calculation of function values for various given combinations of the values of its arguments is called ***tabulation of functions*** . According to the results of tabulation of the function, its graph is built.

Entering argument values

If the argument is represented by a range of its values, then its values are entered in the selected range of cells with a certain step, starting from the minimum and ending with the maximum. To speed up the input of argument values, use the Progression tool or other MS Excel tools for autofilling .

1st method. Dragging the autofill marker

- activate the selected cell and enter the initial value of the range to be created;
- activate the adjacent cell and enter the next value of the range, which will determine the size of the step between the two values;
- select the cells that contain the initial and subsequent values;
- place the mouse pointer in the lower right corner of the selected cells on *the autofill marker* (<) so that it takes the form of a black cross (□);
- when the left mouse button is pressed, the cursor is dragged through a range of cells to fill with data;

- as a result, the selected range will be filled with data differing from each other by a step determined by the difference between the second and first entered numbers;

- when dragging the marker down or to the right, the data will increase, up or to the left, −it will decrease.

2nd method. Progression

If the list to be created consists of numbers, each of which differs from the previous one by some constant value, or a certain number of times, then you can fill a range of cells using the arithmetic or geometric progression tool. For this purpose:

- activate the cell and enter the initial value of the list to be created;

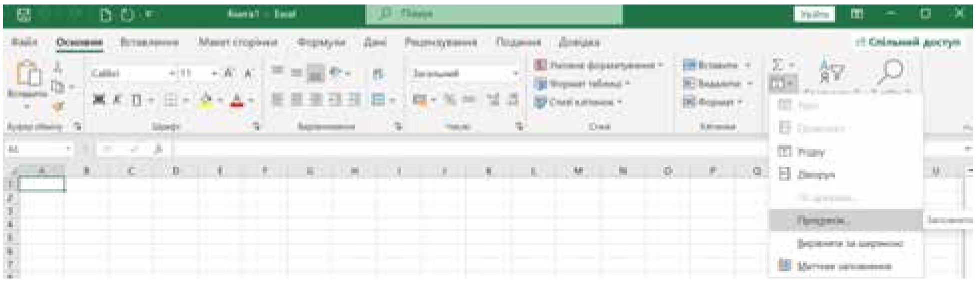
- place the mouse cursor on the autofill marker of the cell with the first value in the list and, while holding the right mouse button, drag the cursor through the cells that need to be filled;

- in the context menu that will appear after releasing the right key, select the **Progression** item ;

- in the dialogue box of the same name, indicate the type of progression and the step of changing the values;

or:

- enter the first value of the list in the selected cell, confirm the entry by pressing the Enter key ;
- activate the cell with the entered value;
- perform actions: **Main ⇒ fill in ⇒Progression ;**
- in the dialog box of the same name that opens, in the **Location** group mark **by columns** or **by terms** ;
- enter the step value in the **Step** field**;**
- in the **Type** zone**,** mark **arithmetic** or **geometric** ;
- in the **Limit value** field indicate the maximum value of the list;
- press the **OK button** .



(Прогрессия - Progression)

Entering the values of two arguments

Calculations in Excel are carried out thanks to the presence of a powerful formula machine, which provides the ability to process data with entering the results of calculations directly into a table. Formulas are usually used to perform operations on data located in different cells of a worksheet, on different sheets, or in different books. A formula in Excel is a sequence of characters beginning with the sign “=” (equal), which can include constant values (constants or references to cells with constants); references to cells containing variables; names; functions; operators The formulas use the following operators: addition "+", subtraction " −", multiplication "*", division "/", raising to the power "^", as well as relative, absolute and mixed references to cell addresses. The result of these actions is recorded in the cell containing the formula after entering it and pressing the Enter key.

If it is necessary to determine the value of the function from two arguments, represented by the ranges of their values, then, alternately, the values of one argument are entered into the selected ranges of cells, and then the second one. When entering the values of two arguments, auto-completion tools are also used. Usually, the value of ***the first argument is entered in a column*** , for example, starting from cell A2, and the value of ***the second argument is entered in a row*** , for example, starting from cell B1. Then, in cell B2, you can enter a formula for calculating the functional dependency, using in it relative (type A1), absolute (type $A$1), or mixed (type $A1 or A$1) references to cell addresses with argument values. For example, when entering the formula for calculating the functional dependence, the value of the argument *x* is entered in the column starting from cell A2, the value of the argument *y* is entered in the row starting from cell B1. Then the formula **=$A2^2+ B$1^2** is entered into cell B2 , which is spread over a rectangular range (using the autofill marker) of cells, the boundaries of which are the cells with the maximum values of the arguments.

In relative links (type A1), the address of the cell to which the link was made is automatically updated when the formula is spread from one cell to another. That is, if the distribution of the formula is carried out from cell A1 in the vertical direction, then the address of the cell in the formula to which the reference is made will change as follows: A2, A3, A4, ... If - in the horizontal, then: B1, C1, D1, ... In addition to relative references, Excel uses absolute references (such as $A$1). The $ symbol fixes the reference, leaving it unchanged when the formula is distributed to other cells. If you need to fix only a row or only a column in the formula, then use mixed links, for example, A$1 or $A1. In this case, the $ symbol fixes part of the link and leaves it unchanged when spreading the formula only vertically or horizontally.

Construction of graphical dependence between table data

For the convenience of analyzing numerical data, designed as a table, various types of graphical dependencies are used. In Excel, depending on the content of the data and the way it is presented, you can build graphs of various types (histograms, pie charts, three-dimensional surfaces, etc.). The graph can be placed on the same sheet as the data or on another sheet. If the data on which it is based changes after creating the graph, the appearance of the graph will also change automatically.

To build a graphical dependency based on tabular data, perform the following sequence of actions:

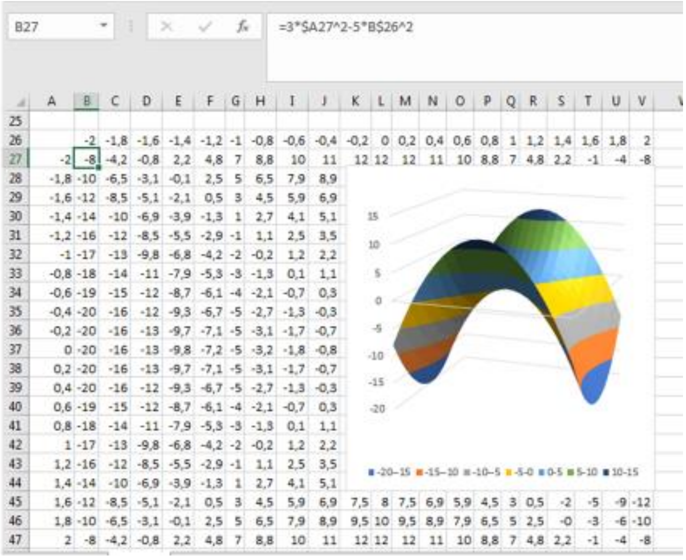
- **Insert ⇒Diagram ⇒ All diagrams**
- in the dialog box that opens, in the **Type** zones, select **Point ,** in the **View** field - **Dot chart with values connected by smoothing lines;**
- choose the required type of diagram and start formatting it;
- to change the type of diagram, call the context menu in the construction field and choose **Change type of diagram ;**
- if the OX and OY axes are incorrectly located (which means, they must be swapped), call up the context menu and choose **Select data** , where with the help of the appropriate commands, the row with the column is changed;
- menu **Select data** is used to add series names, graph legends;
- to edit the names of the axes, the name of the diagram, **the chart layouts** menu items are used on **the Designer** tab .

When constructing a graph of a function that depends on two arguments, perform the following actions:

- Select a rectangular range of cells filled with argument and function values;
- **Insert ⇒Diagram ⇒ All diagrams**
- in the dialog box that opens, select **Surface** in the **Type** areas in the **View** field - **Surface. Displays changing the values of two arguments in the form of a surface ;**

▪ select the necessary one and format it again similarly to the previous schedule.

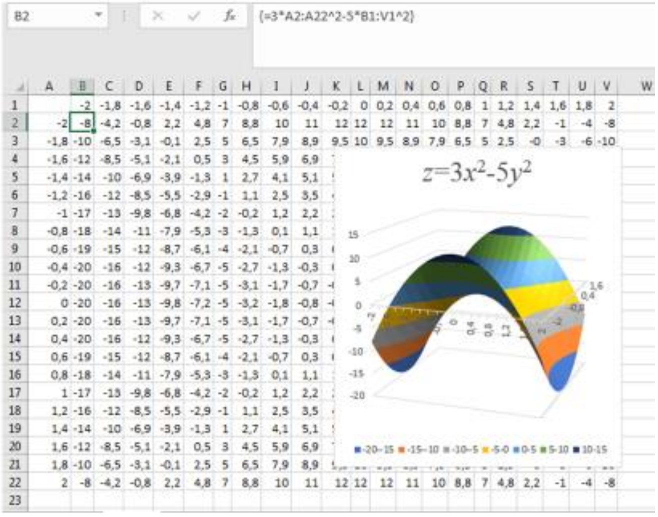
An example of constructing a surface using mixed references to tabulate a function



An example of constructing a surface using array formulas for tabulating a function.

Tabulation using array formulas

- Arguments are entered similarly to the method using mixed links, namely:
  - We enter X coordinates in the column;
  - Enter the Y coordinates in a row;
  - In the form of a table with an offset;
- We highlight the range that needs to be filled with data (completely);
- Enter the formula for calculating the function values;
- Press **Ctrl+Shift+Enter** ;
- We will get a table of values filled with data;
  - If everything is done correctly, the formula will be in curly brackets



Practical work #7

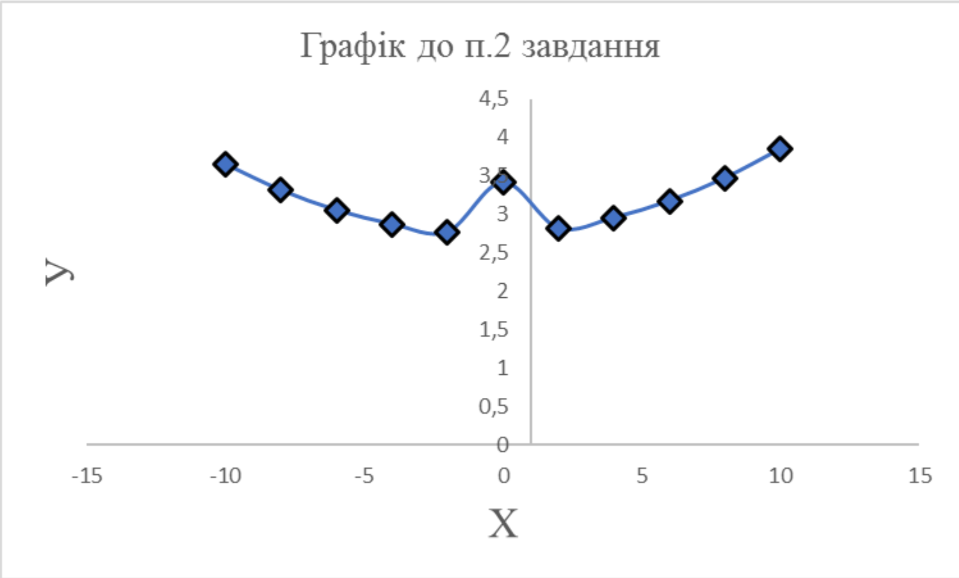
Purpose of work: master the skills of calculating functional dependencies and constructing their graphs

<u>Execution program</u>

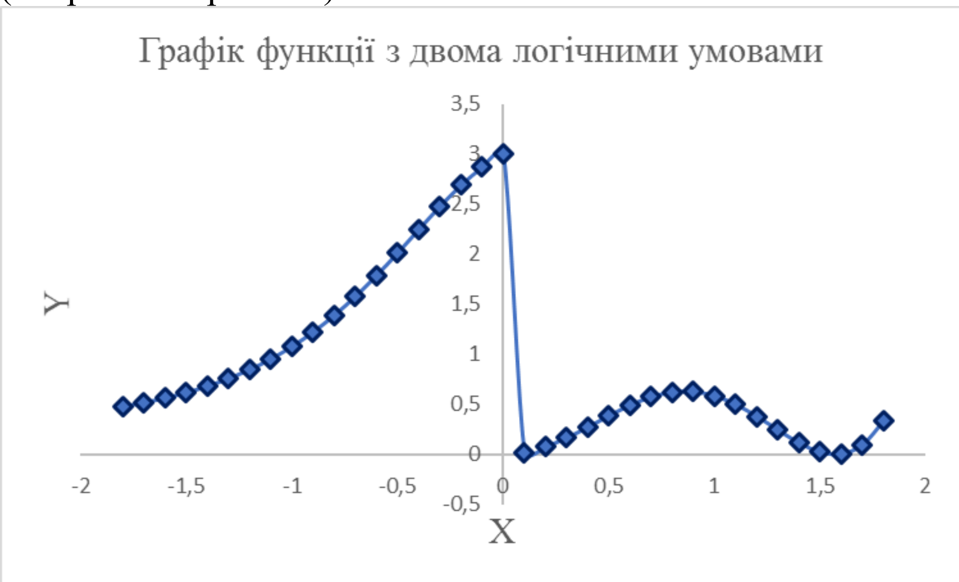
1. Download the Excel spreadsheet.
2. Plot the graph of the function $y = \dfrac{x^3 + x^2 + 1}{100x + 1{,}5} + c, \quad x \in [-10;10], h = 2, c = 2{,}75$.
3. Plot graphs of functions in one coordinate system (on one picture) $f = 0{,}77x^3 + \sin^2 x, \quad x \in [-15;15], h = 3$ and $z = 100 \cdot |x| + 0{,}33x + \sin^2 x$ on the same argument change interval.
4. Plot the function given by the logical condition $g = \begin{cases} \dfrac{3 + \sin x}{1 + x^2}, \ x \le 0 \\ 2x^2 \cos^2 x, \ x > 0 \end{cases}$, якщо $x \in [-1{,}8;\ 1{,}8]$ з кроком $0{,}1$.

(якщо- if, з кроком - with step of)

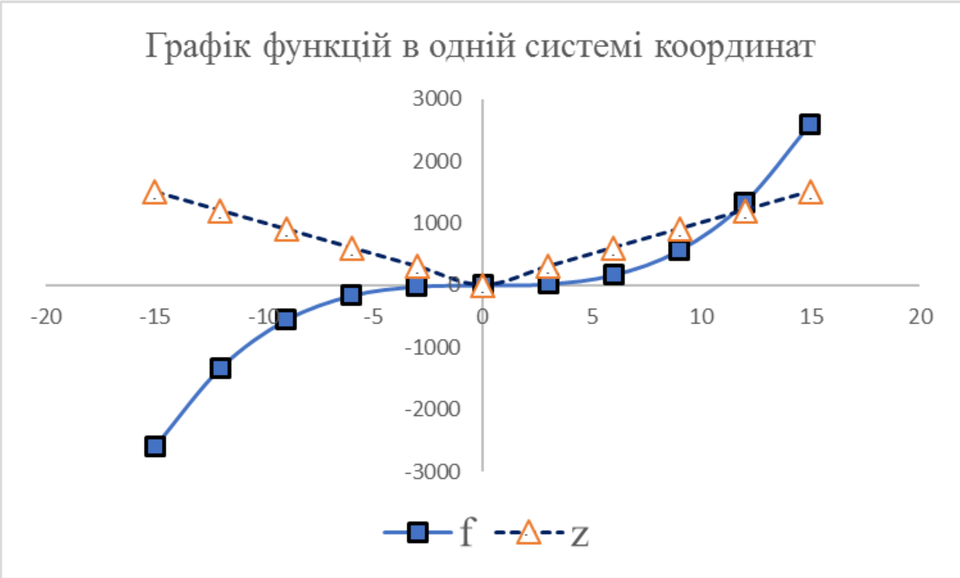
5. Plot the graph of the function of two variables, pre- tabulate the function in one of the described ways $z = 3x^2 - 5y^2, \ x \in [-2;2] \ h = 0{,}2.$
6. Construct a graph of the function of two variables, pre- tabulate the function in one of the described ways $z = \sqrt{x^2 + 2y^2}, \ x \in [-2;2] \ h = 0{,}2.$
7. Format the graphs according to the given samples.



(Graph to the p.2 task)

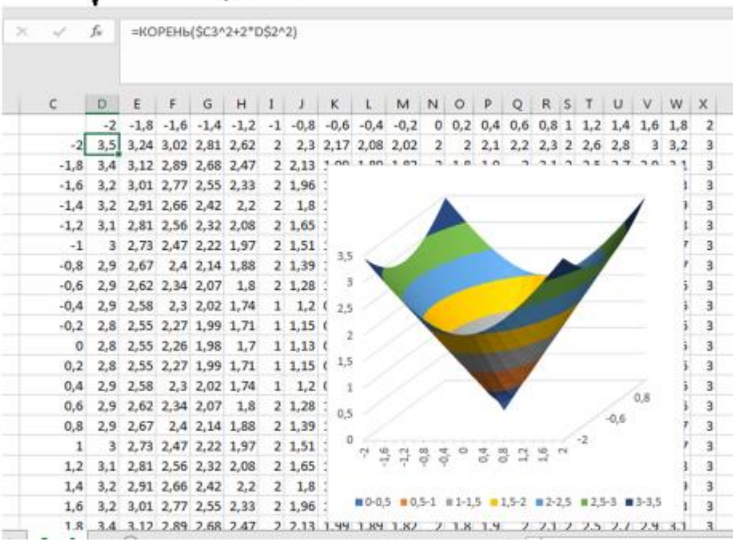


(Function graph with two logical conditions)



(Function graph in one coordinate system)

$$z=\sqrt{x^2+ay^2}\ ,\qquad a=2$$



1.8. Finding the roots of polynomial equations when solving biotechnological problems

Parameter Selection tool allows you to predict results based on known input values, or vice versa, to determine what the input data should be in order to obtain a certain result. One of the aspects of its application is finding the roots of polynomial equations.

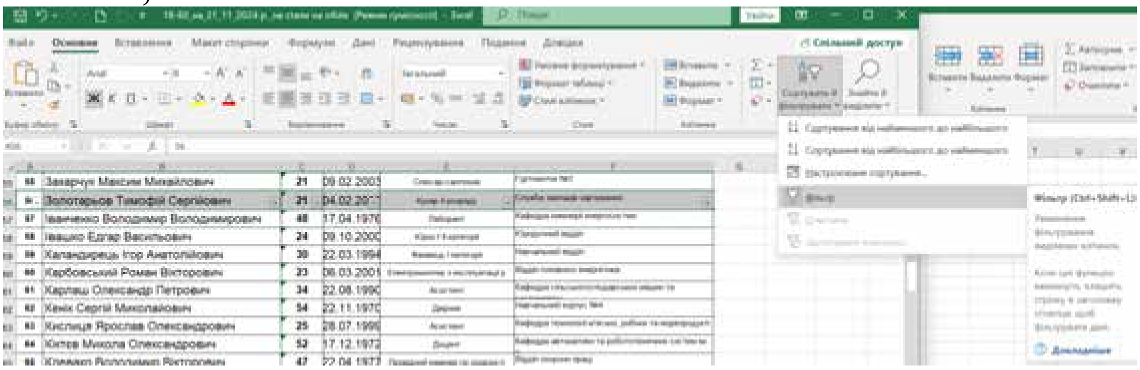
Finding the roots of the equation

The rules for using the tool **Selection of a parameter** for finding the roots of a polynomial equation will be shown in the example.

Let the dependence of the concentration of phosphorus *Y* in oil-contaminated

soil on the time of bioremediation X be described by the equation:
$Y = 0.0035\,X^2 - 1.0766\,X + 93.44$.
It is required to determine the period of time after which the concentration of phosphorus in the soil will be equal to the value that was before the ecological disaster, namely: 135 mg/kg. That is, it is required to solve the following equation:
$0.0035\,X^2 - 1.0766\,X + 93.44 = 135$, or:
$0.0035\,X^2 - 1.0766\,X + 93.44 - 135 = 0$.
After reduction, we have:
$0.0035\,X^2 - 1.0766\,X - 41.56 = 0$
The solution of the equation is all values ***of X*** that satisfy the given equation. To find the roots of the equation, perform the following actions:

- localize the roots, that is, find the spaces on which these roots exist;
- for this purpose, tabulation of the function is carried out, or its graph is built (the graph of the function at the interval of the change of the argument from 1 to 400 days is presented in Fig. 1);
- analyze the resulting graph: the function will take the value 0, if the value of the argument is close to 330;
- enter the value 330 in the selected cell, for example A1;
- a formula is entered in another cell, for example, B1, using a reference to cell A1:
= 0.0035A1 ^2 - 1.0766A1 - 41.56;
- perform the following actions: **Data=>Analysis "what if"=>Parameter selection;**



- in the corresponding dialog box that opens, in the **Set to cell** field indicate B1, in the **Value** field , indicate "0", in the **Change cell value** field enter A1;
- press the **OK** button ;
- the calculation result will be displayed in cell A1: "342".

Thus, the desired period of carrying out cleaning measures will be to be 342 days.

(Dependence of the concentration of phosphorus in the soil on the time of cleaning measures - Залежність концентрації фосфору у ґрунті від часу проведення очисних заходів, Phosphorus concentration mg/kg - концентрація фосфору, Time, days - час, днів)
Figure - An example of constructing a graphical dependence for locating the roots of the equation

Specifying the accuracy of calculations

The root equations are found using the method of successive approximations using parameter selection. In order to set the precision of the root value, perform the following actions:

- **Data=>Analysis "what if"=>Parameter selection** ;
- go to **the Parameters** tab and set **relative fallibility** and **limit number of iterations** , for example, 0.00001 and 10000, respectively.

Finding the three roots of the equation

As a rule, a polynomial equation can have several roots . As an example, consider the following equation:

$$x^3+0.03x^2-0.7x+0.1=0.$$

To find the roots of the equation, perform the following actions:

- localize the roots, i.e. find the spaces on which these roots exist;
- for this purpose, build a graph of the function on the interval [-1;1] with a step of 0.2 (the graph of the function is shown in Fig. 2);
- analyze the resulting graph: the graph crosses the ***X axis*** at three points, approximately: -0.9; 0.18; 0.7 and therefore three roots are localized;
- since the polynomial of the third degree has no more than three roots, they all turned out to be localized;
- set the accuracy of finding the roots, for example 0.00001 (**relative fallibility**) and the limit number of iterations (**limit number of iterations**), for example 1000;

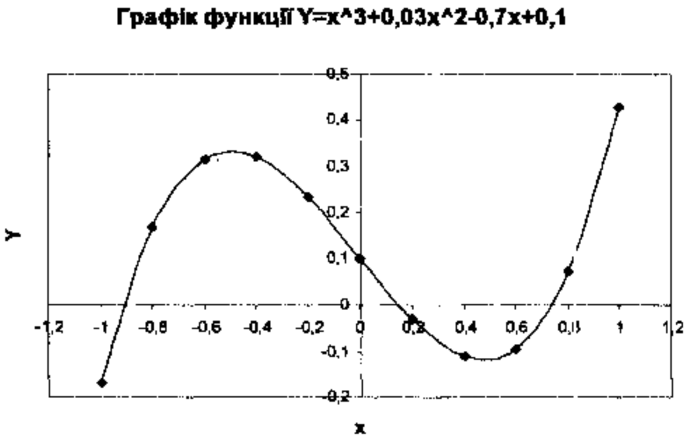


Figure - Graphical dependence for the localization of the three roots of the equation

- enter into the selected cell, for example A1, the first approximation of the root, i.e. –0.9;
- enter the formula in cell B1, using a reference to the address of cell A1: =A1^3+0.03*A1^2-0.7*A1+0.1;
- enter the second approximation in cell A2, i.e. 0.18;
- enter the formula in cell B2, or spread the previous one: =A2^3+0.03*A2^2-0.7*A2+0.1;
- enter the third approximation in cell AZ: 0.7;
- enter the formula in cell VZ:

=AZ ^ 3+0.03*AZ ^ 2-0.7*AZ+0.1;

- perform the following actions: **Data=>Analysis "what if"=>Parameter selection** and alternately find the roots of the equation, which in this case with the given accuracy of calculations are equal to: -0.9149; 0.1482; 0.7565.

Practical work #8

***The purpose of the work: to master the methods of using the* "Parameter Selection"** tool to find the roots of polynomial equations

Execution program

1. Load up MS Excel spreadsheet.
2. Perform tabulation of functions on intervals of changing arguments [–2;2] and plot graphic dependencies.
   2.1 . $x^3 - 5.5x^2 + 0.3x + 5 = 0$;
   2.2. $(x - 0.1)^2 \log(x + 10) - 3 = 0$;
   2.3. $5\sin x - x = 0$;
   2.4. $x^2 \cos 2x = -1$;
3. Find all the roots of the equations.

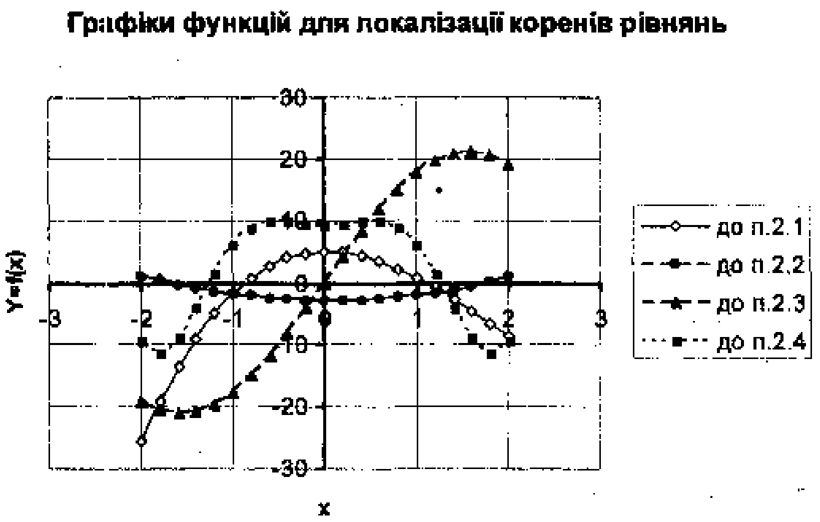


Figure - Graphs of functions for localization of roots of equations

Self-test questions

1. How is the **Parameter Selection** tool called ?
2. What is the basis of its use?
3. What are the rules of use and the sequence of filling in the fields of the **parameter selection** dialog box?
4. What is the procedure for finding the roots of polynomial equations using **parameter selection** ?
5. How to set the accuracy of calculations and the maximum number of iterations? For what purpose are they used?

1.9. Using array formulas in MS Excel

One of the most interesting and powerful features in Excel is the use of arrays in formulas.

An array is a set of elements that can be processed as a single group or individually. In Excel, arrays can be *one-* or *two-dimensional* . The dimensions of the arrays correspond directly to the rows and columns of the Excel table. For example, a one-dimensional array can be a group of cells arranged in a single row (horizontal array) or in a single column (vertical array). A two-dimensional array is placed in several rows and columns. Excel does not support three-dimensional arrays.

Working with array formulas

Entering an array formula

To enter an array formula into a cell or into a range of cells, a certain procedure is performed that allows the Excel software to identify the entered expression as an array formula, as opposed to a regular formula. Namely, the end of the set of the formula must be accompanied by a simultaneous pressing of the key combination **Ctrl+Shift+Enter** , after which the system automatically places the formula in curly brackets.

Selection of array

Selection of the range of cells in which the array is placed is performed in one of the following ways:

- place the cursor in one of the cells of the array;
- perform actions: **Edit ⇒Go** , or press the **F5 key** ;
- in the **Transition** dialog box that opens, press the **Select** button ;
- in the next dialog box **Selection of groups of cells** select the **Current array** switch ;
- click the **OK** button to close the dialog box;

or:

- place the cursor in one of the cells of the array;
- press the key combination **Ctrl** + / .

Editing an array formula

If the array formula is in several cells, editing is performed in all cells of the range as one.

The following rules are followed when editing array formulas:

- ***it is not possible*** to change the contents of any of the cells, the values of which were obtained by calculations using the array formula - when you try to do this, Excel will issue the message " **Cannot change part of the array "** ;
- ***you cannot*** move the values of individual cells to which the array formula is applied (all cells with the array formula are moved together);
- ***you cannot*** remove individual cells to which the array formula is applied (only the entire array is removed);
- ***you cannot*** insert new cells into the array (this rule also applies to inserting new rows and columns).

To edit an array formula:

- select all cells of the array;
- move the cursor to the formula line, or press the **F2 button** ;
- curly brackets are removed;
- make the necessary changes to the array formula;
- after finishing editing the formula, press **Ctrl+Shift+Enter** to confirm the changes.

After performing the specified actions, the content of all cells of the array will change in accordance with the changes made.

Using an array formula for a range of cells

In fig. an Excel document worksheet with calculations of fertilizer sales volumes is presented. To calculate the selling pFig of each type of fertilizer (value in column **D**), the formula for multiplying the quantity of the product (column **B**) by the pFig of the product (column **C**) is usually used. For example, the value of cell **D2** can be calculated using the formula: = **B2** * **C2** , which is then spread over the range of cells corresponding to the cells with the argument values. In this case, we will get five separate formulas in column **D.**

The second way to calculate the five values in column **D** is to use a single array formula. This formula will be placed in the range of cells **D2:D6** , the result of the calculation of which will be five searched values.

To create an array formula for a range of cells:

- select the range of cells in which the result of calculations according to the array formula should be located (in this case, it is **D2:D6**);
- enter the formula **=B2:B6*C2:C6** ;
- press the key combination **Ctrl+Shift+Enter** .

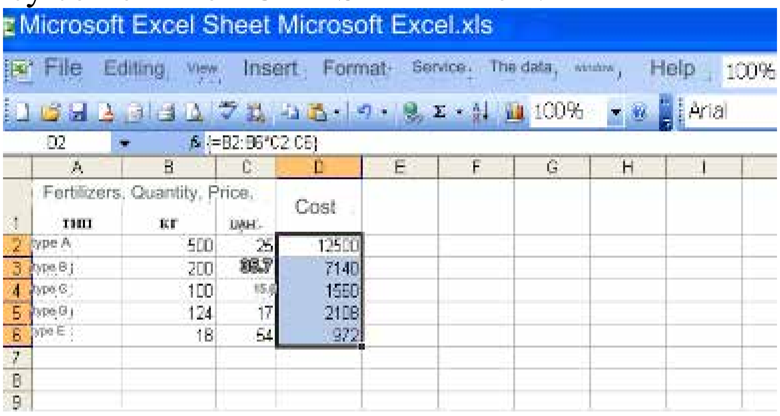


Fig. An example of using an array formula for a range of cells

Using an array formula in a single cell

Array formulas can also return a result in a single cell. In fig. the array formula **{=SUM(B2:B6*C2:C6)}** is entered in cell **D8** . This formula calculates the total amount of sales and allows you to determine the sum of the products of the numbers located in cells **B2** and **C2** , **B3** and **C3** , ... **B6** and **C6** . That is, first the products of the corresponding pairs of array numbers are found, and then these results are added.

To enter an array formula in one cell, perform the following actions:

- select the cell into which the formula will be entered (click on it with the mouse);
- **Insert ⇒Function** ;
- in the dialog box that opens, in the **Category list,** select **Mathematical** ;
- in the **Select the function** field select from **the SUM** list**;**
- enter the formula **=B2:B6*C2:C6** in the corresponding dialog box that will open in the **array 1** line**;**
- press the key combination **Ctrl+Shift+Enter** .

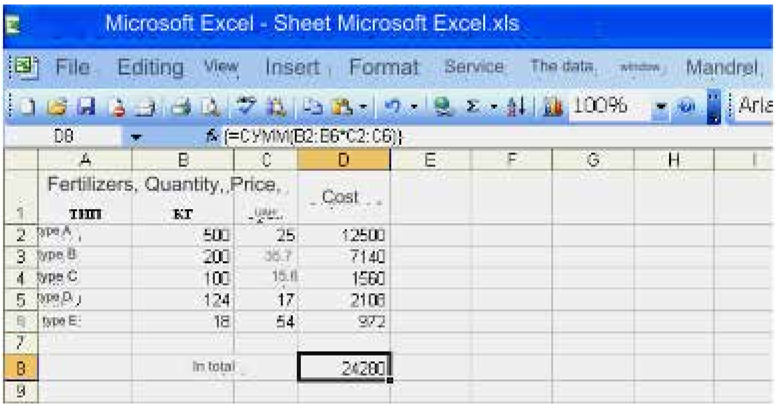


Fig. An example of entering an array formula into one cell

Application of array formulas to perform operations on matFigs

Finding the sum of matFigs

To add matFigs of the same dimension, perform the following actions:

- enter matFigs of the same dimension in the form of arrays or in the form of ranges of cells;
- select a range of cells of the same dimension as the matFigs-additions;
- enter the formula for the sum of the corresponding arrays;
- press the key combination **Ctrl+Shift+Enter** .

In fig. an example of adding 2×2 matFigs given by the range of cells using array formulas is given.

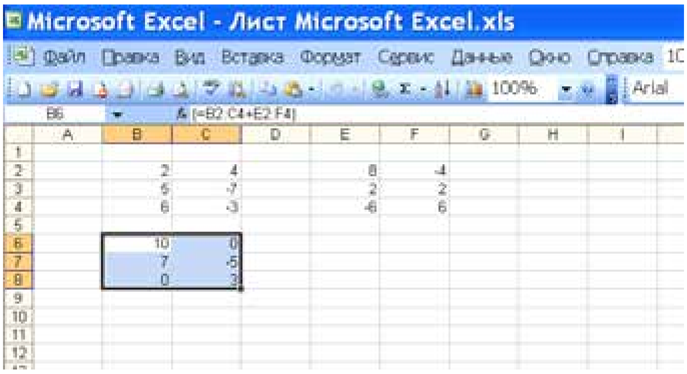


FIg. An example of adding matFigs (two-dimensional arrays)

Finding the product of matFigs

To find the product of matFigs in Excel, use the built-in **MMULT** function of the **Mathematical** category . The result of using the function is an array (matrix) with the same number of rows as array (matrix) 1 and with the same number of columns as array (matrix) 2.

When finding the product of matFigs, the following restrictions are observed:

- the number of columns of array (matrix) 1 must be the same as the number of rows of array (matrix) 2;
- matFigs are entered as array formulas or in a range of cells.

the algorithm for finding the product of matFigs using the built-in **MMULT** function as an example:

$$A = \begin{pmatrix} 1 & 2 & 4 \\ 3 & 2 & 0 \\ -1 & 4 & 2 \end{pmatrix}, D = \begin{pmatrix} 1 \\ 2 \\ 3 \end{pmatrix}. A \times D - ?$$

To find the product of matFigs, perform the following actions:

- enter the matrix (array) 1, for this:
  - select a range of cells that corresponds to the dimensions of the matrix A , for example B2:D4 (see the introduction of a two-dimensional array);
  - **={1;2;4:3;2;0:-1;4;2}** in the formula line ;
  - press the key combination **Ctrl+Shift+Enter** ;
- Enter matrix (array) 2:
  - select a range of cells corresponding to the dimensions of the matrix D , for example F2:F4 (see the introduction of a one-dimensional vertical array);
  - **={1:2:3}** in the formula line ;
  - press the key combination **Ctrl+Shift+Enter** .

To find the result of the product of two matFigs, the corresponding formula is entered as an array formula. For this purpose:

- separate the range of cells corresponding to the number of rows of array 1 and the number of columns of array 2;
- go to the formula line;
- perform actions: **Insert ⇒Function** ;
- in the dialog box that opens, select the category of **Mathematical functions** ;
- in this category, select the **MMULT** function from the list ;
- in the corresponding dialog box that opens, enter a range of cells with the elements of the first matrix (for example, B2:D4) in the **array x** field **;**
- enter a range of cells with the elements of the second matrix (for example, F2:F4 **)** in the **array** field ;
- press the key combination **Ctrl+Shift+Enter** .

or:

- enter =**MMULT(B2:D4 ; F2:F4)** ;
- press the key combination **Ctrl+Shift+Enter** .

The result of the matrix product will be displayed in the form of an array (Fig.).

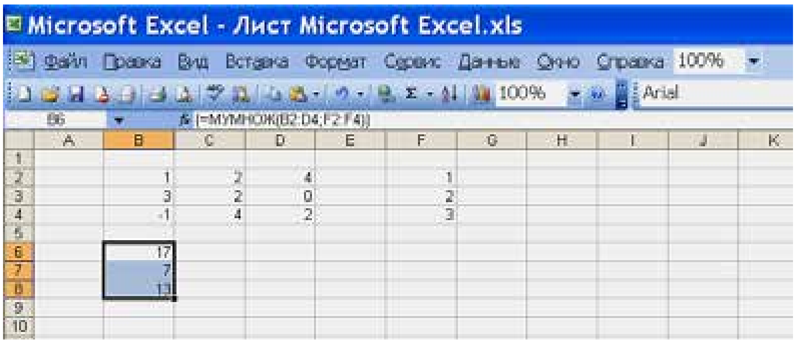


Fig. An example of finding the product of matFigs using array formulas

The result of multiplying the matFigs given in the example corresponds to the mathematical expression:

$$A \times D = \begin{pmatrix} 17 \\ 7 \\ 3 \end{pmatrix}.$$

Finding the determinant of a matrix

To find the determinants of matFigs in Excel, there is a **MDETERM** function of the **Mathematical** category . The matrix determinant is usually used to solve systems of equations with several unknowns. To calculate the determinant, the matrix must contain the same number of rows and columns.

The matrix (array) can be specified as a range of cells, for example A1:C3, or as an array of constants, for example {1;2;3:4;5;6:7;8;9}.

MDETERM function also returns an error value of **#SO!** , if the array has an unequal number of rows and columns.

To find the determinant of the matrix given by the range of values, perform the following actions:

- activate the cell to output the calculation result;
- perform actions: **Insert ⇒Function** ;
- in the dialog box that opens, select the category of **Mathematical functions** ;
- in this category, select the **MDETERM** function from the list;
- in the corresponding dialog box that opens, in the line **array,** enter the corresponding matrix in the form of a range of values **;**
- press a key **enter**

or:

- activate the cell to output the calculation result;
- =**MDETERM (A1:D4)** is entered in the **formula** line ;

- press a key **Enter** .

To find the determinant of a matrix given as an array, for example 3 × 3 in the form ={2;-1;3:1;-2;4:3;-3;0}, perform the following actions:

- activate the cell to output the calculation result;
- perform actions: **Insert ⇒Function** ;
- in the dialog box that opens, select the category of **Mathematical functions** ;
- in this category, select the **MDETERM function from the list;**
- in the corresponding dialog box that opens, in the line **array,** enter the appropriate matrix in the form of a range of cells B2:D4 **;**
- press a key **Enter** .

An example of calculating the matrix determinant using the built-in **MDETERM** function is shown in Fig.

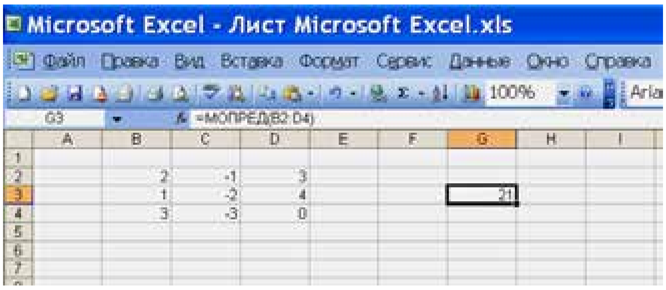


Fig. An example of using the **MDETERM** function

Finding the inverse matrix

To find the inverse matrix in Excel, there is a **MINVERSE** function of the **Mathematical** category . Inverse matFigs, like determinants, are usually used to solve systems of equations with several unknowns.

The matrix (array) must be specified as a numeric array with the same number of rows and columns. In addition, the array can be specified as a range of cells (for example A2:C4) or as an array of constants, for example {1;2;3:4;5;6:7;8;9}.

To find the matrix inverse of the given:

- activate the range of cells corresponding to the dimensions of the original matrix;
- perform actions: **Insert ⇒Function** ;
- in the dialog box that opens, select the category of **Mathematical functions** ;
- in this category, select the **MINVERSE** function from the list;
- in the corresponding dialog box that opens, in the **array** line, enter the appropriate matrix in the form of a range of cells **B2:D4;**
- press the key combination **Ctrl+Shift+Enter** ;

or:

- activate the range of cells corresponding to the dimensions of the original matrix;
- =**MINVERSE (A2:C4)** is entered in the **formula** line ;
- press the key combination **Ctrl+Shift+Enter** .

An example of finding the inverse matrix using the **MINVERSE** function is shown in Fig. .

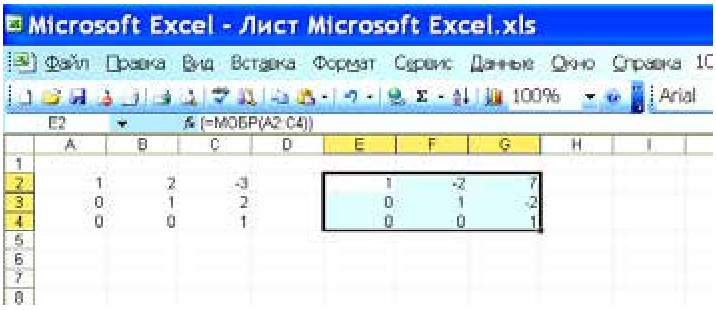


Fig. An example of using **the MINVERSE** function

Practical work #9

<u>**The purpose of the work:**</u> To get acquainted with the features of working with array formulas in Excel, their purpose and use

<u>**Execution program**</u>

1. Launch MS Office Excel.
2. Using the formulas of the arrays **MMULT**, **MDETERM**, find the product of the matFigs AB and the determinant of the matrix A, choosing the option by number in the group list.
3. Complete each task on a separate sheet in an Excel book. Give the file the following name " version number_performer 's last name".

<u>**Control questions**</u>

1. What is an array in Excel?
2. What types of arrays does Excel support?
3. What are the features of creating array formulas?
4. How to edit an array formula?
5. What actions are not allowed when working with array formulas?
6. How to enter an array formula to display the result in one cell?
7. How to enter an array formula into a range of cells?

<u>***Tasks for practical work***</u>

1. $A=\begin{pmatrix} 2 & 3 & 4 & 1 \\ -1 & 2 & 1 & 2 \\ 3 & -2 & 1 & -2 \\ 1 & 7 & -1 & 3 \end{pmatrix}$; $B=\begin{pmatrix} 1 & 7 & 8 \\ -2 & 3 & 2 \\ 2 & 1 & -1 \\ 4 & 3 & 1 \end{pmatrix}$.

2. $A=\begin{pmatrix} 1 & 3 & 2 & 1 \\ -2 & 1 & 1 & 3 \\ -1 & 2 & 1 & 4 \\ 4 & -4 & 3 & 1 \end{pmatrix}$; $B=\begin{pmatrix} 2 & 3 & 1 & 3 \\ 3 & 1 & 2 & -2 \\ -3 & 1 & 3 & 1 \\ 2 & 3 & -2 & 1 \end{pmatrix}$.

3. $A=\begin{pmatrix} -2 & 1 & 3 & 1 \\ 1 & -3 & 4 & 1 \\ 2 & 1 & -3 & 2 \\ 1 & -4 & 1 & 7 \end{pmatrix}$; $B=\begin{pmatrix} 2 & 1 \\ -4 & 2 \\ 1 & 5 \\ 2 & 5 \end{pmatrix}$.

4. $A=\begin{pmatrix} 3 & -1 & 1 & 2 \\ 2 & 1 & 2 & 1 \\ -3 & -2 & 1 & 4 \\ 2 & 4 & -2 & -1 \end{pmatrix}$; $B=\begin{pmatrix} 1 & 2 & 2 & -3 & 1 & 1 \\ -1 & 5 & 4 & -2 & 1 & 2 \\ -1 & 1 & 2 & 3 & 1 & 3 \\ -1 & 1 & 2 & 4 & 2 & 1 \end{pmatrix}$.

5. $A=\begin{pmatrix} 1 & 4 & 2 & 3 \\ 2 & -2 & -1 & 2 \\ 1 & 3 & -1 & 3 \\ -1 & 6 & 1 & 2 \end{pmatrix}$; $B=\begin{pmatrix} 1 & 2 & 3 & 1 & -1 \\ -2 & -5 & 4 & 1 & 2 \\ -1 & 6 & -1 & 2 & 3 \\ 1 & 1 & 2 & 1 & 1 \end{pmatrix}$.

6. $A=\begin{pmatrix} 1 & 2 & 3 & 1 \\ -2 & 1 & 3 & -2 \\ 1 & 4 & 1 & 3 \\ 2 & 3 & -1 & -2 \end{pmatrix}$; $B=\begin{pmatrix} 1 & 5 & 1 \\ -4 & 3 & -1 \\ 4 & 7 & -2 \\ 1 & -1 & 4 \end{pmatrix}$.

7. $A=\begin{pmatrix} 1 & 1 & 4 & 2 \\ -1 & 3 & -2 & 1 \\ 2 & 1 & 3 & -2 \\ 5 & 1 & -3 & -1 \end{pmatrix}$; $B=\begin{pmatrix} 2 & 1 & -1 & 3 \\ 3 & -2 & 4 & -1 \\ -1 & -1 & 2 & 4 \\ 1 & 2 & -1 & 4 \end{pmatrix}$.

8. $A=\begin{pmatrix}-2 & 6 & -1 & 3\\ 1 & -1 & 2 & -1\\ 3 & -2 & 1 & 1\\ 1 & 2 & -3 & 0\end{pmatrix}$; $B=\begin{pmatrix}4 & 1\\ 2 & -1\\ 1 & 2\\ -2 & 4\end{pmatrix}$.

9. $A=\begin{pmatrix}-1 & 4 & 3 & 1\\ 1 & -2 & 1 & 2\\ 2 & -3 & 1 & 0\\ -6 & 1 & 4 & 2\end{pmatrix}$; $B=\begin{pmatrix}1 & 4 & 1 & 2 & 3\\ 1 & -4 & 2 & -3 & 1\\ 0 & 5 & 1 & -4 & 3\\ 1 & 2 & -1 & 1 & 2\end{pmatrix}$.

10. $A=\begin{pmatrix}3 & 4 & 1 & 0\\ -1 & 1 & 3 & 2\\ -1 & 2 & 1 & 4\\ 0 & 1 & 6 & 1\end{pmatrix}$; $B=\begin{pmatrix}2 & 1 & 4 & 1 & -1 & 5\\ -1 & 2 & 3 & -4 & 1 & -1\\ -4 & 1 & -2 & 4 & 1 & 0\\ 1 & 7 & 1 & 2 & -1 & 2\end{pmatrix}$.

11. $A=\begin{pmatrix}4 & -1 & 11 & 2\\ 1 & -2 & -1 & 2\\ -1 & 8 & 4 & 1\\ 1 & -6 & 1 & 3\end{pmatrix}$; $B=\begin{pmatrix}1 & 4 & 1\\ -1 & 4 & 2\\ 1 & 4 & 1\\ 7 & 1 & 0\end{pmatrix}$.

12. $A=\begin{pmatrix}1 & 0 & 5 & 2\\ -4 & 5 & -2 & 1\\ 3 & 1 & 6 & 1\\ 4 & -1 & -4 & 2\end{pmatrix}$; $B=\begin{pmatrix}4 & 2 & 1 & 1\\ -2 & 4 & -2 & 1\\ 2 & 1 & 3 & -4\\ 1 & -3 & -1 & 5\end{pmatrix}$.

13. $A=\begin{pmatrix}1 & 4 & 3 & 2\\ 3 & -1 & 1 & 5\\ -1 & 2 & 4 & 1\\ 4 & 1 & -3 & 2\end{pmatrix}$; $B=\begin{pmatrix}2 & 0\\ 0 & -4\\ -3 & 1\\ 4 & -5\end{pmatrix}$.

14. $A=\begin{pmatrix}4 & 1 & 1 & 3\\ -2 & 1 & -3 & 1\\ -4 & 2 & 3 & 0\\ 1 & 1 & 4 & 2\end{pmatrix}$; $B=\begin{pmatrix}1 & 2 & 4 & 3 & -1\\ -4 & 1 & 2 & 1 & -2\\ 2 & -4 & 3 & 1 & 3\\ 1 & 1 & 2 & 4 & -1\end{pmatrix}$.

15. $A=\begin{pmatrix}1 & 3 & 2 & 1\\ -4 & -2 & 1 & 3\\ 1 & 3 & 5 & -1\\ 1 & 2 & -1 & 4\end{pmatrix}$; $B=\begin{pmatrix}4 & 1 & 2 & 1 & 0 & -1\\ -4 & 1 & 4 & 7 & 1 & -2\\ 1 & -2 & -1 & -1 & 0 & 1\\ -1 & 4 & 1 & 3 & -1 & 0\end{pmatrix}$.

16. $A=\begin{pmatrix}-1 & 4 & -2 & 1\\ 1 & 0 & 4 & 5\\ 2 & -1 & 5 & -1\\ -4 & 5 & 1 & 1\end{pmatrix}$; $B=\begin{pmatrix}-2 & 1 & -2\\ 1 & 4 & 2\\ 4 & -2 & -3\\ 2 & 3 & 1\end{pmatrix}$.

17. $A=\begin{pmatrix}-4 & -2 & 3 & 1\\ 2 & -3 & 1 & 0\\ 2 & 3 & 4 & 1\\ 3 & 1 & 1 & -1\end{pmatrix}$; $B=\begin{pmatrix}1 & 3\\ -2 & -3\\ 1 & -5\\ 2 & -1\end{pmatrix}$.

18. $A=\begin{pmatrix}3 & 1 & 2 & 1\\ 2 & -4 & 4 & 3\\ 2 & 1 & 4 & -1\\ 4 & -2 & -1 & 3\end{pmatrix}$; $B=\begin{pmatrix}5 & 1 & 4 & 2\\ -1 & -5 & 2 & 1\\ 1 & 2 & 1 & 1\\ 4 & -1 & -1 & -4\end{pmatrix}$.

19. $A=\begin{pmatrix}-4 & -3 & 1 & 1\\ 4 & 3 & 2 & 1\\ 2 & -1 & 5 & -1\\ 1 & -1 & 4 & -2\end{pmatrix}$; $B=\begin{pmatrix}2 & 2 & -1 & -3 & 0 & 1\\ 1 & 1 & 4 & 3 & 1 & -1\\ -2 & 2 & -2 & 1 & 1 & 0\\ 1 & 6 & -1 & 4 & 1 & 1\end{pmatrix}$.

20. $A=\begin{pmatrix}-3 & -2 & 1 & 4\\ -1 & 5 & -1 & 0\\ 2 & 4 & 4 & 2\\ 2 & -1 & 5 & -1\end{pmatrix}$; $B=\begin{pmatrix}1 & 4 & -2 & -3 & 1\\ 2 & -2 & -1 & 5 & 0\\ 1 & 1 & 2 & 6 & -1\\ 6 & -2 & -1 & -2 & 1\end{pmatrix}$.

21. $A=\begin{pmatrix}4 & 2 & 1 & 0\\ -1 & -2 & 3 & -4\\ 2 & 5 & 1 & 2\\ 1 & -4 & -1 & 0\end{pmatrix}$; $B=\begin{pmatrix}2 & 3\\ 2 & -1\\ -1 & 4\\ 3 & 2\end{pmatrix}$.

22. $A=\begin{pmatrix}1 & -4 & -2 & 3\\ -2 & 5 & -2 & -1\\ 5 & -2 & 1 & 6\\ 1 & -1 & 4 & 3\end{pmatrix}$; $B=\begin{pmatrix}-4 & 3 & -1 & -2\\ 2 & 1 & -2 & 0\\ 1 & -5 & 1 & -3\\ 1 & 0 & 1 & 1\end{pmatrix}$.

23. $A=\begin{pmatrix}4 & 3 & 1 & 1\\ -1 & 5 & -2 & -1\\ 2 & -1 & -3 & 4\\ 1 & 5 & -1 & -2\end{pmatrix}$; $B=\begin{pmatrix}1 & 1 & 5\\ -5 & -1 & 0\\ 1 & 2 & -1\\ -2 & 0 & 1\end{pmatrix}$.

1.10. Solving systems of linear algebraic equations

Cramer's rule

For simplification, we will consider a system of three linear equations with three unknowns x_1, x_2, x_3, which can be written as follows:

$$\begin{cases} a_{11}x_1 + a_{12}x_2 + a_{13}x_3 = h_1, \\ a_{21}x_1 + a_{22}x_2 + a_{23}x_3 = h_2, \\ a_{31}x_1 + a_{32}x_2 + a_{33}x_3 = h_3, \end{cases} \quad (1)$$

the numbers a_{ij} *(and, j* =1,2,3) are the coefficients of the system; the first index i is the number of the equation, the second - j is the number of the unknown x_i , at which this coefficient stands. Numbers $h_1\, h_2,\, h_3$ — free members of the system.

If all free members of system (1) are equal to zero $h_1 = h_2 = h_3 = 0$, then the system is called **homogeneous.** If there is at least one non-zero free term, then the system is called **inhomogeneous.**

The main determinant of the system is the determinant consisting of coefficients with unknowns

$$\Delta = \begin{vmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{vmatrix} \quad (2)$$

To find the solution of system (1), we perform the following actions. We multiply each of the equations by the corresponding algebraic additions to the first coefficient of this equation. Namely, multiply the first equation on A_{11}, the second equation — on A_{21} and the third - on A_{31}. We will get

$$\begin{cases} A_{11}(a_{11}x_1 + a_{12}x_2 + a_{13}x_3) = h_1A_{11}, \\ A_{21}(a_{21}x_1 + a_{22}x_2 + a_{23}x_3) = h_2A_{21}, \\ A_{31}(a_{31}x_1 + a_{32}x_2 + a_{33}x_3) = h_3A_{31}, \end{cases}$$

Let's add these equations, collecting the corresponding coefficients for the unknowns x 1, x_2, x_3. We have

$$(a_{11}A_{11} + a_{21}A_{21} + a_{31}A_{31})x_1 + (a_{21}A_{11} + a_{22}A_{21} + a_{32}A_{31})x_2 +$$
$$+(a_{13}A_{11} + a_{23}A_{21} + a_{33}A_{31})x_3 = h_1A_{11} + h_2A_{21} + h_3A_{31}.$$

In the first brackets, we have the distribution of the main determinant (by the elements of the first column (property 9). In the second and third brackets, we have the sum of the products, respectively, of the second and third hundredths by the algebraic additions to the first column. Therefore, according to property 10, these expressions are equal to zero. Thus , we get

$$\Delta \cdot x_1 + 0 \cdot x_2 + 0 \cdot x_3 = h_1 A_{11} + h_2 A_{21} + h_3 A_{31}.$$

In this equality, on the right is a distribution over the elements of the first column of the determinant, in which the first column is composed of free terms and the other two coincide with the corresponding columns of the main determinant . Let's mark

$$\Delta_1 = \begin{vmatrix} h_1 & a_{12} & a_{13} \\ h_2 & a_{22} & a_{23} \\ h_3 & a_{32} & a_{33} \end{vmatrix}$$

Then the last equation takes the form:

$$\Delta \cdot x_1 = \Delta_1.$$

Similarly, multiplying each of the equations of system (1) by the algebraic complements of the elements of the second (third) columns and performing the same transformations, we obtain

$$\Delta \cdot x_2 = \Delta_2., \quad \Delta \cdot x_3 = \Delta_3.,$$

where

$$\Delta_2 = \begin{vmatrix} a_{11} & h_1 & a_{13} \\ a_{21} & h_2 & a_{23} \\ a_{31} & h_3 & a_{33} \end{vmatrix}, \quad \Delta_3 = \begin{vmatrix} a_{11} & a_{12} & h_1 \\ a_{21} & a_{22} & h_2 \\ a_{31} & a_{32} & h_3 \end{vmatrix}.$$

Thus, system (1) reduced to an equivalent system:

$$\Delta \cdot x_1 = \Delta_1., \quad \Delta \cdot x_2 = \Delta_2., \quad \Delta \cdot x_3 = \Delta_3., \quad (3)$$

Let $\Delta \neq 0$ Then x_1, x_2, x_3 can be expressed from system (3) .

$$x_1 = \frac{\Delta_1}{\Delta}, \quad x_2 = \frac{\Delta_2}{\Delta}, \quad x_3 = \frac{\Delta_3}{\Delta}. \quad (4)$$

Formulas (4) make up the content **of Cramer's rule:** if the main determinant of system (1) is not equal to zero $\Delta \neq 0$, then the system has a unique solution, which is determined by formulas (4).

Formulas (4) are also called **Cramer's formulas.**

Determinants Δ_1, Δ_2, Δ_3 are obtained from the main determinant Δ (see (2)) by replacing the corresponding column of coefficients with unknowns by a column of free terms.

Cramer's rule also applies when solving a system *of n* linear equations with *n* unknowns, that is, a system of the form

$$\begin{cases} a_{11}x_1 + a_{12}x_2 + ... + a_{1j}x_j + ... + a_{1n}x_n = h_1, \\ a_{21}x_1 + a_{22}x_2 + ... + a_{2j}x_j + ... + a_{2n}x_n = h_2, \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ a_{i1}x_1 + a_{i2}x_2 + ... + a_{ij}x_j + ... + a_{in}x_n = h_i, \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ a_{n1}x_1 + a_{n2}x_2 + ... + a_{nj}x_j + ... + a_{nn}x_n = h_n \cdot \end{cases} \quad (5)$$

This system can be abbreviated as:

$$\sum_{j=1}^{n} a_{ij}x_j = h_i \qquad (i = 1, 2, ...n).$$

The main determinant Δ of system (5) will be the determinant composed of coefficients for unknowns $x_1, x_2, ... x_n$ i.e

$$\Delta = \begin{vmatrix} a_{11} & a_{12} & \dots & a_{1j} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2j} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ a_{i1} & a_{i2} & \dots & a_{ij} & \dots & a_{in} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nj} & \dots & a_{nn} \end{vmatrix}$$

Cramer's rule. If the main determinant of the system of *n* linear equations with *n* unknowns is different from zero ($\Delta \neq 0$), then the system has a unique solution expressed by the formulas:

$$x_1 = \frac{\Delta_1}{\Delta}, , \quad x_j = \frac{\Delta_j}{\Delta}, , \quad x_n = \frac{\Delta_n}{\Delta}.$$

where Δ_j *(j =1,2,... ,n)* is the determinant obtained by Δ replacing the elements of the *jth* column with a column of free members,

$$\Delta_j = \begin{vmatrix} a_{11} & a_{12} & \dots & h_1 & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & h_2 & \dots & a_{2n} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ a_{i1} & a_{i2} & \dots & h_i & \dots & a_{in} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & h_n & \dots & a_{nn} \end{vmatrix}$$

Note that this method requires cumbersome calculations and is rarely used when $n > 3$. Therefore, it is convenient to use Excel array formulas to solve SLAE.

Examples. Solve a system of linear equations using Cramer's rule.

a) Let the system of two equations with two unknowns be given:

$$\begin{cases} 2x_1 - x_2 = 3, \\ 3x_1 + 5x_2 = -2. \end{cases}$$

The solution. We compile the main determinant from coefficients with unknowns and using the **MDETERM function.**

$$\Delta = \begin{vmatrix} 2 & -1 \\ -2 & 5 \end{vmatrix} = 13 \neq 0$$

, so the system has a unique solution

We calculate Δ_1 and Δ_2, replacing Δ the first and second columns, respectively, with a column of free members. We have

$$\Delta_1 = \begin{vmatrix} 3 & -1 \\ -2 & 5 \end{vmatrix} = 13 \; ; \quad \Delta_2 = \begin{vmatrix} 2 & 3 \\ 3 & -2 \end{vmatrix} = -13 \, .$$

We find x_1 and x_2 using formulas (4):

$$x_1 = \frac{\Delta_1}{\Delta} = \frac{13}{13} = 1 \; ; \quad x_2 = \frac{\Delta_2}{\Delta} = \frac{-13}{13} = -1 \, .$$

b) Let the given system of three equations with three unknowns:

$$\begin{cases} x_1 - 2x_2 + 5x_3 = 0 \\ 2x_1 + x_2 - x_3 = -6 \\ 5x_1 + x_2 = -14 \end{cases}$$

The solution. We compile the main determinant and calculate it using the **MDETERM function**

$$\Delta = \begin{vmatrix} 1 & -2 & 5 \\ 2 & 1 & -1 \\ 5 & 1 & 0 \end{vmatrix} = -4 \neq 0.$$

Therefore, the system has a unique solution. We calculate Δ_1; Δ_2, Δ_3:

$$\Delta_1 = \begin{vmatrix} 0 & -2 & 5 \\ -6 & 1 & -1 \\ -14 & 1 & 0 \end{vmatrix} = 12;$$

$$\Delta_2 = \begin{vmatrix} 1 & 0 & 5 \\ 2 & 6 & -1 \\ 5 & -14 & 0 \end{vmatrix} = -4; \qquad \Delta_3 = \begin{vmatrix} 1 & -2 & 0 \\ 2 & 1 & 6 \\ 5 & 1 & 14 \end{vmatrix} = -4.$$

According to formulas (4), we have

$$x_1 = \frac{\Delta_1}{\Delta} = \frac{12}{-4} = -3; \quad x_2 = \frac{\Delta_2}{\Delta} = \frac{-4}{-4} = 1; \quad x_3 = \frac{\Delta_3}{\Delta} = \frac{-4}{-4} = 1.$$

Remark. If the main determinant of the system $\Delta = 0$, then it is obvious that Cramer's formulas can’t be used. Therefore, system (1) or (5) cannot have a unique solution. At the same time, from equations (3):

$$\Delta \cdot x_j = \Delta_j \qquad (j = 1, 2, \ldots, n)$$

we have that $\Delta_j \neq 0$ for at least one number j the solution system is not has($0 \cdot x_j = \Delta_j$, a $\Delta_j \neq 0$ which is impossible). If $\Delta_j = 0$ for everyone

j =1, 2,... n, then the system has either many solutions or no solution at all. A system of equations that has a solution (one or many) is called **compatible,** and a system that does not have a solution is called **incompatible.**

Solving and studying systems of linear equations using matFigs

Consider the system (1) of three linear equations with three unknowns (but all conclusions are valid for any n $2 \geq$). Let's make the matrix A from the coefficients with unknowns — the system matrix, the column matrix X from the unknowns, and the column matrix H from the free terms, i.e.

$$A = \begin{pmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{pmatrix}; \quad X = \begin{pmatrix} x_1 \\ x_2 \\ x_{31} \end{pmatrix}; \quad H = \begin{pmatrix} h_1 \\ h_2 \\ h_3 \end{pmatrix}. \quad (6)$$

Taking into account the definition of the product of matFigs and the condition of equality of matFigs, we obtain the equivalent expression of system (1) in matrix form

$$AX=H \qquad (7)$$

Equation (1) is called **a matrix equation.** Let $|A| \neq 0$ Then, as is known, on the one hand, system (1) has a unique solution, on the other hand, the matrix A has an inverse A^{-1}.

Multiply both parts of equality (7) on the left by A^{-1} and get:

$$A^{-1}AX = A^{-1}H\,;\; EX = A^{-1}H\,.$$

Given that $EX=X$, we have the solution *of X in* matrix form:

$$X=A^{-1}N. \qquad (8)$$

To obtain the values of the unknowns x_1, x_2, x_3, we will use the fact that the matFigs on the left and right in (8) are equal.

This method of solving system (1) (or (5)) is called **the matrix method.**

If A is a singular matrix: $A = 0$, then A^{-1} does not exist, and if there is a solution of system (1) (or (5)), then it is not unique.

An example. Solve the system by the matrix method

$$\begin{cases} x_1 - 2x_2 + 5x_3 = 0 \\ 2x_1 + x_2 - x_3 = -6 \\ 5x_1 + x_2 = -14 \end{cases}$$

The solution. Let's write down the matrix of system A and look for A^{-1} using **the MDETERM** and **MINVERSE** Excel functions .

1) $$A = \begin{pmatrix} 1 & -2 & 5 \\ 2 & 1 & -1 \\ 5 & 1 & 0 \end{pmatrix}, \quad |A| = \begin{vmatrix} 1 & -2 & 5 \\ 2 & 1 & -1 \\ 5 & 1 & 0 \end{vmatrix} = -4 \neq 0.$$

The matrix A has an inverse, and the system has a unique solution.

$$A^{-1} = \begin{pmatrix} 1 & 5 & -3 \\ -5 & -25 & 11 \\ -3 & -11 & 5 \end{pmatrix} \cdot (-1/4).$$

Let's write out the matrix-column H of the free members of the system and find X according to formula (8) using **the MMULT function** :

$$H = \begin{pmatrix} 0 \\ -6 \\ -14 \end{pmatrix}; \qquad X = \begin{pmatrix} x_1 \\ x_2 \\ x_3 \end{pmatrix};$$

$$X = A^{-1}H = \begin{pmatrix} 1 & 5 & -3 \\ -5 & -25 & 11 \\ -3 & -11 & 5 \end{pmatrix} \cdot \begin{pmatrix} 0 \\ -6 \\ -14 \end{pmatrix} \cdot (-1/4) = \begin{pmatrix} -3 \\ 1 \\ 1 \end{pmatrix}.$$

Therefore, $x_1 = -3$, $x_2 = 1$, $x_3 = 1$.

Practical work #10

The purpose of the work: To get acquainted with the features of working with array formulas in Excel for solving systems of linear algebraic equations

Execution program

1. Launch MS Office Excel.
2. Using the formulas of **the MMULT**, **MDETERM**, and **MINVERSE arrays** , find the solutions of the SLAE according to Cramer's rule and the matrix method, choosing the option by the number in the group list.
3. Compare the obtained results.
4. Complete each task on a separate sheet in an Excel book. Give the file the following name " version number_performer 's last name".
5. Save in your own folder.

Tasks for practical work

1. $\begin{cases} 2x - y + 3z = 9, \\ x + 3y + 2z = 2, \\ 3x - 3y + z = 8. \end{cases}$

2. $\begin{cases} 2x + y + z = 3, \\ x + 3y - 2z = -6, \\ 3x - 2y + z = 7. \end{cases}$

3. $\begin{cases} 3x + y + 2z = 0, \\ 2x - 2y + z = -2, \\ x - 4y + 3z = -9. \end{cases}$

4. $\begin{cases} 3x - 2y + z = -1, \\ 2x + y + 3z = -3, \\ 4x - 3y + 6z = -11. \end{cases}$

5. $\begin{cases} 2x + 2y + z = 2, \\ 3x - 2y + 3z = 1, \\ x + 3y - 2z = -2. \end{cases}$

6. $\begin{cases} 2x + 2y - z = -2, \\ 3x + y - 3z = -8, \\ x + y + 5z = 10. \end{cases}$

7. $\begin{cases} 2x + 2y + 3z = -6, \\ 2x - 3y - z = -3, \\ 3x + 4y + 2z = -3. \end{cases}$

8. $\begin{cases} 2x - 2y + 3z = -10, \\ 2x + y + 5z = 11, \\ 3x - 4y + 2z = -11. \end{cases}$

9. $\begin{cases} 4x + 2y + z = 7, \\ 2x + 2y - 3z = -1, \\ 3x + 3y - 5z = -2. \end{cases}$

10. $\begin{cases} 4x - 2y - z = 9, \\ 2x - 3y + 2z = 9, \\ 3x - 5y - 3z = 8. \end{cases}$

11. $\begin{cases} 2x + 4y - 5z = 3, \\ 3x + 3y - 2z = 7, \\ 2x - y - 2z = 1. \end{cases}$

12. $\begin{cases} 2x + 5y + 4z = 13, \\ 3x - 2y - 3z = 1, \\ x + y - 2z = 1. \end{cases}$

13. $\begin{cases} 3x - y + 2z = 3, \\ 2x + 3y - z = 8, \\ x - 2y + 3z = -3. \end{cases}$

14. $\begin{cases} 3x + 4y + 6z = 4, \\ 2x + 3y + 5z = 2, \\ x - 2y - 4z = 4. \end{cases}$

15. $\begin{cases} 2x - 4y + 5z = 0, \\ 3x - 2y + 3z = 1, \\ 4x + 5y - 2z = -2. \end{cases}$

16. $\begin{cases} 3x - 3y + 2z = 5, \\ 2x + 4y - 5z = 4, \\ 5x - 2y + 3z = 3. \end{cases}$

17. $\begin{cases} 4x - 3y + 2z = -6, \\ 5x - 2y + 3z = -3, \\ 3x - 5y + 4z = -5. \end{cases}$

18. $\begin{cases} 5x - 6y + 2z = -13, \\ 3x - 8y + 4z = -11, \\ 4x - 5y + 3z = -8. \end{cases}$

19. $\begin{cases} 2x - 3y - 4z = 3, \\ 3x + y + 2z = 7, \\ x + 2y - z = -1. \end{cases}$

20. $\begin{cases} 2x + 3y + 3z = 4, \\ x - 4y + 2z = 8, \\ 3x + 2y - 5z = -1. \end{cases}$

21. $\begin{cases} 3x + 4y + 5z = 0, \\ 2x - 3y + 2z = 10, \\ x + 2y + 4z = 1. \end{cases}$

22. $\begin{cases} 3x - 4y - 3z = 8, \\ 2x + 3y + 2z = -2, \\ 2x - 2y - 4z = 2. \end{cases}$

23. $\begin{cases} 5x - 2y + 3z = 0, \\ 3x - 4y - 5z = 4, \\ 2x - 3y + 4z = -5. \end{cases}$

24. $\begin{cases} 4x - 2y + 5z = -3, \\ 3x + 3y - 2z = 8, \\ 5x - 4y + 3z = -2. \end{cases}$

25. $\begin{cases} 4x + 2y - 2z = 0, \\ 2x + 3y - 4z = -5, \\ 3x - 4y + 5z = 12. \end{cases}$

26. $\begin{cases} 3x - 4y + 4z = 11, \\ 4x + 2y - z = 1, \\ 5x + 2y + 3z = 6. \end{cases}$

27. $\begin{cases} 5x - 2y - z = 6, \\ 6x - 3y - 2z = 5, \\ 4x - 4y + 3z = 10. \end{cases}$

Control questions

1. What is an array in Excel?
2. What types of arrays does Excel support?
3. What are the features of creating array formulas?
4. How to edit an array formula?
5. What actions are not allowed when working with array formulas?
6. How to enter an array formula to display the result in one cell?
7. How to enter an array formula into a range of cells?

1.11. Solving problems of linear programming with minimization of the objective function

Solving any technical and economic problem consists in achieving a certain defined goal with a limited number of means and resources. The optimal solution to the problem is considered to be the one that ensures the achievement of the goal with minimal costs. At the first stage, a mathematical model for solving the problem is formulated. Combinations of various types of model elements form different classes of optimization problems that require their own solution methods. Integral solutions of the problem that satisfy all restrictions and boundary conditions are called *admissible.* An admissible solution that maximizes (minimizes) the objective function is called an *optimal* solution. There can be many, one, or none possible solutions . It depends on the number of variables *n* in the optimization problem, the type and number of constraints *t. A necessary requirement* for the existence of admissible solutions of the optimization problem is the fulfillment of the condition ***n>t.***

The mathematical model of the task of finding the optimal solution consists of the following components:

- *initial data;*
- *variables*
- *dependencies*

Each of these components has its own types.

The initial data can be *deterministic* (when the exact values are known) and *stochastic* (if the values are random values subject to statistical distributions).

Variables can be *continuous* or *discrete.*

Dependencies between variables (objective function, constraints) can be *linear* and *non-linear* . *Linear* are such dependencies that contain variables in the first degree. All other dependencies are called non-linear.

One of the most common problems of this class is *the linear programming problem* , which has deterministic inputs, continuous variables, and linear dependencies.

The linear programming problem is a partial case of the generalized optimization problem and is written by a mathematical model:

$$\begin{cases} Z = \sum_{j=1}^{n} c_j x_j \to \max, (\min, Const) \\ \sum_{j=1}^{n} a_{ij} x_j \le b_i \\ d_j \le x_j \le D_j \\ i = \overline{1,m}, j = \overline{1,n} \end{cases}$$

The given form of recording the task of finding the optimal solution, as a rule, consists of four parts:

- An objective function $Z = \sum_{j=1}^{n} c_j x_j$ that specifies an optimization criterion and can lead to a maximum, minimum, or some constant value (constant).
- Constraints establishing dependence between variables $\left(\sum a_{ij} x_j \le b_j\right)$.
- Boundary conditions that set the limits in which the desired values of the variables in the optimal solution can change . $d_j \le x_j \le D_j$.
- $i = \overline{1,m}$ $j = \overline{1,n}$, where *m* is the number of constraints, *n* is the number of variables.

To solve problems of linear programming, use the tool ***Search for a solution.***

Example. According to the results of a qualitative assessment of the farm's natural pasture lands, in order to preserve and use grass stands, it is recommended to feed the pasture by applying fertilizers in the amount of: nitrogen - 65 kg/ha, phosphorus - 15 kg/ha, potassium - 20 kg/ha. Labor productivity when applying organic fertilizers is 5 t/hour, when applying complex mineral fertilizers is 0.7 t/hour. The time resource for applying fertilizers is 20 hours. The cost and chemical composition of fertilizers are given in Table 1.8. The area of the pasture is 25 hectares.

Table 1.8

Cost and chemical composition of fertilizers

Type of fertilizer	Cost, hryvnias/ton	Chemical composition, kg/t		
		nitrogen	phosphorus	potassium
Organic	70	8	2	5
Complex mineral	1400	250	120	120

It is required to distribute the use of fertilizers in such a way that the cost of applied fertilizers is minimal while meeting all requirements. Solving the problem can be divided into the following stages:

- *Designation of unknown variables* . Let's enter the following designations of unknown variables: X_1 – amount of organic fertilizers, t; X_2 – amount of complex mineral fertilizers, i.e.
- *Definition of the objective function* . Taking into account the cost of organic fertilizers, which is UAH 250/t, and complex mineral fertilizers – UAH 1,400/t, the target function is formulated:

$Z=250X_1 + 1400X_2 \rightarrow \min$,

which means, the total cost of fertilizers intended for use should be minimal.

- *Introduction of restrictions* . Limitations on the values of the variables are determined based on the results of the environmental examination regarding the required amount of fertilizer application: nitrogen – 65 kg/ha, phosphorus – 15 kg/ha, potassium – 20 kg/ha and time resource – 20 hours.

Restrictions on the rate of nitrogen application. 1 ton of organic fertilizers contains 8 kg of nitrogen, and 1 ton of complex mineral fertilizers contains 250 kg. Therefore, the total amount of nitrogen that can be applied to the pasture will be determined by the expression: $8X_1+250X_2$, which should not be less than 65 kg/ha·25ha= 1625 kg.

Therefore, *the restriction on the use of nitrogen* will be as follows: $8X_1+250X_2 \geq 1625$

Restrictions on the rate of phosphorus application.

$2X_1 + 120X_2 \geq 375$

Restrictions on the rate of potassium intake.

$5X_1+120X_2 \geq 500$

Time limit . $\frac{1}{5}X_1 + \frac{1}{0,7}X_2 \leq 20$, or

$0.7X_1 + 5X_2 \leq 70$

Special restrictions. The unknown variables and the objective function cannot be equal to zero or acquire negative values.

$X_1 \geq 0,\ X_2 \geq 0,\ Z \geq 0.$

Solving the problem of linear programming.

Enter the initial data and formulas for calculation, as shown in fig. (a fragment of the MS Excel document is presented in formula checking mode).

The results of the calculation according to the formulas are given in the table.

To find the optimal solution, perform the following actions:

- **Data=>Analysis=>Search for a solution;**

- in the corresponding dialog box that opens, in the ***Set target cell*** field , specify the address of the cell with the formula for determining the target function, in this case B6;
- in the field ***Equal*** , set the check box ***to the Minimum value;***
- in ***the Changing cells*** field , indicate the range of cells containing the values X_1 , X_2 , namely: B3:B4 (place the cursor in the input field, use the mouse to select the desired range of cells);
- to the right of the ***Restrictions*** field , press the ***Add*** button***;***
- in the dialog box ***Adding restrictions,*** enter the link to the cell containing the restriction formula in the left field, select the appropriate sign in the middle field, and enter the address of the cell containing the restriction value in the right field;
- press the ***Add*** button and enter the following restriction;
- after entering the last limit, press the ***OK*** button***;***
- as a result of the performed actions, the following restrictions will be entered in ***the Restrictions*** field : $B$8>=$C$8, $B$9>=$C$9, $B$10>=$C$10, $B$11<=$C$11, $B $12>=$C$12, ***$B$13>=$C$13,*** $B$14>=$C$14;
- press the ***Execute*** button**.**

	A	B	C	D	E	F
1	Вид добрива	Кількість добрив	Вартість, грн/т	Хімічний склад добрив, кг/т		
2				азот	фосфор	калій
3	Органічні добрива X_1	1	70	8	2	5
4	Комплексні мінеральні добрива X_2	1	1400	250	120	120
5						
6	Цільова функція Z	=C3*B3+C4*B4				
7	Обмеження	Ліва частина	Права частина			
8	за нормою внесення азоту	=D3*B3+D4*B4	1625			
9	за нормою внесення фосфору	=E3*B3+E4*B4	375			
10	за нормою внесення калію	=F3*B3+F4*B4	500			
11	за часом	=0,7*B3+5*B4	70			
12	X_1	=B3	0			
13	X_2	=B4	0			
14	Z	=B6	0			

Figure. Preparation of input data for finding a solution

Table 1.9

Results of input data preparation

Type of fertilizer	**Amount of fertilizers, i.e**	**Cost, hryvnias/ton**	**Chemical composition of fertilizers, kg/t**		
			nitrogen	**phosphorus**	**potassium**
Organic fertilizers X_1	1	70	8	2	5
Comp. mineral, fertilizers X_2	1	1400	250	120	120
Objective function Z	1470				
Limitation	**The left part**	**The right part**			
according to the rate of nitrogen application	258	1625			
according to the rate of phosphorus application	122	375			

according to the rate of potassium application	125	500			
by time	5.7	70			
X_1	1	0			
X_2	1	0			
Z	1470	0			

After the calculations and an affirmative answer, Excel will make changes to the initial table that relate to the maximum value of the objective function and cells with the values X_1 - the amount of organic fertilizers, t; X_2 - the amount of complex mineral fertilizers, t. The results of the found solution are shown in the table.

Thus, the minimum costs for applying fertilizers are UAH 9,100, while only mineral fertilizers are applied in the amount of 6.5 tons.

Table. 1.10

Solution search results

Type of fertilizer	***Number fertilizers***	***Cost, hryvnias/ton***	***Chemical composition of fertilizers, kg/t***		
			nitrogen	***phosphorus***	***potassium***
Organic fertilizers X_1	**0**	**70**	**8**	**2**	**5**
Complex mineral fertilizers X_2	**6.5**	**1400**	**250**	**120**	**120**
Objective function *Z*	**9100**				
Limitation:	**Left part**	**rights part**			
according to the contribution rate nitrogen	**1625**	**1625**			

according to the contribution rate phosphorus	**780**	**375**			
according to the rate of potassium application	**780**	**500**			
By time	**32.5**	**70**			
X_1	**0**	**0**			
X_2	**6.5**	**0**			
Z	**9100**	**0**			

Practical work #11

<u>The purpose of the work:</u> to master the methods of using the **Solution search** tool for solving linear programming problems with minimization of the objective function

<u>Execution program</u>

1. Download the Excel spreadsheet.
2. Determine the amount of fertilizers that should be applied under the condition of minimizing costs, if it is recommended to fertilize the pasture by applying fertilizers in the amount (not less than): nitrogen - 75 kg/ha, phosphorus - 25 kg/ha, potassium - 35 kg/ha. Labor productivity when applying organic fertilizers is 4 t/hour, when applying complex mineral fertilizers is 1.5 t/hour. The time resource for applying fertilizers is 25 hours. The cost and chemical composition of fertilizers are given in the table. The area of the pasture is 35 hectares.

Table 1.11

Cost and chemical composition of fertilizers

Type of fertilizer	Cost, hryvnias/ton	Chemical composition, kg/t		
		nitrogen	phosphorus	potassium
Organic fertilizers	350	15	4	9
Complex mineral fertilizers	1300	210	150	130

3. Find optimal solutions to problems after selecting one problem by

number in the group list

1. max $Z = 2x_1 + x_2$
$-x_1 + 2x_2 \le 4$
$3x_1 + 6x_2 \le 12$
$x_1 \ge 0,\ x_2 \le 2$

2 . max $Z = x_1 - 2x_2$
$x_1 + 3x_2 \le 6$
$-2x_1 + x_2 \le 4$
$x_1 \le 0,\ x_2 \le 2$

3 . max $Z = 2x1 - 3x2$
$x_1 + 2x_2 \le 6$
$-2x_1 + 6x_2 \le 6$
$x_1 \ge 0,\ x_2 \ge 1.8$

4 . min $Z = x_1 + 2x_2$
$-x_1 + x_2 \le 4$
$2x_1 + x_2 \ge 6$
$x_1 \ge 0,\ x_2 \ge 2.8$

5 . max $Z = 2x_1 + x_2$
$-x_1 + 3x_2 \le 6$
$2x_1 + 6x_2 \le 12$
$x_1 \ge 0,\ x_2 \ge 1$

6 . min $Z = 3x1 + 4x2$
$-x_1 + 3x_2 \le 6$
$2x_1 + x_2 \ge 8$
$x_1 \ge 0,\ x_2 \le 2.6$

7. min $Z = -x_1 + x_2$
$2x_1 - 3x_2 \le 6$
$-3x_1 + x_2 \le 3$
$x_1 + 4x_2 \le 8$
$x_1 \ge 1,\ x_2 \ge 0$

8 . min $Z = 2x_1 - x_2$
$x_1 - 4x_2 \le 8$
$3x_1 - x_2 \ge 3$
$2x_1 + 3x_2 \le 12$
$x_1 \ge 0,\ x_2 \ge 0$

9. min $Z = 2x1 + 3x2$
$2x_1 + 6x_2 \ge 12$
$-x_1 + 2x_2 \le 4$
$x_1 \le 6,\ x_2 \ge 0$

10 . min $Z = -2x_1 + x_2$
$-x_1 + 3x_2 \le 3$
$3x_1 - x_2 \ge 6$
$2x_1 + 4x_2 \ge 8$
$x_1 \le 3,\ x_2 \ge 0$

11 . max $Z = x_1 + 2x_2$
$3x_1 - x_2 \ge 3$
$3x_1 + 6x_2 \le 12$
$-x_1 + 2x_2 \le 4$
$x_1 \ge 0,\ x_2 \ge 0$

12 . max $Z = 3x_1 + x_2$
$-x_1 + 2x_2 \le 4$
$2x_1 - 3x_2 \le 6$
$6x_1 + 2x_2 \le 12$
$x_1 \ge 1,\ x_2 \ge 0$

13 . max $Z = -x_1 + 3x_2$
$x_1 - 2x_2 \le 4$
$-2x_1 + 6x_2 \le 12$
$2x_1 + x_2 \le 6$
$x_1 \ge 0,\ x_2 \ge 0$

14. max $Z = 2x1 + 3x2$
$4x_1 - 6x_2 \le 12$
$2x_1 + 3x_2 \ge 6$
$x_1 \ge 1,\ x_2 \le 2$

15 . max $Z = 3/2\, x_1 + x_2$

16 . max $Z = 3x_1 + x_2$

$6x_1 + 2x_2 \geq 6$
$2x_1 - 5x_2 \leq 10$
$x_1 + 2x_2 \leq 8$
$x_1 \geq 1,\ x_2 \leq 0$

$x_1 - 2x_2 \leq 4$
$-x_1 + 3x_2 \leq 6$
$x_1 \geq 3,\ x_2 \geq 0$

17 . max $Z = x_1 + 2x_2$
$x_1 + 2x_2 \geq 6$
$-3x_1 + x_2 \leq 3$
$2x_1 - 2x_2 \leq 6$
$x_1 \geq 1,\ x_2 \geq 0$

18 . max $Z = 2x1 + 3x2$
$x_1 - 2x_2 \leq 4$
$-x_1 + 2x_2 \leq 4$
$x_1 + 2x_2 \geq 4$
$x_1 \geq 0,\ x_2 \geq 0$

19 . max $Z = x_1 + 3x_2$
$x_1 + x_2 \geq 2$
$-2x_1 + 3x_2 \leq 6$
$3x_1 - 2x_2 \leq 6$
$x_1 \geq 0,\ x_2 \geq 0$

20 . max $Z = x_1 + x_2$
$2x_1 - 4x_2 \leq 8$
$-2x_1 + 3x_2 \leq 6$
$2x_1 + 4x_2 \geq 8$
$x_1 \geq 0,\ x_2 \geq 0$

21 . max $Z = -x_1 + 2x_2$
$-x_1 + 2x_2 \geq 4$
$2x_1 + 3x_2 \leq 6$
$2x_1 - 3x_2 \geq 6$
$x_1 + x_2 \geq 6$
$x_1 \geq 0,\ x_2 \geq 0$

22. max $Z = 2x_1 - x_2$
$3x_1 + 2x_2 \leq 6$
$4x_1 + x_2 \leq 4$
$3x_1 - 2x_2 \geq 6$
$x_1 \geq 0,\ x_2 \geq 4$

23 . max $Z = -x_1 + 3x_2$
$-3x_1 + 3x_2 \leq 9$
$x_1 + x_2 \leq 4$
$2x_1 - x_2 \geq 4$
$x_1 + x_2 \geq 6$
$x_1 \geq 0,\ x_2 \geq 0$

24 . max $Z = 2x_1 - x_2$
$3x_1 + 3x_2 \leq 9$
$x_1 - x_2 \geq 3$
$-x_1 + x_2 \geq 3$
$x_1 \geq 4,\ x_2 \geq 0$

25. max $Z = -x_1 + 3x_2$
$-2x_1 + 3x_2 \leq 6$
$x_1 - x_2 \geq 3$
$x_1 \geq 0$
$x_2 \geq 2$

26 . max $Z = x_1 + x_2$
$3x_1 - 6x_2 \leq 12$
$-x_1 + x_2 \leq 4$
$x_1 + x_2 \geq 4$
$x_1 \geq 0,\ x_2 \geq 0$

Self-test questions

1. What are the components of the task of finding the optimal solution?
2. What can be the input data of the task of finding a solution?
3. What can the variables be?

4. What can be the dependencies between variables?
5. What tasks are solved using the **Solution search** tool?
6. How to call the **Solution search** tooland what data is entered in the fields of the dialog box of the same name?
7. How is the optimal solution of the problem called?
8. How is an admissible solution to the problem called?
9. What are the conditions for the existence of an admissible solution to the problem?
10. What is related to linear programming problems?
11. How to formulate the objective function and the system of constraints?
12. What is the sequence of solving linear programming problems using the **Solution search** tool?
13. How can you accept the proposed solution and how can you refuse it?
14. Why is it recommended before using **Solution search** tool to make a copy of the working document?

1.12. Solving systems of non-linear equations using the tool " Search solutions "

MS Excel **Solution Search** is a powerful auxiliary tool for performing complex calculations. It allows you to find a set of variable values that meet certain criteria based on a given value of the result.

Search solutions allows finding solutions of systems of nonlinear equations. For example, it is necessary to solve the following system of nonlinear equations:

$$\begin{cases} x^2 + y^2 = 3 \\ 2x + 3y = 1 \end{cases}$$

It is known that a pair of values (x , y) is a solution of a system of equations if and only if it is a solution of the following equation with two unknowns:

$$\left(x^2 + y^2 - 3\right)^2 + \left(2x + 3y - 1\right)^2 = 0$$

With the help of the **Solution search** tool , instead of a system of equations, an equivalent equation is solved. Geometrically, the solution of this system of equations is the point of intersection of a straight line with a circle whose radius is $\sqrt{3} = 1{,}73205.$. Therefore, this equation has no more than two solutions. Determined by the **Solution search** tool, solution to a nonlinear problem depends on the initial approximation, therefore, its successful selection is essential For this purpose:

- localize the roots of the equation by calculating the right-hand side of the equation by the variables *x and y* on the interval [-1.7;+1.7] with a step of 0.3 (this interval was taken because the roots of the equation will be inside a circle whose radius is approximately 1.73205);

▪ to calculate the values of the equation in the range of cells A2:A13 enter the value of the variable *x* in the range from -1.7 to +1.7 with a step of 0.3;

▪ in the range of cells B 1 : M 1, enter the corresponding values of the variable *y* at the same interval and with the same step;

▪ enter the formula in cell B2:

=($A2 ^2+B$1^2-3)_^2+(2*$A2+3*B$1-1)^2;

▪ spread the formula over the range of cells B2:M 13;

▪ analyze the obtained tabular values and set the *x and y values* at which the function will approach 0 as closely as possible, in this case it will take the values 0.08 and 0.4325;

▪ *x* and *y (1.6; -0.8) and (-1.4; 1.3)* are taken as the initial approximation, respectively , which correspond to the obtained minimum values of the function.

To use the **solution search tool** , the following preparation is carried out:

▪ in the selected cell, for example A16, enter the first value of *x,* which is equal to 1.6;

▪ in cell B16, enter the first value *of y,* which corresponds to the first value of *x* and is equal to -0.8;

▪ enter the formula in cell SI6:

=(A16^2+B16^2-3)^2+(2*A16+3*B16-1)^2;

▪ *x* = -1.4 in cell A17 ;

▪ *y* =1.3 in cell B17 ;

▪ enter the formula in cell C17:

=(A17^2+B17^2-3)^2+(2*A17+3*B17-1)^2;

▪ perform the following actions: **Data=>Analysis => Search for a solution** and fill in the fields of the dialog box that will open;

▪ enter the address of cell SI6 in the **Set target cell** field**;**

▪ select the **Equal** to Value item in the group and set 0 in the corresponding field;

▪ enter the range of cells $A$16:$B$16 in the **Changing cells** field**;**

▪ press the **Execute** button ;

▪ in the request window that opens, you need to make sure that the **Save found solution** item is selected and click **the OK** button .

▪ *x* = 1.57634, *y* = -0.7173 will be found ;

▪ perform similar actions to find another solution to the equation, for which: x=- 1.269 and y=1.179.

Practical work #1 2

The purpose of the work: to master the methods of solving systems of nonlinear equations using the " **Search for a solution** " tool

Execution program

1. Download Excel spreadsheet.
2. Solve systems of nonlinear equations:

$$1)\begin{cases}2x^2+5y^2=3\\5x+9y=3\end{cases},\qquad 2)\begin{cases}7x^2+6y^2=3\\5x+3y=2\end{cases},$$

$$3)\begin{cases}5x^2+6y^2=3\\7x+3y=1\end{cases},\qquad 4)\begin{cases}3x^2+2y^2=2\\2x+7y=2\end{cases},$$

$$5)\begin{cases}5x^2+y^2=3\\3x+5y=3\end{cases}.$$

Self-test questions

1. What is the procedure for solving a system of nonlinear equations using **Solution Search** ?
2. Why is it necessary to localize the roots of the equation?
3. How are the roots of the equation localized?
4. What is the order of entering the two arguments to the tab function?
5. Which use references to cell addresses when tabulating a function from two arguments?
6. How to tabulate a function from two arguments?
7. What type of graph is used to display the graphical dependence of a function on two arguments?
8. What values of the arguments are chosen as approximate values?

1.13. Solving linear programming problems with objective function maximization

The MS Excel ***solution search*** tool also allows solving linear programming problems in which it is required to find a parameter of the problem that provides the maximum value of the objective function subject to certain restrictions.

Example. Determine the structure of crops of winter wheat, millet and buckwheat, so that the profit from the sale of products is maximum under the following conditions:

- the total area of crops does not exceed 1150 hectares;
- reserves of mineral fertilizers amount to 1,250 tons;
- labor resources - 65,000 man-hours;
- the area of millet crops should not be less than 270 hectares.

Norms of labor costs and the amount of profit based on 1 ha of crops are given in Table 1.12.

Table 1.12

Norms of labor costs and the amount of profit

	A	B	C	D	E
1	Indicators	Unit measurement	Accounts for 1 hectare		
2			winter wheat	millet	buckwheat
3	Labor costs	man-hours	72	65	53
4	Consumption of fertilizers	c	1.7	1.6	1.1
5	Profit	Faculty of Arts	165	85	285

To solve the problem, make its mathematical model. For this purpose:

- enter the following designations:
- X_1 - area of winter wheat crops, ha;
- X_2 - the area of millet crops, ha;
- X_3 - area of buckwheat crops, ha;
- make up the target function: $Z = 165X_1 + 85X_2 + 285X_3 \rightarrow \max$;
- constitute a system of restrictions:
- the sum of the sown areas of individual crops should not exceed the total sown area: $X_1 + X_2 + X_3 \leq 1150$;'
- restrictions on labor resources: $72X_1 + 65X_2 + 53X_3 \leq 565000$;
- restrictions on mineral fertilizers: $1.7X_1 + 1.6X_2 + 1.1X_3 \leq 1250$;
- restrictions on the area of millet sowing: $X_2 \geq 270$;
- crop areas cannot be less than zero: $X_1 > 0$, $X_2 > 0$, $X_3 > 0$;
- the objective function cannot be less than zero: $Z > o$.

Fill in the table with additional data:

- enter into the cells, for example, in C 6 , D6, E 6 , designations of variables (areas of individual crops): X_1, X_2, X_3;
- in cells C7, *D7,* E7 enter arbitrary values of variables, for example 1 , which will change as a result of finding the optimal solution;

▪ in cell B9, enter the formula for determining the objective function, using references to the corresponding cells with variables;

▪ in cells B11, B12...B19 enter formulas for calculating the left parts of the restrictions, using references to the corresponding cells;

▪ enter the right part of the restrictions in cells C11, C12...C19;

▪ this completes the data preparation for finding the optimal solution.

The results of entering data into the table for finding the optimal solution in the formula display mode are shown in the table.

To find the optimal solution, perform the following actions:

▪ **Data=>Analysis => Solution search** ;

▪ in the corresponding dialog box that opens, in the **Set target cell** field , specify the address of the cell with the formula for determining the target function, in this case B9;

▪ in the field **Equal,** set the flag to **the Maximum value** ;

▪ in the **Changing cells** field , indicate the range of cells containing the values X_1, X_2, Xz, namely: C7:E7 (place the cursor in the input field, use the mouse to select the desired range of cells);

▪ to the right of the ***Restrictions*** field , press the ***Add*** button***;***

▪ in the dialog box ***Adding restrictions,*** enter the link to the cell containing the restriction formula in the left field, select the appropriate sign in the middle field, and enter the address of the cell containing the restriction value in the right field;

Table 1.13

Data preparation for finding the optimal solution

	A	B	**C**	D	E
1	Indicators	Unit of measurement	Accounts for 1 hectare		
2			winter wheat	millet	buckwheat
3	Labor costs	man-hours	72	65	53
4	Consumption of fertilizers	c	1.7	1.6	1.1
5	Profit	conditional units	165	85	285
6			XI	X2	Khz
7			1	1	1
9	Objective function	**=C5*C7+D5*D7+E5*E7**			
10	Restriction system:				
11	by the total area sown of individual cultures	**=C7+D7+E7**	1150		

12	on labor resources	**=C3*C7+D3*D7+E3*E7**	65000		
13	on mineral fertilizers	**=C4*C7+D4*D7+E4*E7**	1250		
14	by the area of millet sowing	**=D7**	270		
15	crop area values are positive				
16	XI	**=C7**	0		
17	X2	**=D7**	0		
18	X3	**=E7**	0		
19	the objective function has a positive value	=B9	0		

- press the **Add** button and enter the following restriction;
- after entering the last limit, press the **OK** button ;
- as a result of the performed actions, the following restrictions will be entered in **the Restrictions** field : $B$11<=$C$11, $B$12<=$C$12, $B$13<=$C$13, $B$14<=$C$14, $B $16>=$C$16, $B$17>=$C$17, $B$18>=$C$18, $B$19>$C$19;
- press the **Execute** button .

After the calculations and an affirmative answer, Excel will make changes to the initial table that relate to the maximum value of the objective function and cells with the values X_1 - the area of winter wheat sowing; X_2 - millet sowing area; X_3 - buckwheat sowing area.

Table 1.14

The results of the search for the optimal solution

Indicators	Unit measurement	Accounts for 1 ha of crops		
		winter wheat	millet	buckwheat
Labor costs	man-hours	72	65	53
Consumption of fertilizers	c	1.7	1.6	1.1
Profit	conditional units	165	85	285
		XI	X2	X3
		0	270	743.63
Objective function	234886.36			
Restriction system:				
by the total area of crops of individual cultures	1013.64	1150		
on labor resources	56962.73	65000		
on mineral fertilizers	1250.00	1250		
by the area of millet sowing	270.00	270		
crop area values are positive				
XI	0.00	0		
X2	270.00	0		
X3	743.64	0		
objective function value is positive	234886.36	0		

The found solution is shown in the previous table.

According to the obtained data, in order to achieve the maximum profit, which will amount to 234886.36 units, under these restrictions, the farm should sow buckwheat in the amount of 743.63 hectares and millet in the amount of 270 hectares.

Practical work #13

The purpose of the work: to master the methods of using the tool ***Search for a solution*** for solving problems of linear programming with the maximization of the objective function

Execution program

1. Download Excel spreadsheet.
2. Determine the structure of crops of spring wheat, corn and sugar beets, so that the profit from the sale of products is maximum under the following conditions:
   - the total area of crops does not exceed 1000 hectares;
   - stocks of mineral fertilizers - 1200 tons;
   - labor resources - 70,000 people. hours;
   - the sugar beet area is no more than 200 hectares.
   - The norms of labor costs and the amount of profit per 1 ha of crops are given in the table:

Table 1.15

Norms of labor costs and the amount of profit

Indicators	Unit measurement	Accounts for 1 ha of crops		
		Spring wheat	corn	Sugar beets
Labor costs	man-hours	70	60	56
Consumption of fertilizers	C	1.6	1.5	1.0
Profit	Conditional units	161	75	275

Self-test questions

1. What are the problems of linear programming with the maximization of the objective function?
2. What are the differences in filling in the fields of the **Find a solution** dialog box for finding the maximum value of the objective function compared to finding the minimum?
3. How to formulate the objective function and the limit system in this case?
4. In which cases is it usually required to find the maximum of the objective function, and in which cases - the minimum?
5. What are the consequences of the incorrect formulation of the

system of restrictions?

6. In what cases do they refuse to accept the found decision?

7. How to make changes or additional restrictions in the system of restrictions already formulated and entered in the corresponding field of the **Search for a solution** dialog box ?

1.14. Forecasting methods in the Excel spreadsheet

Sometimes we need to know in advance "what will happen". It helps to make the right decision. This is the case in science prediction is called forecasting. The basis of forecasting is observational data, experimental data.

Frequency analysis

When processing statistical data in horticulture, demography, marketing, when analyzing the chemical-technological evaluation of fruits of economic indicators, the question arises: "How often among the results that are observed or investigated, there are values that belong to a certain range?". The answer to this question determines the correct behavior in the future. For example, when determining the concentration of nitrogen dioxide in the atmospheric air of different parts of the city, several data were obtained. If there are different permissible concentration limits (0.04 mg/dm ^{3}, 0.05 mg/dm ^{3}, 0.06 mg/dm ^{3}, 0.085 mg/dm ^{3}), it is necessary to determine the number of districts whose indicators fall within the specific limit.

Fill out the spreadsheet as indicated below.

Concentration of nitrogen dioxide (mg/dm ^{3})				Concentration limits (mg/dm ^{3}	Number of districts
0.065	0.088	0.065	0.055	8.00	
0.05	0.09	0.04	0.02	10.60	
0.065	0.065	0.092	0.07	11.50	
0.055	0.015	0.075	0.035	15.40	
0.03	0.025	0.075	0.085		

Then you need to do the following actions:

- highlight the cells in the **Number of districts** column (there are one more of them than cells with concentration boundaries);
- we use the **FREQUENCY** statistical function **,** where the first argument are cells with a defined concentration by district, the second argument is cells with specified concentration limits;
- finish work with the function by pressing **Ctrl** + **Shift** + **Enter** .

The result of the analysis will be displayed in the column **Number of districts** :

Concentration of nitrogen dioxide (mg/dm ^{3})				Concentration limits (mg/dm ^{3})	Number of districts
0.065	0.088	0.065	0.055	0.04	6
0.05	0.09	0.04	0.02	0.05	1
0.065	0.065	0.092	0.07	0.06	2
0.055	0.015	0.075	0.035	0.085	8
0.03	0.025	0.075	0.085		3

It shows that in three districts the concentration of the harmful substance reaches above the maximum permissible (0.085 mg/dm ^{3}), in eight districts the concentration is 0.06-0.085 mg/dm ^{3}. That is, after performing such an analysis, it is possible to predict the deterioration of the atmospheric air indicators of the entire city.

Approximation

Approximation is one of the forecasting methods that allows you to describe the observed results with an analytical function, that is, it uses an equation that describes the experimental points. First, it is necessary to build a graphical dependence between the experimental data (the type of graphical dependence is *" Point "*), and then find an equation (mathematical model).

An example of assumptions about the relationship between features can be equations:

$y = a + b \cdot x$ – linear dependence;

$y = a + b_1 \cdot x + b_2 \cdot x^2 + b_3 \cdot x^3 + \ldots + b_6 \cdot x^6$ – polynomial dependence;

$y = a + b \cdot \ln x$ – logarithmic dependence;

$y = a \cdot x^b$ – power dependence;

$y = a \cdot e^{b \cdot x}$ – exponential dependence.

The form of the corresponding equation is chosen by conducting an analysis of the placement of experimental data.

Finding the parameters of the equation

To find the parameters of the equation (mathematical model) that would describe this dependence, it is necessary:

- select the constructed graph (click once with the left mouse button on one of the points of the graph);
- call the context menu of the object;
- in the menu that appears, select the item **"Add a trend line "** ;
- in the dialog box, on **the "Type"** tab , select one of the proposed lines of functional dependencies , by which the approximation of the experimental points is planned;

- in the **"Parameters"** tab , check the item **" show equation on the diagram "** ;
- press the **" Ok "** button ;
- an approximating line with the equation by which it is constructed will appear on the graph.
- select the item "**Trend line format "** ;
- in the dialog box that appears, in the **"Type"** tab , select another functional dependency;
- in the **"Parameters"** tab , check the item **" put the approximations reliability value on the diagram "** ;
- press the **" Ok "** button .

Substitution table

A substitution table is an Excel tool that shows how changing specified values in formulas affects the results of those formulas. These tables allow you to quickly calculate several versions within the framework of one operation, as well as to view and compare the results of different options on one sheet. That is, substitution tables are one of the methods of forecasting, as calculations of the "what-if" type are carried out. Substitution tables work only with one or two values (variables) at the same time.

Create a lookup table with one variable

A lookup table with one change is formed so that the values that are entered are located either in a column (oriented on different columns) or in a row (oriented on different rows). Formulas used in a lookup table must refer to a cell for input. An input cell is a cell where values from the substitution table are substituted. Any cell on the worksheet can be an input cell. To create a table, perform the following actions:

1. In a separate column or in a separate line, enter the list of values that need to be inserted into the input cell.
2. If the values are located in a column, then enter the formula in the cell that is one line above and one cell to the right of the first value. To the right of the first formula, we enter any other formulas.
3. If the values are located in a row, then enter the formula in the cell that is located one column to the left and one row below the first value. In the same column, but below, enter any other formulas.
4. Select a range of cells with formulas and substitution values.
5. In the main menu, select the command **Data => Analysis " what if "=> Table data** .
6. If the substitution table is column-oriented, then enter a link to the input cell in the " **Substitute values by columns in"** . If the

substitution table is oriented by rows, then enter a link to the input cell in the " **Substitute values by rows in"** .

Create a substitution table with two variables

A two-variable lookup table uses one formula with two sets of values. The formula must reference two different input cells. To create a table, perform the following actions:

1. In a sheet cell, enter a formula that has a link to two data entry cells.
2. In the same column below the formula, enter the substitution value for the first variable. Substitution values for the second variable are entered in the row to the right of the formula.
3. Select the range of cells with the formula and both sets of substitution data.
4. Execute the main menu command **Data => Analysis " what if "=> Table data** .
5. In the " **Substitute values by columns in"** field enter a link to the input cell for the substitution values that are in the row to the right of the formula.
6. In the " **Substitute values by lines in"** field enter a reference to the input cell for the substitution values that are in the column below the formula.

Practical work #14

The purpose of the work: to develop forecasting methods using substitution tables, trend lines, and frequency analysis.

Work execution program

1. Launch the Excel spreadsheet.
2. Apply frequency analysis when the effectiveness of the insecticide is determined on the example given in the task (Fig. 1).
3. On sheet *Sheet2,* create the table given in the task about the effect of temperature on damage to strawberry leaves by Phytophthora cactorum (Fig. 2).
4. Build a graphic relationship between temperature and the degree of damage to the leaves (Fig. 2, " dot schedule ").
5. Approximate the experimental data with a function (see task, Fig. 2).
6. Determine the equation of the indicated dependence and the accuracy of the approximation.
7. Create table 1 from the assignment for laboratory work on *the Substitution Table sheet, where the concentration of the substance is calculated according to the specified formula.*

8. With the help of a substitution table, analyze (forecast) the influence of waste water consumption on the concentration of the substance in the control body of the river (table 2 from the assignment for laboratory work).
9. Analyze (forecast) the impact of changes in two values (wastewater consumption, concentration of a substance in wastewater) on the concentration of a substance in the control body of the river (table 3 from the laboratory task).
10. Save the created document in your own folder.

Tasks for practical work

Table 1. Calculation of the concentration of the substance sodium monochloroacetate in the control body of the river (PDA = 0.05 mg/dm3)

Substance concentration in wastewater, mg/dm³ (Cst)	0.03
Substance concentration in the background of the river, mg/dm³ (Cf)	0.01
Annual water consumption, m³/sec (Q)	0.1
Waste water consumption, m³/sec (q)	0.2
Substance concentration, mg/dm³ (Cf*Q+Cst*q)/(Q+q)	0.0233333

Table 2. Calculation of the influence of waste water consumption on the concentration of sodium monochloroacetate in the control body of the river (substitution table one variable)

Waste water consumption, m³/sec	Substance concentration, mg/dm³
	0.023
0.005	0.011
0.050	0.017
0.095	0.020
0.140	0.022
0.185	0.023
0.230	0.024

a cell with a formula

Table 3. Study of the effect of wastewater consumption and the concentration of a substance in wastewater on the concentration of a substance in the control body of the river (substitution table of two variables)

	Formula	Substance concentration in wastewater					
	0.023	0.010	0.015	0.020	0.025	0.030	0.035
waste water consumption	0.005	0.010	0.010	0.010	0.011	0.011	0.011
	0.050	0.010	0.012	0.013	0.015	0.017	0.018
	0.095	0.010	0.012	0.015	0.017	0.020	0.022
	0.140	0.010	0.013	0.016	0.019	0.022	0.025
	0.185	0.010	0.013	0.016	0.020	0.023	0.026
	0.230	0.010	0.013	0.017	0.020	0.024	0.027

Effectiveness of the action of the insecticide (zolon , k.e.) against the first generation of the eyed weevil, %						Efficiency limits, %	Number of experiments
71.6	71.9	89.5	89.4	76.8	79.8	75	2
99.9	97.6	95.9	99.1	97.8	98.1	85	4
99.8	98.4	99.6	94.8	99.8	98.5	90	8
99.1	99.2	95.9	97.4	98.6	98.0	96	13
93.4	89.3	92.8	91.2	92.9	91.9		15
86.2	91.3	92.7	86	93.4	89.9		
93.9	94.7	79.5	88.1	75.8	86.4		

Fig. 1. Frequency analysis

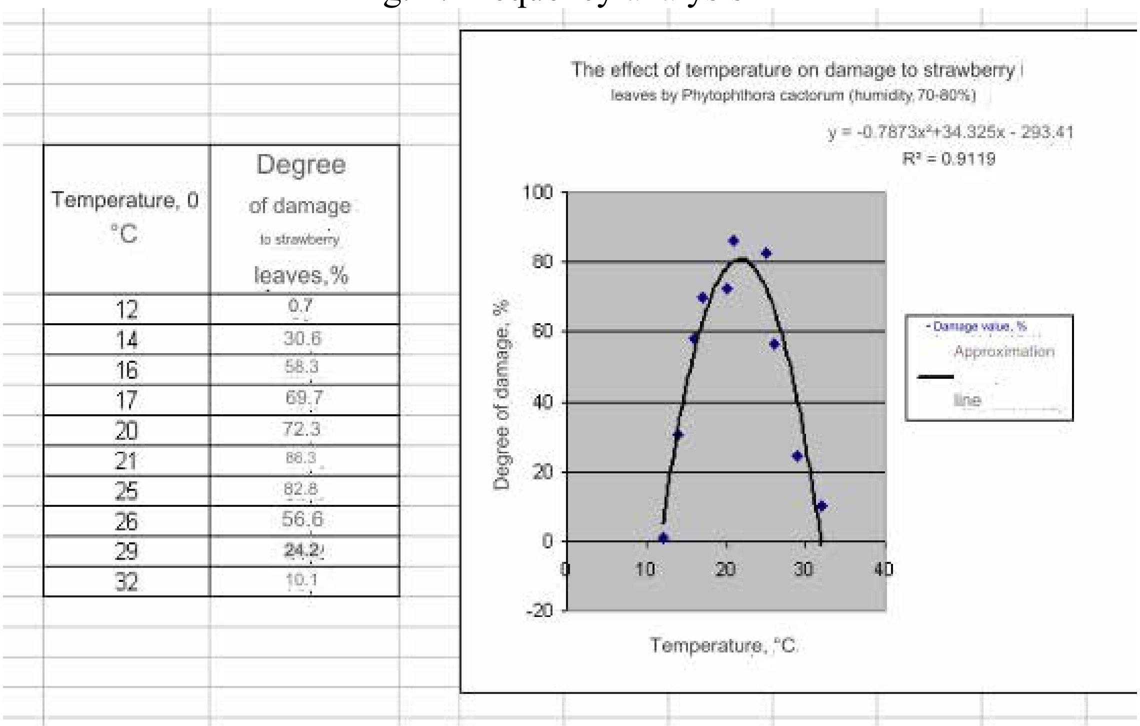

Temperature, 0 °C	Degree of damage to strawberry leaves,%
12	0.7
14	30.6
16	58.3
17	69.7
20	72.3
21	86.3
25	82.8
26	56.6
29	24.2
32	10.1

Fig. 2. Effect of temperature on damage to strawberry leaves by Phytophthora cactorum

<u>Self-test questions</u>

1. What is the sequence of finding the equation of the approximating line?
2. How to bring the equation of the approximating line to the working field?
3. How to change the type of approximating line?
4. What is the purpose of the **FREQUENCY function** ?
5. What is the purpose of substitution tables?

6. What can substitution tables consist of?
7. How to create a table with one variable?
8. How to conduct a bivariate analysis?

1.15. Use of built-in functions when conducting calculations

Application of built-in functions

Functions are predefined formulas that perform calculations on given values (arguments) in the specified order. Each function consists of an equal sign (=), a name, and an argument(s) whose value(s) is used in the calculation. The argument list can consist of numbers, text, logical values, a range of cells, and formulas, which in turn can contain built-in functions.

When using the built-in functions, **the Functions Wizard** is used, which are called using the ***f** x icon* or a sequence of actions:

- **Insert ⇒Function** ;
- in the **Functions Wizard** window in the **Category** field , select the function category, in the **Select function** field - the function itself;
- in the dialog box that opens, set the arguments of the function (arguments are entered from the keyboard or using the mouse, selecting the desired range of cells with the given stroke).

MS Excel contains the following categories of functions: **Financial** , **Date and time** , **Mathematical** , **Statistical** , **References and arrays** , **Working with the database Data** , **Text** , **Logical** and others.

Functions of the " Statistical " category

The Statistical category includes functions for determining the main statistical indicators of a sample population of data and others. The following functions are the most used among them:

AVERAGE(number1; number2;...) – determination of average values of sample totalities (function arguments are ranges of cells with elements of sample totalities);

STDEVP(number1, number2...) – determination of mean squared deviations of sample totalities;

CONFIDENCE(alpha; standard deviation; size) – determination of the absolute confidence error of the mean value. The arguments of the function are the reliability level α, the mean square deviation, and the number of sample values. For applied studies $\alpha = 0.05$, which corresponds to the confidence probability P_D =95%.

An example of using statistical functions (in formula display mode). Each type of function is entered once and is spread over a range of cells in which similar calculations are performed.

Вибіркове середнє значення	Вибіркове середнє квадратичне відхилення	Абсолютна довірча похибка
=СРЗНАЧ(C4:G4)	=СТАНДОТКЛОНП(C4:G4)	=ДОВЕРИТ(0,05;I4;5)
=СРЗНАЧ(C5:G5)	=СТАНДОТКЛОНП(C5:G5)	=ДОВЕРИТ(0,05;I5;5)

(Sample average value - вибіркове середнє значення, sample average square deviation - вибіркове середнє квадратичне відхилення, absolute confidence error - абсолютна довірча похибка, AVERAGE - СРЗНАЧ, STDEVP - СТАНДОТКЛОНП, CONFIDENCE - ДОВЕРИТ)

Functions of the " Text " category

To **the Text category** includes about 24 text functions. Among them are the following text functions:

LEFT(text; number_of_characters) – outputs the specified number of characters from the beginning of the line;

CONCATENATE (text1; text2; ...) - combines several text lines into one. The "&" symbol, which is equivalent to the **CONCATENATE** function, is also used to combine text data . In order to make a gap between the last name and the first name, use the following sequence of characters: "gap" (quotes, gap, quotes). In order to put a period between the elements that are being combined, it is also entered between two quotation marks: "." .

Application examples

	A	B	C	D	E	F	G	H	I	J	K	L
1	**Повторні вимірювання**					**Вибіркове середнє значення**	**Вибіркове середнє квадратичне відхилення**	**Абсолютна довірча похибка**	**Межі довірчого інтервалу для середнього значення генеральної сукупності**	**Межі довірчого інтервалу для середнього значення генеральної сукупності**		
2	1,2	1,13	1,23	1,23	1,19	1,20	0,04	0,036	1,196-0,03≤Xср≤1,196+0,03	1,2±0,03	≤	±
3	108	110	108	108	126	112,00	7,87	6,902	112-6,90≤Xср≤112+6,90	112±6,90		

A	B	C	D	E	F	G	H	I	J	K	L
Repeat measurements					Sampling average value	Sample mean square deviation	Absolute mistrust	Limits of the confidence interval for the mean value of the general population	Limits of the confidence interval for the mean value of the general population		
1,2	1.13	1.23	1.23	1.19	1.20	0.04	0.036	1.196-0.03 Xcp 1.196+0.03	[illegible]	≤	±
108	110	108	108	126	112.00	7.87	6,902	112-6.90 Xcp≤112+6.90	112±6.90		

I	J	K	L
Межі довірчого інтервалу для середнього значення генеральної сукупності	Межі довірчого інтервалу для середнього значення генеральної сукупності		
=F2&"-"&ЛЕВСИМВ(H2;4)&$K$2&"Xcp"&$K$2&F2&"+"&ЛЕВСИМВ(H2;4)	=ОКРУГЛ(F2;2)&$L$2&ЛЕВСИМВ(H2;4)	≤	±
=F3&"-"&ЛЕВСИМВ(H3;4)&$K$2&"Xcp"&$K$2&F3&"+"&ЛЕВСИМВ(H3;4)	=ОКРУГЛ(F3;2)&$L$2&ЛЕВСИМВ(H3;4)		

I	J	K	L
Limits of the confidence interval for the mean value of the general population	Limits of the confidence interval for the mean value of the general population		
=F2&"-"&LEFT(H2;4)&$K$2&"Xcp"&$K$2&F2&"+"&LEFT(H2;4)	=CIRCLE(F2;2)&$$2&LEFT (H2;4)	≤	±
F3&"-"&LEFT(H3;4)&$K$2&"Xcp"&$K$2&F3&"+"&LEFT(H3;4)	=CIRCLE (F3;2)&$$2&LEFT (H3;4)		

Functions of the " Logical " category

Logical functions are used to carry out calculations, the course of which depends on the fulfillment (or non-fulfillment) of a certain condition.

Basic logical functions:

IF(log_output ; value_if_true ; value_if_false) – gives one value if the logical condition is asserted, and another if it is not asserted. The arguments of the **IF** function can be numbers, text fragments, and zeros. The **IF** function supports up to 64 levels of nesting.

AND (logical_value1; logical_value_2;…) – outputs the value **TRUE** if all arguments have the value **TRUE** .

Logical functions also include the following functions:

- **COUNTIF(range ; criterion)** – counts the number of non-empty cells from the specified range, the value of which corresponds to the criterion;
- **SUMIF (range ; criterion ; range summation)** – calculates thSe sum of the values in the cells of the range that meet the conditions.

`=ЕСЛИ(P10<=$J$3;$H$3;ЕСЛИ(P10<=$J$4;$H$4;ЕСЛИ(P10<=$J$5;$H$5;$H$6)))`

	O	P	Q	R	S	T
9	№ поля	Вміст рухомого калію, мг/100 г грунту	Тип екологічної ситуації за вмістом калію			
10	1 .	3,8	Кризова			
11	2 .	4,6	Передкризова			

`=IF (P10<=$J$3;$H$3;IF (P10<=$J$4;$H$4;IF (P10<=$J$5;$H$5;$H$6)))`

	O	P	Q	R	S	T
9	field no	The content of mobile potassium, mg/100 g of soil	Type of ecological situation according to potassium content			
10	1 .	3.8	Crisis			
11	2 .	4.6	Pre-crisis and			

Practical work #15

The purpose of the work : to get acquainted with various types of built-in functions of the spreadsheet processor and the features of their application.

Execution program

1. Launch the Excel spreadsheet.

2. Create a table. 1.15 from the task, calculate the mean, variance, standard deviation, absolute error of the mean using the appropriate built-in functions,
3. Derive thSe bounds of the confidence interval for the mean using the built-in **CONCATENATE** function (see application examples).
4. Create a table. 1.16 from the task.
5. Create a table. 1.17 from the task in which the "Type of environmental situation" is determined using **the IF() logical function** , using references to cell addresses with data in table 2 (see application example)

Tasks for practical work

Table 1.16
The type of ecological situation depending on the potassium content

	H	I	J
1	Типи екологічної ситуації за вмістом калію	Вміст рухомого калію, мг/100 г грунту	
2		мінімальне значення	максимальне значення
3	Кризова	0,0	4,0
4	Передкризова	4,1	8,0
5	Задовільна	8,1	12,0
6	Благополучна	12,0	
7			

	H	I	J
1	Types of ecological situation according to potassium content	The content of mobile potassium, mg/100 g of soil	
2		minimum value	maximum value
3	Crisis	0.0	4.0
4	Pre-crisis	4.1	8.0
5	Satisfactory	8.1	12.0
6	Auspicious	12.0	
7			

Table 1.17

Assessment of the ecological situation of field lands

field no	The content of mobile potassium, mg/100 g of soil	Type of ecological situation according to potassium content
1.	3.8	Crisis
2.	4.6	Pre-crisis
3.	9.5	Satisfactory
4.	2.5	Crisis
5.	13	Auspicious
6.	8,9	Satisfactory
7.	5,6	Pre-crisis

Table 1.15

Data for determining statistical indicators

SOIL INDICATORS										
Item no .	**The name of the indicator**	**Repeat measurements**					**Sampling average value**	**Sample mean squared deviation**	**Absolute mistrust**	**Limits of the confidence interval for the mean value of the general totality**
		1	**2**	**3**	**4**	**5**				
1	**Soil density , g/ ^{cm3}**	1,2	1.13	1.23	1.23	1.19				
2	**MPRPM in 0-100 cm, mm**	108	110	108	108	126				
3	**Hydrolytic acidity, mg- eq /100 g**	2.34	2.11	2.21	2.86	1.88				
4	**Acid exchange , pH saline**	5.68	6.01	5.98	5.56	6.25				
5	**Acidity relevant, pH is water**	6.21	6.53	6.52	60.7	6.95				
6	**The sum of absorbed bases, mg- eq /100 g of soil**	26.6	27.8	29.1	25.9	30.84				
7	**Humus content, %**	3.36	3.38	3.14	2.93	3.49				
8	**Content of easily hydrolyzed nitrogen, mg/kg**	83.3	87.6	81.3	54	106.7				
9	**The content of mobile phosphorus, mg/kg**	100	62.5	67.5	47.5	47.5				
10	**Content of exchangeable potassium, mg/kg**	150	112.5	125	75	75				
11	**Boron content, mg/kg**	0.67	0.81	0.63	0.51	0.61				
12	**Manganese content, mg/kg**	17.8	17.1	17.8	16.8	15.1				
13	**Cobalt content, mg/kg**	1.29	1.21	1.21	1.19	0.87				
14	**Copper content, mg/kg**	5.2	5.4	4.5	4.9	4.6				
15	**Zinc content, mg/kg**	3	3.8	4.6	4.6	3.9				

Self-test questions

1. What is the purpose of built-in functions?
2. How are built-in functions called?
3. What are the categories of built-in functions?
4. How are functions used in formulas?
5. What can be function arguments?
6. What are the main functions included in the **Statistical category** ?
7. Give examples of the use of statistical functions.
8. What functions are included in **the Text category** ?
9. Give examples of the use of built-in text functions.
10. What functions are included in the **Logical category** ?
11. Explain the mechanism of application of logical functions.
12. What is the built-in **Date and Time** category used for ?
13. What functions belong to the **Date and time category** ?

1.16. Detection of the presence and assessment of the closeness of statistical dependence between variables

The dependence of random variables, in which each value of one of them corresponds to the distribution law of the second, that is, a change in one of the variables causes a change in the distribution of the value of the second, is called *statistical.* The statistical dependence of random variables, in which the influence of a change in one of the values on the average value of the second is studied, is called *correlation.* For example, correlation is the dependence of the average values of hematological and biochemical indicators of peripheral blood of pigs on the time that has passed since the introduction of the drug that affects these indicators.

One of the indicators that allows you to establish the presence of a linear relationship between two variables and evaluate its closeness is *the pair correlation coefficient* .

The pairwise correlation coefficient $r_{x,y}$ of two values *X* and *Y* is determined by the formula:

$$r_{x,y} = \frac{\sum_{i=1}^{n}(X_i - \overline{X}\ )\cdot(Y_i - \overline{Y}\ )}{\sqrt{\sum_{i=1}^{n}(X_i - \overline{X})^2 \cdot \sum_{i=1}^{n}(Y_i - \overline{Y})^2}}, \qquad (1)$$

where X_i, Y_i – variables, the relationship between which is studied;
$\overline{X}, \overline{Y}$ – average values of the studied variables;
n is the number of observations.

The modulus of the pair correlation coefficient does not exceed unity, that is $|r_{x,y}| \le 1$, which is equivalent to the double inequality: $-1 \le r_{x,y} \le 1$. If the correlation coefficient is statistically significant, then there is a linear relationship between the variables. If $r_{x,y}$ >0, then the relationship between the variables is direct, if $r_{x,y}$ <0, then the relationship is inverse. If the correlation coefficient is statistically insignificant or equal to zero, then the two random variables X and *Y* do not have a linear dependence, but may have a nonlinear one.

The statistical significance of the pairwise correlation coefficient is determined using the Student's test.

The calculated value of the criterion $t_{розр}$ is calculated according to the formula:

$$t_{розр} = \frac{r_{x,y}\sqrt{(n-2)}}{\sqrt{1-r_{x,y}^{2}}}, \qquad (2)$$

where $r_{x,y}$ are the values of the pair correlation coefficient;
n is the number of observations.

The calculated absolute value of the Student's criterion is compared with the table (critical) value. If the calculated value of the criterion is greater than the table value, then the accepted null hypothesis that the correlation coefficient is equal to zero is rejected, that is, the value of the correlation coefficient is statistically significant.

The tabular (critical) value of the criterion is calculated using the built-in MS Excel function **TINV of the Statistical** category **,** the arguments of which are the level of significance ($\alpha = 0{,}05$) and the number of degrees of freedom (f =(n -2)).

Built-in MS Excel array formulas for working with data

To simplify complex calculations, use the built-in formulas of MS Excel arrays, performing the following actions: **Insert ⇒Function⇒ Mathematical** . According to the array formula, several types of calculations can be performed at the same time, the result of which can be a single value or an array of values. An array formula handles multiple sets of values called array arguments. Each array argument must include the same number of columns and rows. Arguments are separated by “;”.

Array formulas include:

SUMXMY2(array_x;array_y) – the sum of the squares of the difference of the corresponding values of two arrays.

SUMPRODUCT(array_x; array_y) – the sum of the products of the corresponding elements of two arrays.

Built-in MS Excel functions for determining correlation characteristics

Built-in MS Excel functions for determining correlation characteristics are grouped in the **Statistical** category .

The correlation coefficient is calculated by one of two built-in functions: **CORREL** or **PEARSON,** whose arguments are ranges of cells with input data.

Practical work #16

Execution program

1. LaunchMS Excel spreadsheet.
2. Enter the data from the table task. "Dependence of blood indicators of pigs on time" : the value of one of the indicators (Y) and the column "Day of observation" (X).
3. Calculate the mean value of a series of observations using the corresponding built-in function.
4. Complete the table with the following columns:

Indicator (Y_i)	Observation day (X_i)	Y_p	$Y_i - Y_p$	X_p	$X_{and} - X_p$

where Y_s , X_s are the average values of indicators.

5. Fill the table with values, using relative and absolute references to the addresses of cells with data.
6. Calculate the components of formula (1) with the help of the formulas of **the SUMPRODUCT** and **SUMXMY2** arrays**.**
7. Calculate the coefficient of pair correlation according to formula (1), using the calculated values of the components.
8. Check the correctness of calculations using the built-in function **CORREL** or **PEARSON** .
9. Calculate the calculated value of the Student's criterion according to formula (2).
10. Calculate the critical (table) value of the Student criterion using the built-in **TINV** function .
11. In the free cell, enter the formula for comparing the calculated and critical values of the criterion using the built-in logical function **IF** so that in the case of confirming the significance of the correlation coefficient, the inscription "Significant!" is displayed, and in the opposite case - "Not significant".
12. Draw conclusions about the presence and closeness of the linear relationship between the variables.

Tasks for practical work

Dependence of pig blood parameters on time

Dynamics of biochemical indicators of blood serum of pigs after the use of a modified isotonic solution								
Item no .	Observation day (X and)	The name of the indicators (Y and)						
		total protein, g/l	albumin, %	globulin, %	α-globulin, %	β-globulin, %	γ-globulin, %
1	5	52.9	48.4	51,58	24,21	15,12	12.25
2	14	53.7	47.6	52.4	24.86	15.2	12.34
3	30	56.9	47.4	52.6	21.56	16.4	14.64
4	60	63.4	48.5	51.48	19.88	16.8	14.8
5	90	69.1	41.55	58.45	21,16	16.1	21,19
6	150	72.1	41,51	58,49	20.9	16.2	21.3
7	270	76	41,18	58.82	19.85	16.82	22.16

Self-test questions

1. What relationship between variables is called correlation?
2. What characteristics are used to establish the presence of a correlation between two random variables?
3. What does the magnitude and sign of the pair correlation coefficient indicate?
4. How is the statistical significance of the pairwise correlation coefficient tested?
5. What built-in functions are used to determine the correlation coefficient?
6. What are array formulas used for?
7. What are used as arguments of array formulas?

Reference list

1. Harina S.M. Methodical instructions for performing laboratory work in the discipline "Computational mathematics and programming" for students from the field of study 6.051401-"Biotechnology", part 2. - K.: NAU Publishing Center, 2007. - 88 p.
2. Harina S.M. Methodical instructions for performing laboratory work in the discipline "Computational mathematics and programming" for students from the direction of training 6.051401-"Biotechnology", part 1. - K.: NAU Publishing Center, 2006. - 95 p.
3. Information technologies: study guide / R.O. Tarasenko, S.M. Harina, T.P. Worker . - K.: NAU Publishing Center, 2005. - 200 p.
4. Information technologies: study guide / R.O. Tarasenko, S.M. Harina, T.P. Worker . - K.: Alefa , 2008. - 312 p.
5. Computational mathematics and programming part 1 (title from the screen) [Electronic resource] Access mode http://elearn.nubip.edu.ua/course/view.php?id=379
6. Computational mathematics and programming part 2 (name from the screen) [Electronic resource] Access mode http://elearn.nubip.edu.ua/course/view.php?id=380
7. Kiryanov D. Self-tutorial Mathcad 15/ Mathcad Prime 1.0 / Kiryanov Dmitry - St. Petersburg: BHV-Petersburg, 2012. - 432 p.
8. Excel 2013. Bible user / Walkenbach John – Moscow: Williams , 2015 . - 933 p.

CHAPTER 2. MODERN NETWORK AND INFORMATION AND COMMUNICATION TECHNOLOGIES

2.1. Network devices and means of communication

Twisted pair, coaxial cable and fiber optic lines are most often used as means of communication. When choosing the type of cable, the following indicators are taken into account:

- The cost of installation and maintenance;
- Information transfer speed;
- Limitation on the size of the information transmission distance (without additional repeater amplifiers);
- Security of data transfer.

The main problem is to provide these indicators at the same time, for example, the highest data transfer rate is limited to the maximum possible data transfer distance, which still provides the necessary level of data protection. Easy expandability , ease of expansion of the cable system affect its cost and security of data transmission.

Network cards are responsible for transferring information between network units. Any network card consists of a connector for a network conductor and a microprocessor that encodes/decodes network packets, as well as auxiliary software and hardware complexes and services. Each card has its own MAC address - a unique identifier of the device.

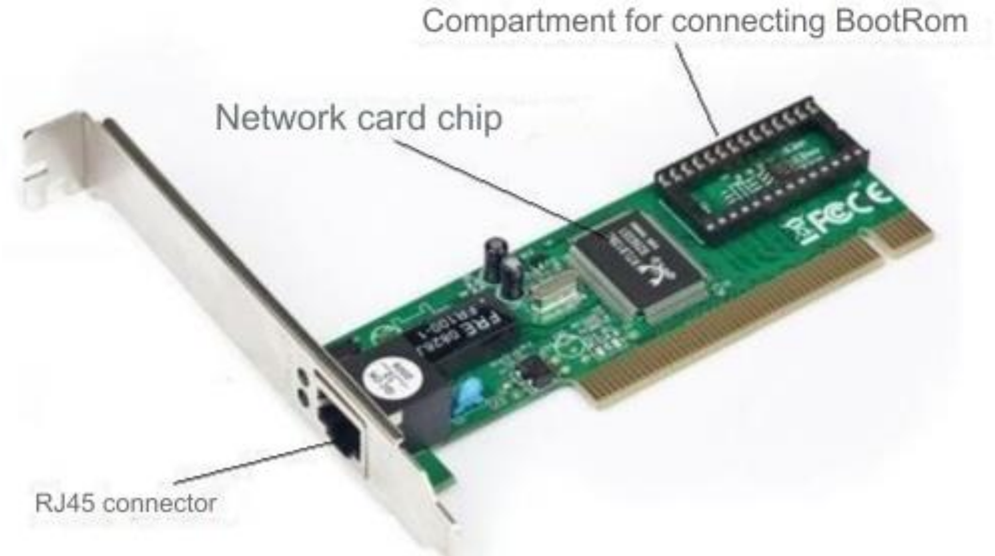


Figure 2.1 - Network map

Coaxial cable has an average pFig, is well protected against interference and is used for communication over long distances (several kilometers).

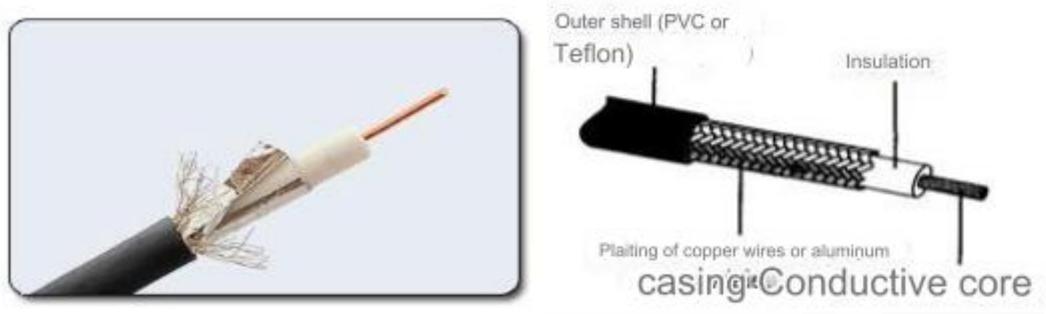
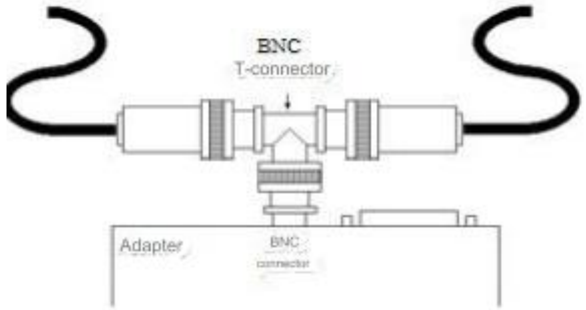


Figure 2.2 - Coaxial cable

The speed of information transfer is from 1 to 10 Mbit/s, and in some cases it can reach 50 MbIit/s. Coaxial cable is used for basic and broadband information transmission.



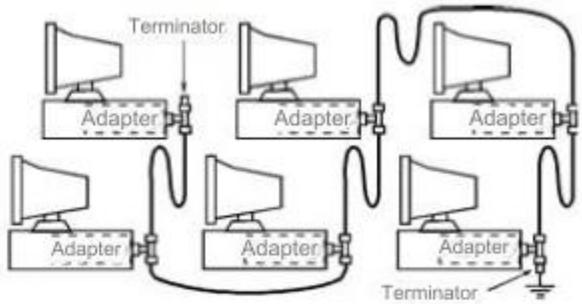


Figure 2.3 – Connecting the adapter Figure 1.4 – Connecting computers to a thin coaxial network cable with a thin cable

The minimum set of equipment for a single-segment network on a thin cable should include the following elements:

• network adapters (by the number of computers connected to the network) - (*network interface card*) - a peripheral device that allows computer to interact with other devices networks ; lengths of cable with *BNC connectors* at both ends, the total length of which is sufficient to connect all computers;

• *BNC T- connectors* (by the number of network adapters) (Fig. 1.5, a) (intended to connect three cables);

• one *BNC* terminator without grounding (the terminator is an energy absorber at the end of a long line , resistance of which is equal to wave resistance of this line) (Fig. 1.5, b);

• one *BNC* terminator with grounding (Fig. 1.5, c).

(a) (b) (c)

Figure 2.5 – General view of BNS: (a) - BNC T- connectors , BNC terminator without grounding (b) and with grounding (c)

If the network is created from several segments using repeaters and hubs, it should be taken into account that some hubs have built-in 50-ohm terminators (sometimes they are disconnected), which simplifies coordination problems.

A hub is a connecting component to which all computers connect in network by “star” topology (Fig. 1, 5, b).

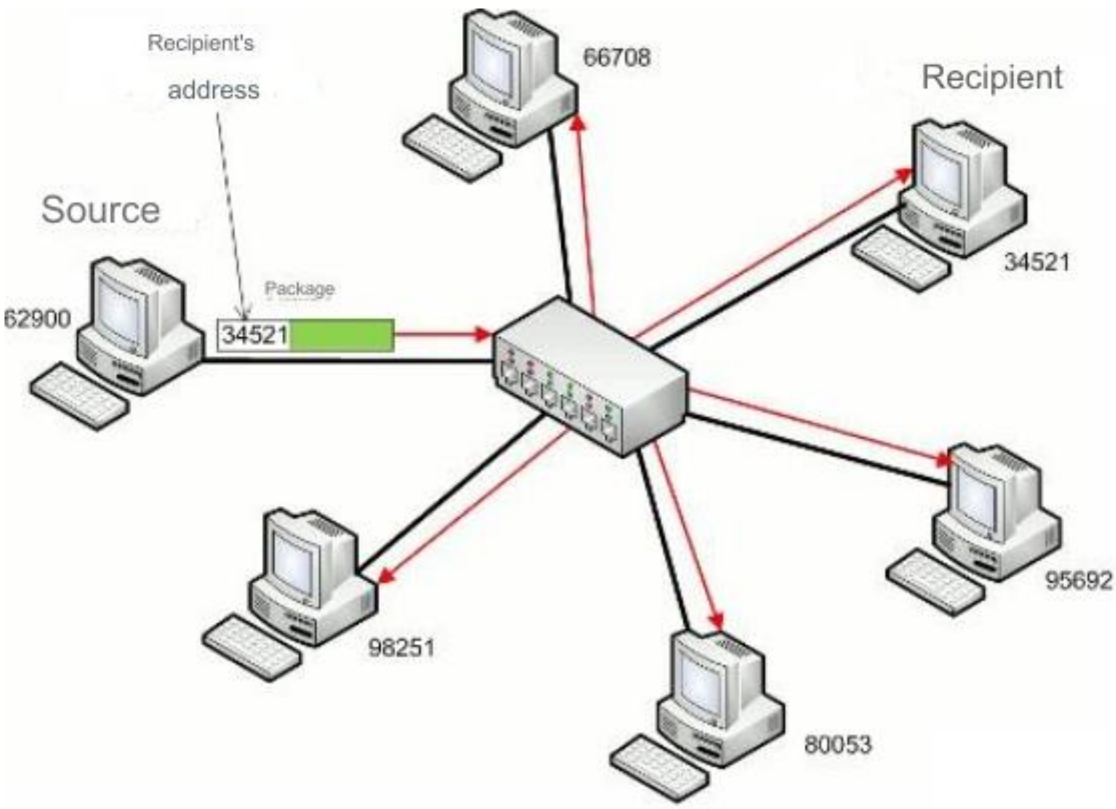


Figure 2.5, b - Example of work with a hub

Ethernet cable is also a coaxial cable with a wave resistance of 50 Ohms (Fig. 1.6).

Figure 2.6 – General view of Ethernet cables (RG-8, 10Base5)

It is also called thick Ethernet or yellow cable. It uses a 15-pin standard plug. Due to interference protection , it is an expensive alternative to conventional coaxial cables. The average data transfer speed is 10 Mbit/s. The maximum available distance without a repeater does not exceed 500 m, and the total distance of the Ethernet network is about 3000 m. The Ethernet cable, thanks to its trunk topology, uses only one load resistor at the end.

Cheaper than Ethernet cable is the Cheapernet cable (RG58) connection (Figure 1.7) or, as it is often called , thin Ethernet . It is also a 50-ohm coaxial cable with a data transfer rate of 10 Mbit/s. When connecting Cheapernet cable segments, repeaters are also needed. Computer networks with a Cheapernet cable have a low cost and minimal costs during expansion. Network cards are connected using widely used small-sized bayonet connectors (SR-50) (Figure 1.8) (bayonet is a type of connection).

Figure 2.7 - General view of the Cheapernet cable (RG-58, 10Base2)

Additional shielding is not required. The cable is connected to the PC using T-connectors . The distance between two workstations without repeaters can be a maximum of 300 m and a minimum of 0.5 m, the total distance for a network on a

Cheapernet cable is about 1000 m. The Cheapernet receiver is located on the network board both for galvanic isolation between the adapters and and to amplify the external signal

Figure 2.8 – General view of SR-50 type connectors

1.1.4 Broadband coaxial cable

Broadband coaxial cable (Figure 2.9) is immune to interference, easily expandable, but its pFig is high

Figure 2.9 – General view of broadband coaxial cable

RG-59 (75 Ohm): wire - 24 AWG (0.6 mm, copper, stranded), external . diam . - 6.1 mm, screen (95% mesh), light, flexible

The speed of information transfer is equal to 500 Mbit/s. When transmitting information in the base band of frequencies for a distance of more than 1.5 km, an amplifier or a so - called repeater is required . Therefore, the total distance when transmitting information increases to 10 km. For computer networks with a "tire" or "tree" topology, the coaxial cable must have a matching resistor (terminator) at the end.

The cheapest cable connection is a twisted two-wire connection , often called a "twisted pair ") (Fig. 2.10).

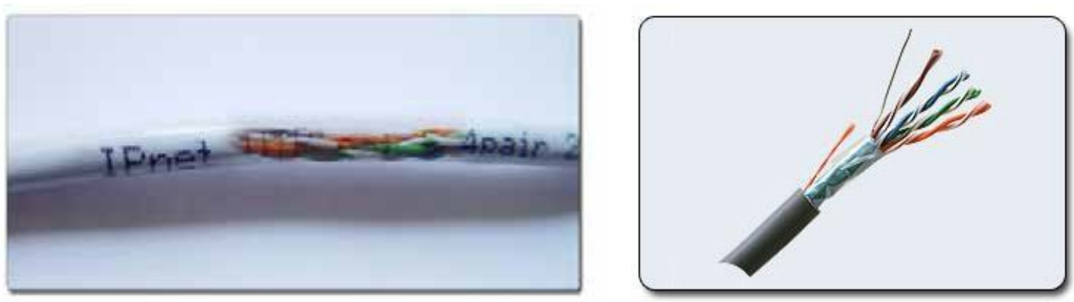


Figure 2.10 – Twisted pair

Such a connection allows you to transfer information at a speed of up to 10 Mbit/s, it is easily expanded, but it is fail-safe . The length of the cable cannot exceed 1000 m at a transmission speed of 1 Mbit/s. The advantages are a low pFig and trouble-free installation.

An unshielded twisted pair consists of eight wires. Each wire is insulated separately; all eight wires are assembled into four twisted pairs. Curling the wires prevents cross interference caused by adjacent pairs and external sources. All four pairs are placed in a common envelope.

With cables of the "twisted pair" type, RJ45 connectors are used (Fig. 2.11), the same as for standard telephone cables, only with eight contacts instead of four or six.

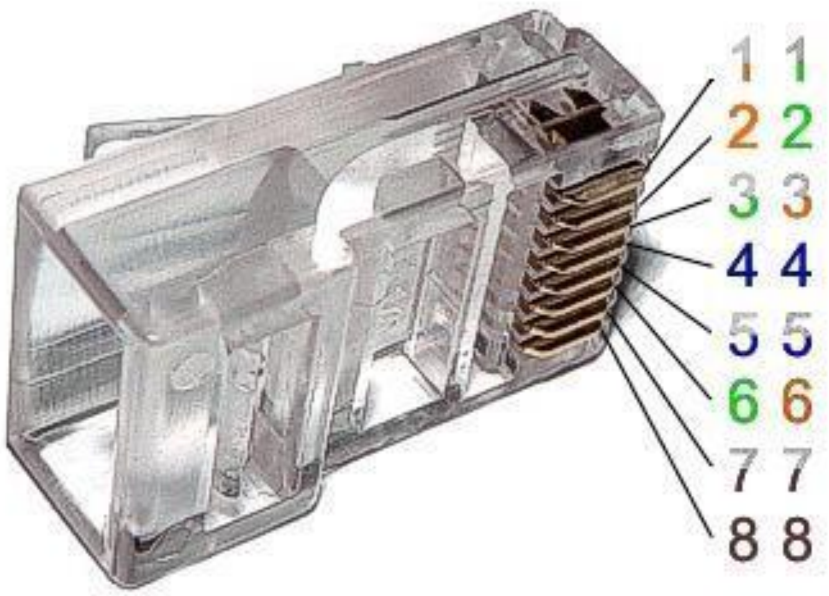


Figure 2.11 – General view of the RJ45 connector

to increase the immunity of information, that is, a twisted pair enclosed in a shield, similar to the shield of a coaxial cable. This increases the cost of twisted pair and brings its pFig closer to the pFig of coaxial cable.

Twisted pair has been used in telephone networks for more than a decade, but it was adapted to computer networks relatively recently. Twisted pair has supplanted coaxial cable from the LOM world thanks to several distinct advantages. First, the "twisted pair" cable consists of eight separate wires, which makes it more flexible than coaxial and, accordingly, makes it easier to lay. Secondly, thousands of ready-made qualified installers of telephone cables can be safely involved in the laying of cables for LOM. In new buildings, telephone and network cables are often laid by the same contractor at the same time.

The minimum set of equipment for a twisted pair network includes the following elements:

• network adapters (according to the number of computers connected to the network) with *RJ-45 UTP connectors;*

• cable segments with *RJ-45 connectors* at both ends (by the number of computers to be joined);

• one hub that has as many UTP ports with *RJ-45 connectors* as it is necessary to connect computers.

Fiber optic lines (10 BaseFL)

The most expensive are optical conductors (Fig. 2.12), also called cable.

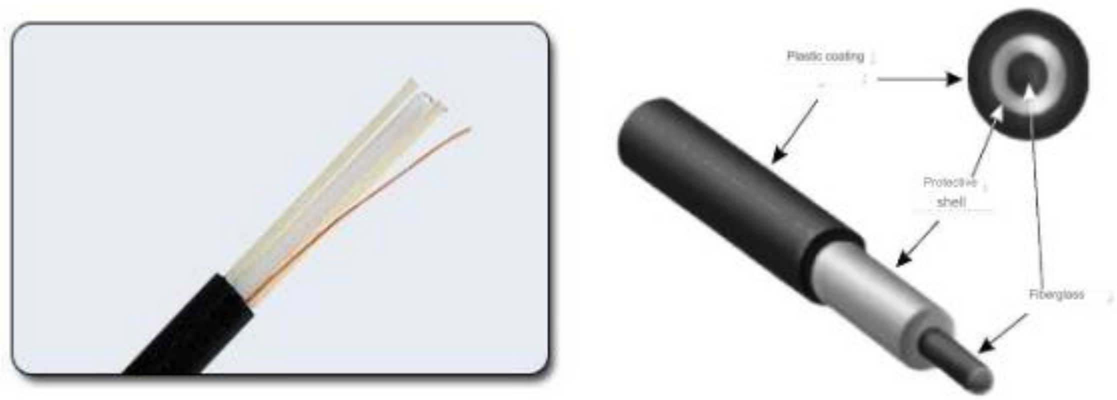


Figure 2.12 - Optical fiber

The speed of information spread from them reaches 100 Mbit/s, and on experimental equipment samples - 200 Mbit/s. Allowable removal of more than 50 km. The external influence of obstacles is practically absent. At the moment, this is the most expensive connection for LOM. They are used where electromagnetic interference fields occur or information transmission over very long distances without the use of repeaters is required. They have properties because the technique of branching in fiber optic cables is very complicated. Optical conductors are combined in JIBM using a star-shaped connection.

In this case, information is transmitted over two fiber optic cables that transmit signals in different directions (as in *10BASE-T).* Two-wire fiber optic cables are sometimes used , containing two cables in a common outer sheath, but more often - two single cables. Contrary to popular belief, the cost of fiber optic cable is not too high (it is close to the cost of thin coaxial cable). Although, in general, the equipment in this case turns out to be significantly more expensive, because it requires the use of expensive fiber optic transceivers.

IEEE 802.3d specification Fiber Optical Inter Repeater Link (FOIRL) was proposed in 1987. It was intended to ensure information interaction of repeaters (*network equipment for amplification of signal*) , which are at a considerable (up to 1000 m) distance from each other. SMA and ST type connectors were used for connection to the fiber optic line (FOL).

In the future, however, this technology was not developed, as new network technologies of the 10 Base -F family appeared, which also used fiber -optic cable for data transmission and provided the best information and operational characteristics.

Using a fiber optic cable for data transmission

The main advantages of data transmission over fiber -optic communication lines are:

• The high speed of data transmission is the limit of 3GHz for industrial WANs, while for a copper cable this value is no more than 500 MHz.

• Insensitivity to electromagnetic interference
• Absence of electromagnetic radiation during data transmission
• Provision of galvanic isolation between the transmitter and data receiver

Fiber optic cable consists of the following components: optical fiber, optical screen, protective screen.

Its own transmission medium - an optical fiber is a glass or plastic core, the thickness of which, depending on the purpose of the cable, can vary from units to hundreds of microns. The diameter of the central fiber clearly determines the performance characteristics of the used fiber optic cable. Cables with a fiber diameter of 10 microns are called single-mode by the name of the radiation mode of the transmitting element - the laser. Cables with a fiber diameter of 60 microns or more are called multimode . Single mode fiber optic cables (Single Mode Fiber - SMF) are more difficult to manufacture and operate, however, they are able to provide a greater range of information signal spread. Cheaper to manufacture and convenient to use are multi-mode (Multi Mode Fiber - MMF) cables provide a shorter range of information signal spread.

To indicate the type of fiber optic cable, use the expression types: <Fiber diameter> / <Screen diameter>, in micro meters, for example: 62.5/125

Currently, multimode is the most widely used for data transmission in local networks fiber optic cable, however, only single-mode can be used to provide data transmission at speeds above 1 GHz over long distances fiber optic cable.

The 10 Base F (IEEE 802.3j) set of standards defines physical layer protocols for data transmission over fiber optic cable in IEEE 802.3 networks.

Specification 10 Base FB (Fiber Back Bone) defines a special protocol of the physical level, which is designed to ensure the improvement of the efficiency of information interaction of repeaters in IEEE 802.3 networks.

To ensure the synchronization of the clock generators in the absence of sent and frames, the transmitter and receiver exchange 2.5 MHz synchronizing sequences.

The 10 Base FB protocol is not universal and does not provide, in particular, information interaction between the repeater and the workstation.

Specification 10 Base FP (Fiber Passive) defines a physical layer interface to ensure the interaction of local network components using the principle of a passive optical splitter. When using the 10 Base FP technology, it is possible to build a passive unifying structure that can ensure the interaction of 33 workstations located at a distance of up to 500 m.

Specification 10 Base FL (Fiber Link) defines the data transfer protocol over two fiber -optic cables at a speed of 10 Mbit/ s over a distance of up to 2000 m. The

10 Base FL physical layer protocol provides information interaction in various options:

- Workstation - workstation
- The workstation - repeater Repeater - repeater

Base FL protocol parameters

No	Parameter	Parameter value
1	Data transfer speed	10 Mbit
2	Cable type	62.5/125
3	Max. segment length	2000 m
4	Type of connectors	ST

10BASE-FL uses a multimode cable and light with a wavelength of 850 nanometers, but there is also equipment for using a single-mode cable (with a maximum length of up to 5 km). Fiber optic transceiver is called *FOMAU* (Fiber Optic MAU). It performs all the functions of a conventional transceiver *(MAU),* but, in addition, converts an electrical signal to an optical signal during transmission and back when receiving. *FOMAU* also generates and monitors the link integrity signal transmitted in the pauses between packets. The integrity of the communication line, as in the case of *10BASE-T* , is displayed by the " Link " LEDs and is determined by the presence of an " Idle " signal with a frequency of 1 MHz between transmitted packets. To connect the transceiver to the adapter, a standard *AUI* cable (Fig. 1.13) is used, the same as in the case of *10BASE5* , but its length should not exceed 25 meters. There are also network adapters with built-in *FOMAU transceivers* , which have only external fiber optic connectors and do not require transceiver cables.

Figure 2.13 – General view of *the AUI* cable

The length of optical fiber cables connecting the transceiver and the hub can reach 2 kilometers without the use of any repeaters. Thus, it is possible to join a local network of computers located in different buildings, spread over the territory.

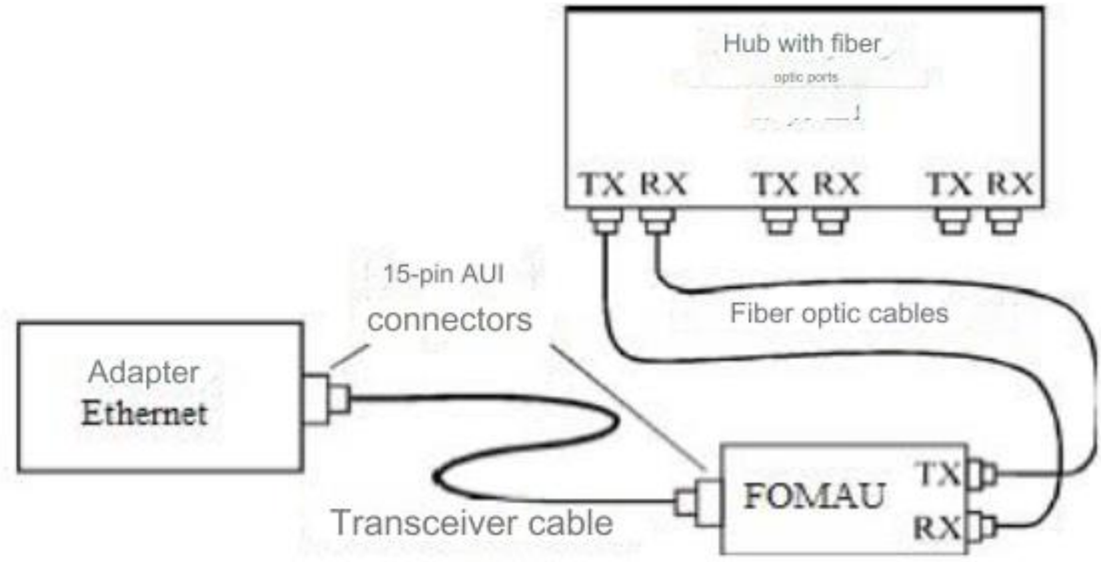


Figure 2.14 – Connection of adapter and hub in 10BASE-FL

As in the case of 10BASE-T, several hubs can be connected together to obtain a tree topology. In general, the 10BASE-FL segment is most often used to connect two hubs. And computers are connected to hubs according to the 10BASE-T standard. Thus, it is possible to combine the advantages of both segments - the low cost of 10BASE-T and the long distances of 10BASE-FL.

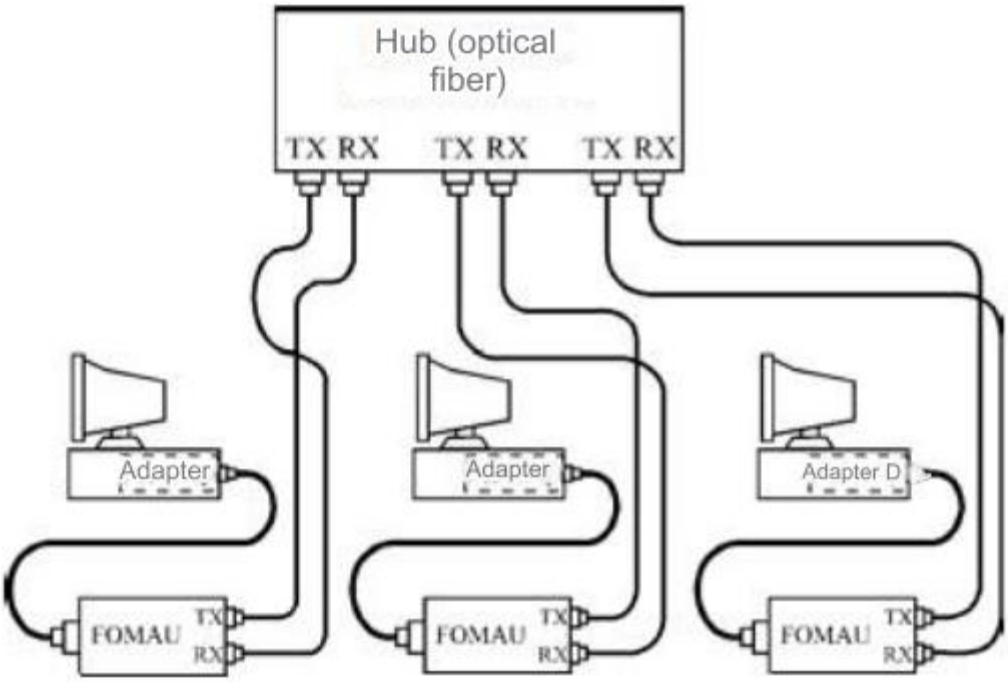


Figure 2.15 – Connecting computers to a network according to the 10BASE-FL standard

The minimum set of equipment for connecting two computers with a fiber optic cable includes the following elements:

• two network adapters with transceiver connectors;

• two optical fiber transceivers (FOMAU);

• two transceiver cables;

• two fiber optic cables with ST connectors (or SC or MIC connectors) on the ends.

There are many optical connectors . Their main types are presented in table 2.2. Version of SC connector in Double format for multimode fiber (Fig. 2.16).

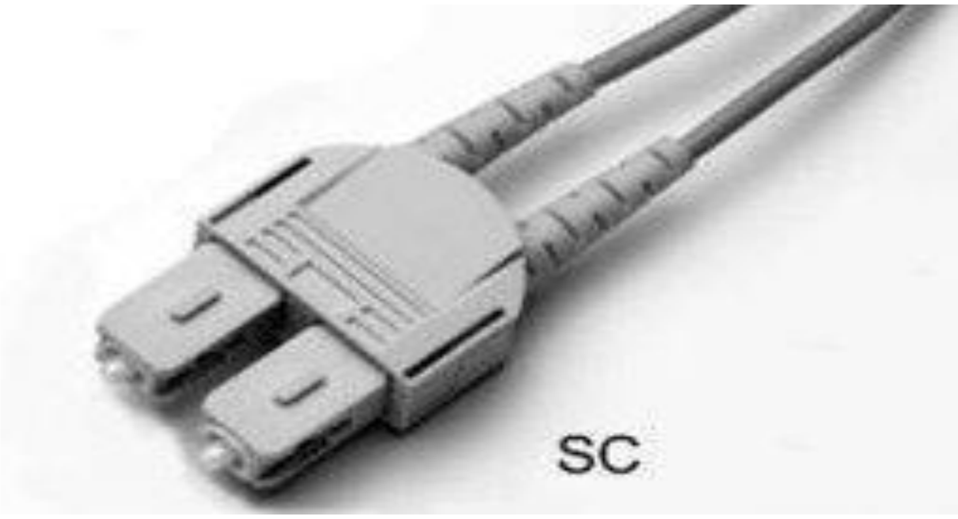


Figure 2.16 – SC connector in Double format

Table 2. 2 **-** Types of optical connectors

Marking	Appearance	**Description**	**Losses (Db) at 1300 nm for multimode / singlemode**
1	2	3	4
ST - Straight Tip connector		Initial type, now deprecated. Fixation by turning around the axis by 1/4 turn. The rotation of the base is excluded due to the longitudinal groove in the socket connector. Requires a lot of free space during assembly / disassembly. The optical tip is ceramic, 2.5 mm in diameter with a rounded end.	0.25/0.3

FC - Fiber - Optic **Connector**		ST-type development. The threaded fixation of the frame provides excellent performance.	0.2/0.6
SC - Square/Subscriber **Connector**		Installation / removal is carried out only by reciprocating movement, no rotating parts (mainly). Optical tip - 2.5 mm in diameter, almost completely hidden by the case. The case has latches for fixing in the socket. Can have a device for attaching a paired tip or be produced in duplex option. The color of the case for single-mode is blue, for multi-mode - gray.	0.2/0.25
LC - Little *or* Local Connector		A small version of the SC connector . The case is equipped with a latch similar to a latch on an RJ-45 connector. Ceramic tip, diameter 1.25 mm.	0.1/0.1

Indicators of the three most typical means of communication for data transmission are given in tables 1.3-1.4.

Table 2.3 – Main indicators of means of communication

Indicators	**Means of communication for data transmission**		
	Two-wire twisted pair	*Coaxial cable*	*Fiber optic cable*
PFig	Low	Relatively high	High
Build-up	Very simple	It is problematic	Simple

Eavesdropping protection	Insignificant	good	High
Problems with grounding	No	Possible	No
Susceptibility to obstacles	There is	There is	Absent

Table 2.4 – Comparative characteristics of network conductors

Cable type (10 Mbps = approx 1 MB per second)	Data transfer speed (megabits per second)	Max official segment length, m	Max unofficial segment length, m	The possibility of recovery at damage / Lengthening	Tendency to interference	Cost
Twisted pair						
Unshielded twisted pair	100/10/1000 Mbit / s	100/100/100 m	150/300/100 m	good	average	low
Shielded twisted pair	100/10/1000 Mbit / s	100/100/100 m	150/300/100 m	good	low	average
P-296 field cable	100/10 Mbit / s	------	300 (500) / 800 m	good	low	High
Four-wire telephone cable	30/10 Mbit / p	------	No more than 30 m	good	High	Very low
Coaxial cable						
Thin coaxial cable	10 Mbps	185 m	250 (300) m	bad Soldering is required	High	low
Thick Coaxial cable	10 Mbps	500 m	600 (700)	bad Soldering is required	High	average
Optical fiber						
Single mode fiber optic	100-1000 Mbit	Up to 100 km	----	Special equipment is required	Absent	$1-3 per meter

Multimode fiber optic	1-2 Gbit	Up to 550 m	----	Special equipment is required	Absent	$1-3 per meter

There are a number of principles for building LOM based on the components discussed above. Such principles are also called topologies , which we will consider in the next section.

2.2 Computer network topologies

The concept of a star network topology comes from the field of mainframe computers, in which the main machine receives and processes all data from peripheral devices as an active data processing node. This principle is used in data transmission systems, for example, in RelCom network e-mail . All information between two peripheral workplaces passes through the central node of the computer network.

The bandwidth of the network is determined by the computing power of the node and is guaranteed for each workstation. Data collisions do not occur.

Cabling is quite simple because each workstation is connected to a node. Cabling costs are high, especially when the central node is not geographically located in the center of the topology.

When expanding computer networks, previously completed cable connections cannot be used: a separate cable must be laid from the center of the network to the new workplace.

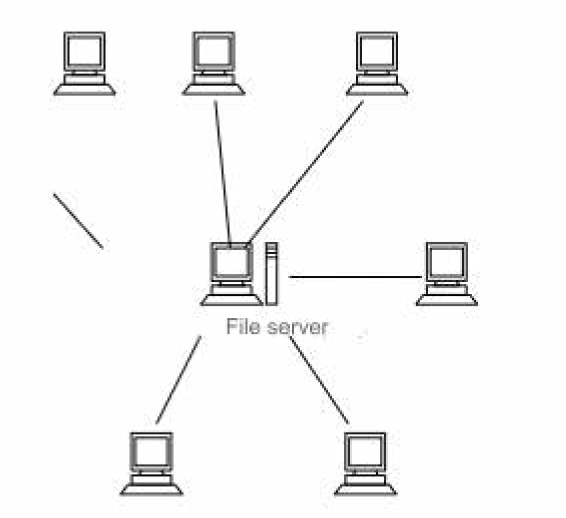


Figure 2.17 – Structure of the LOM topology in the form of a "star"

The star topology is the fastest of all computer network topologies , since data transmission between workstations passes through the central node (with good performance) on separate lines used only by these workstations. The frequency of information transfer requests from one station to another is low compared to that achieved in other topologies .

The performance of the computer network primarily depends on the power of the central file server. It can be a bottleneck of a computer network. In the event of failure of the central node, the operation of the entire network is disrupted.

The central control node - the file server implements the optimal protection mechanism against unauthorized access to information. The entire computing network can be controlled from its center.

In a ring network topology, workstations are connected to each other in a circle, that is, workstation 1 to workstation 2, workstation 3 to workstation 4, etc. The last workstation is connected to the first. The communication link is closed in a ring (Figure 1.18).

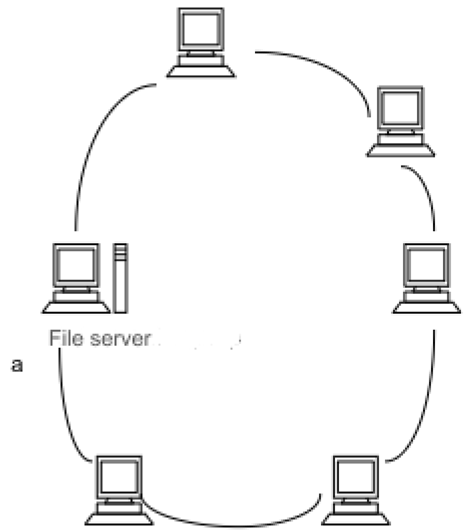


Figure 2.18 – The structure of the ring topology of LOM

Cabling from one workstation to another can be quite difficult and expensive, especially if the geographic location of the workstations is far from the ring shape (for example, in a line).

Messages circulate regularly in a circle. The workstation sends information to the specified final address after receiving a request from the ring. Message forwarding is very efficient because most messages can be sent "on the road" over the cable system one at a time. It is very easy to make a circular request to all stations. The duration of information transfer increases in proportion to the number of workstations included in the computer network.

The main problem with the ring topology is that each workstation must actively participate in forwarding information, and in case of failure of at least one of them, the entire network is paralyzed. Malfunctions in cable connections are easily localized.

Connecting a new workstation requires a short-term shutdown of the network, because the ring must be open during installation. There is no limit to the length of the computer network, as it is ultimately determined solely by the distance between two workstations.

A special form of ring topology is a logical ring network. Physically, it is mounted as a connection of star topologies . Individual stars are turned on with the help of special switches , which are sometimes called "hub". Depending on the number of workstations and the length of the cable between the workstations, active or passive hubs are used. Active hubs additionally contain an amplifier for connecting 4 to 16 workstations. A passive hub is an exclusively branching device (for a maximum of three workstations). Management of an individual workstation in a logical ring network is the same as in a conventional ring network. Each workstation is assigned an address corresponding to it, by which control is transferred (from the oldest to the youngest and from the youngest to the oldest). The disconnection occurs only for the lower (nearest) node of the computer network, so that only in rare cases can the operation of the entire network be disrupted.

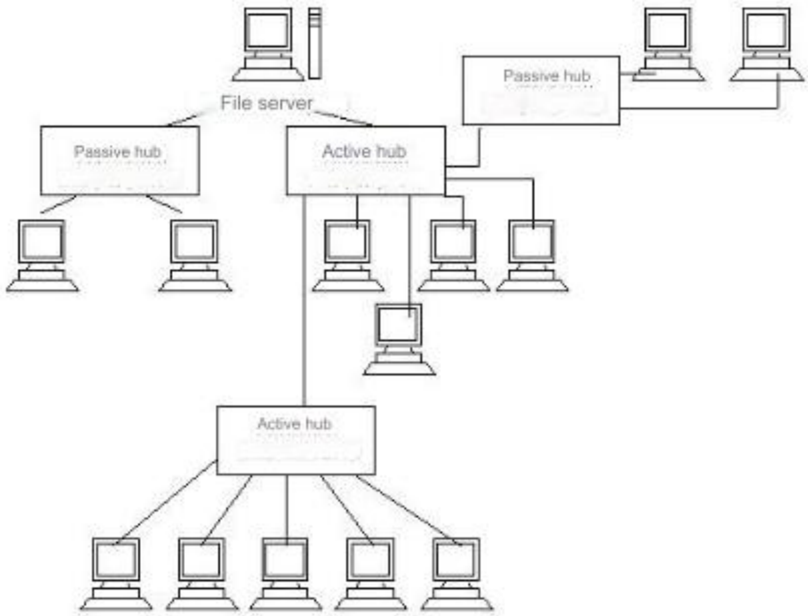


Figure 2.19 – The structure of the logical ring node LOM

With the bus topology, the information transmission environment is presented in the form of a communication path available to all workstations, to which they must all be connected. All workstations can directly communicate with any workstation on the network.

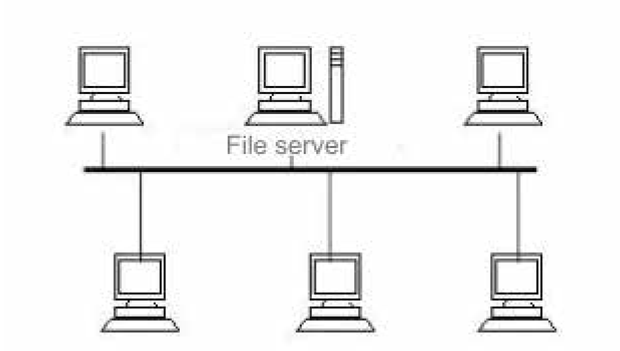


Figure 2.20 – The structure of the bus topology of the LOM

Workstations can be connected to or disconnected from the entire computer network at any time without interrupting the operation of the entire computer network. The functioning of a computer network does not depend on the state of an individual workstation.

In a standard situation, a thin cable or Cheapernet cable with a triple connector is often used for an Ethernet bus network. Disconnecting and especially connecting to such a network requires a bus break, which causes a violation of the circulating flow of information and a system freeze.

New technologies offer passive plug boxes through which stations can be disconnected and/or connected while the computer network is operating.

Due to the fact that workstations can be connected without interrupting network processes and the communication environment, it is very easy to listen to information, that is, to branch information from the communication environment.

In LOM with direct (non- modulating) transmission of information, there can always be only one station that transmits information. To prevent collisions, in most cases, a time division method is used, according to which each connected workstation is given the exclusive right to use the data channel at certain times. Therefore, the requirements for the bandwidth of the computer network at increased load are increased, for example, when new workstations are introduced. Workstations are connected to the bus using TAP devices (Terminal Access Point). TAP is a special type of connection to a coaxial cable. A needle-shaped probe is introduced through the outer sheath of the outer conductor and the dielectric layer to the inner conductor and is connected to it.

In modulated broadband LOM, different workstations receive, as needed, a frequency on which these workstations can send and receive information. The transmitted data is modulated on the corresponding carrier frequencies, that is, modems for modulation and demodulation are located between the information transmission medium and workstations, respectively. The technique of broadband messages allows simultaneously transporting a fairly large amount of information in the communication environment. For the further development of discrete data transport, it does not matter what the original information is fed into the modem (analog or digital), as it will still be transformed in the future.

The main characteristics of the three most typical computer network topologies are given in Table 2.5.

Table 2.5 – Main characteristics of computer network topologies

Characteristics	**Computer network topologies**		
	Star	*Ring*	*Bus*
Cost of expansion	Insignificant	average	average
Joining subscribers	passive	active	passive
Protection against failures	Insignificant	Insignificant	High
System dimensions	Any	Any	Limited
Protection against eavesdropping	good	good	Insignificant
Connection cost	Insignificant	Insignificant	High
System behavior at high loads	good	Satisfactory	bad
Ability to work in real time	Very good	good	bad
Cabling	good	Satisfactory	good
Service	Very nice	Average	Average

Along with the well-known "ring", "star" and "bus" computer network topologies , a combined one, for example a tree structure, is also used in practice. It is formed mainly in the form of combinations of the aforementioned computer network topologies . The base of the computer network tree (root) is located at the point where information communication lines (branches of the tree) gather.

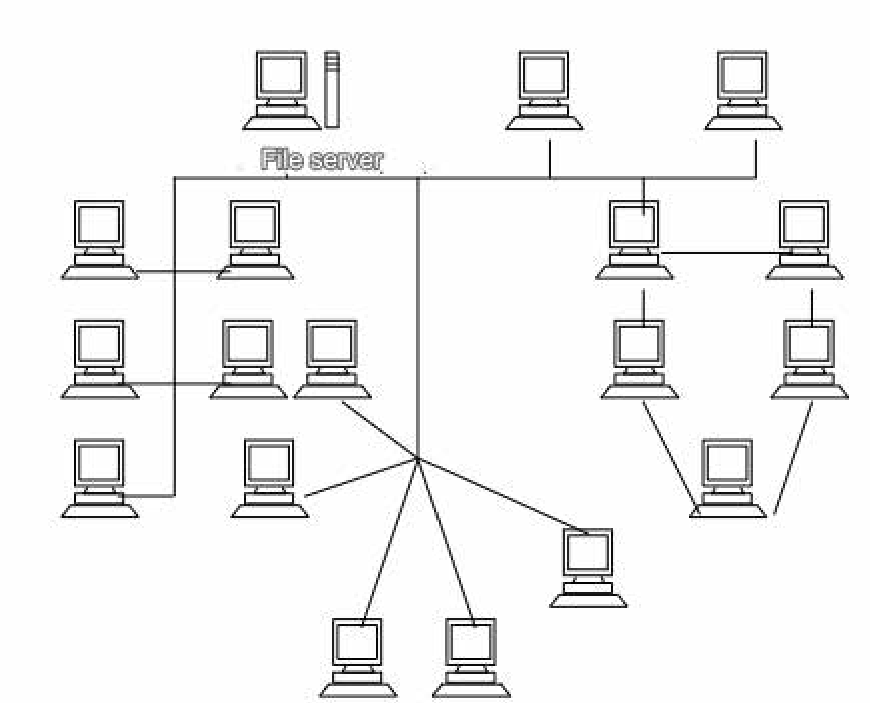


Figure 2.21 – Tree structure of LOM

Computer networks with a tree-like structure are used where it is impossible to directly apply basic network structures in their pure form. Network amplifiers and/or switches are used to connect a large number of workstations in accordance with adapter boards. A switch that simultaneously has the functions of an amplifier is called an active hub.

In practice, two of their varieties are used, which provide the connection of eight or sixteen lines, respectively.

A device to which a maximum of three stations can be connected is called a passive hub. A passive hub is usually used as a splitter. It does not need an amplifier. The prerequisite for connecting a passive hub is that the maximum possible distance to the workstation should not exceed several tens of meters.

Many people think that this is the most difficult stage of laying a network, because there are so many conductors, it is so easy to get tangled in them, you need to buy a special crimping tool , etc. In fact, everything is quite simple. To crimp the twisted pair, you will need special pliers and a pair of RJ-45 connectors , as shown in Figures 2.22 and 2.23.

Figure 2.22 - RJ-45 connectors

Sequence of actions during crimping:

1. Carefully cut the end of the cable, it is best to use the cutter that is built into the crimping tool.

Crimping tool RJ-45 | Twisted pair insulation stripping knife

Figure 2.23 – Crimping tool RJ-45

2. Remove the insulation from the cable. You can use a special knife for stripping the insulation of twisted pair, its blade protrudes exactly to the thickness of the insulation, so you don't damage the conductors.

Figure 2.24 – Twisted pair insulation stripping

However, if there is no special knife, you can use an ordinary one or take scissors, or use the knives of a crimping tool.

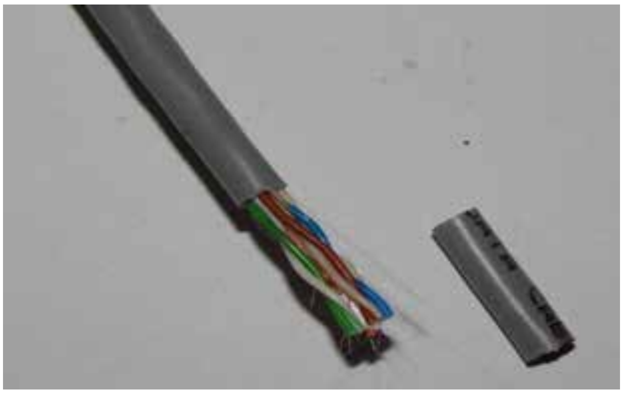


Figure 2.25 – Twisted pair without insulation

3. Separate and unravel the wires, align them in one row, while observing the color sequence

Figure 2.26 - Layout of the color sequence

4. After cutting off the wires so that they remain a little more than a centimeter

(Cut off the redundant)

Figure 2.27 – Cutting length of twisted pair wires

5. Insert the conductors into the RJ-45 connector

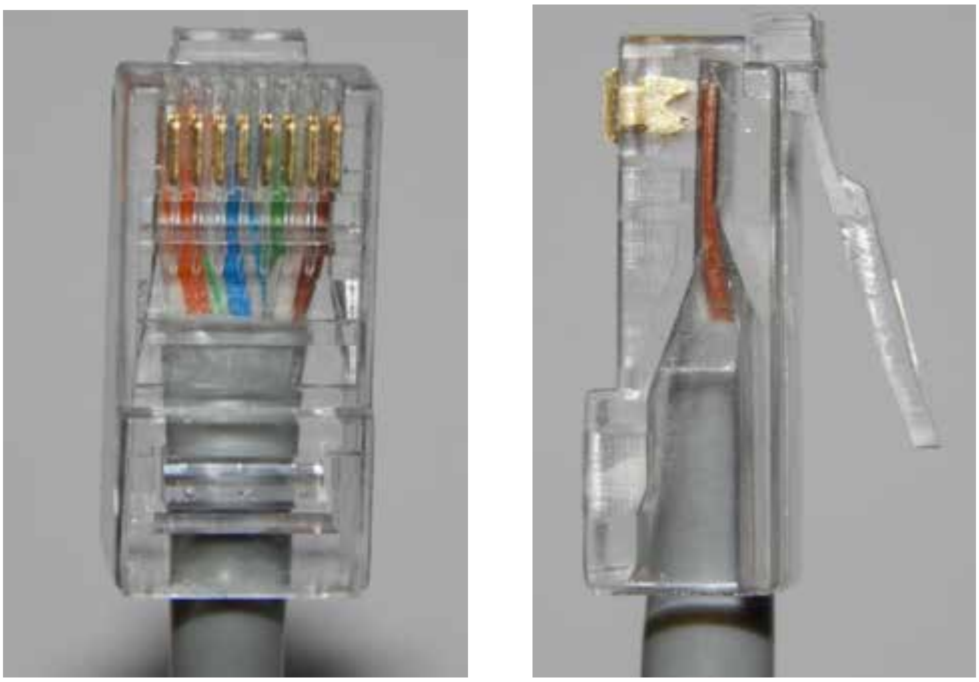


Figure 2.28 – Inserted conductors into the RJ-45 connector

6. Check that the wiring is correctly arranged
7. Make sure that all the wires are fully inserted into the connector and rest against its front wall
8. Place the connector with the installed pair in the pliers, then gently but firmly crimp

Figure 2.29 – Crimping a connector with an installed pair

There are two common standards for diluting color pairs: Siemon 's T568A and AT & T's T568B. Both of these standards are completely equivalent.

With such a layout, the information is carried by the conductors: White-green, Green, White-orange, Orange.

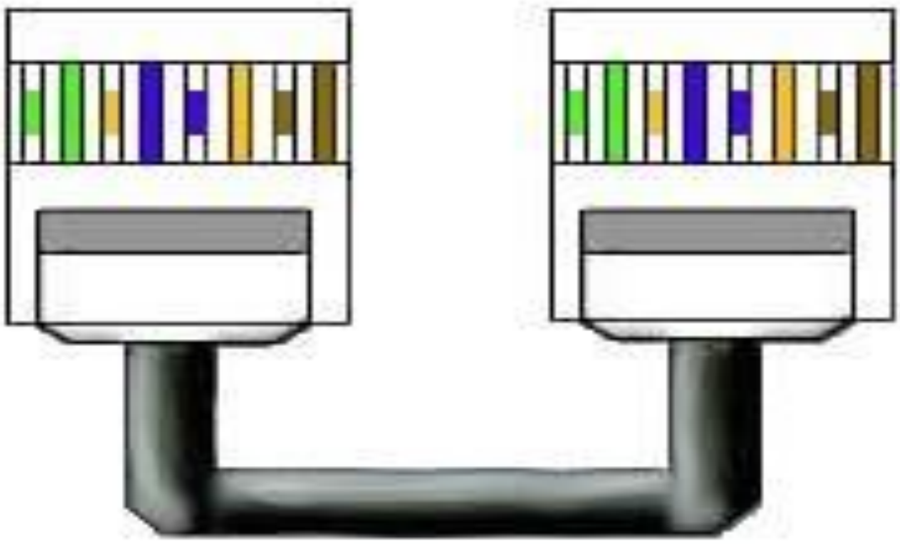


Fig. 2.30 View of the network card connection – Switch according to the T568A standard

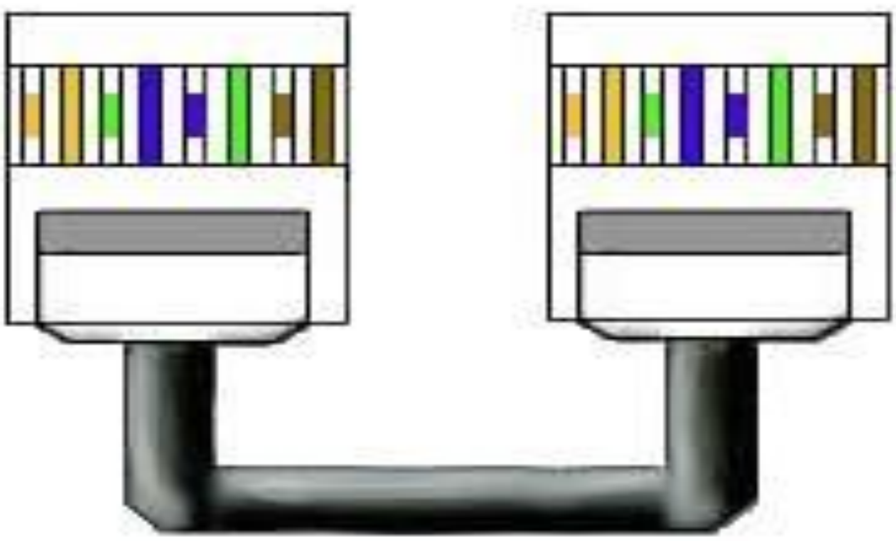


Fig. 2.31 Network card - switch connection according to the T568B standard

With such a layout, the information is carried by the conductors: White-orange, Orange, White-green, Green.

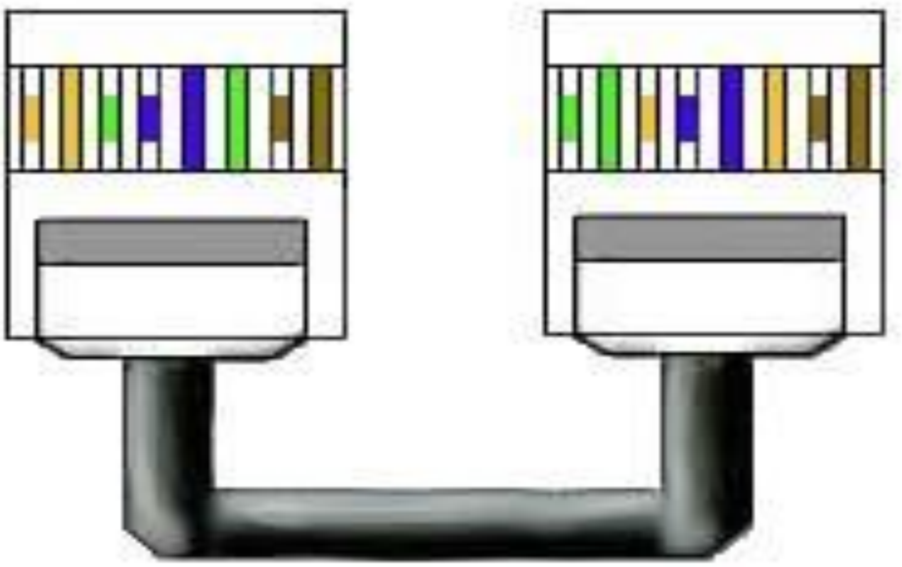


Fig. 2.32 Network card - network card connection (crossover cable)

Crimping in this way, you may need a twisted pair in 2 cases:

1. To connect 2 computers without a switch.
2. To connect 2 or more Hub / Switch

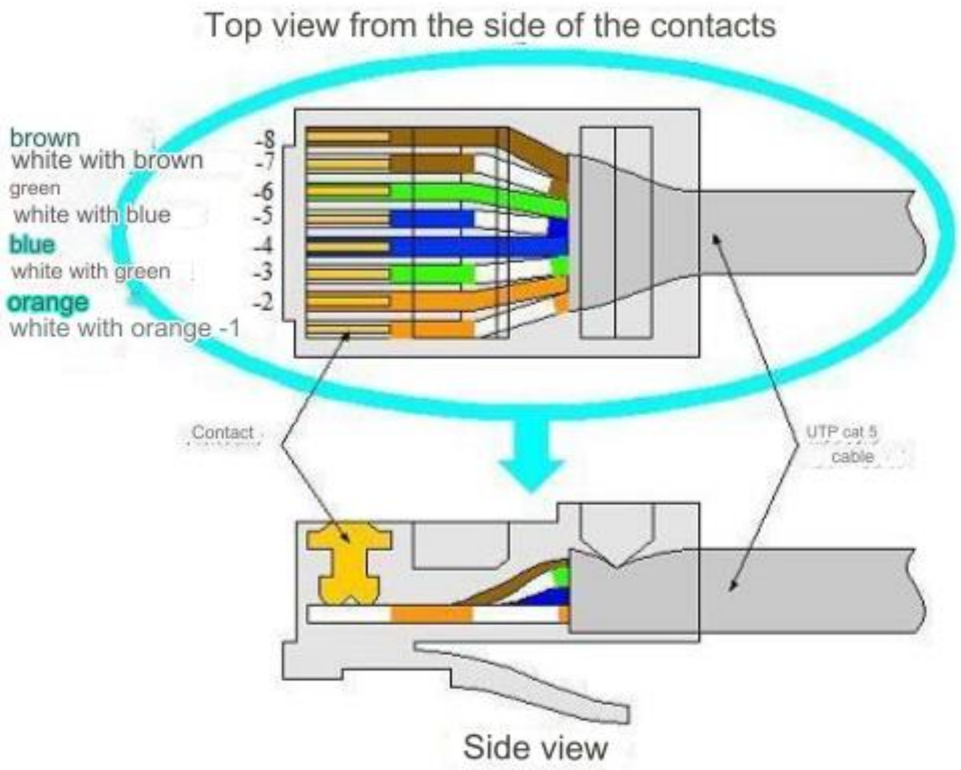


Fig. 2.33 View of contacts

2.2 Addressing in IP networks

The WINDOWS network operating system contains a set of utilities useful in diagnosing a network using TCP / IP protocols.

The main tasks of these utilities are:

- Determination of network parameters and characteristics;
- Determination of network performance;
- In the event of a network malfunction - localization of the segment or service causing the malfunction.

The main parameters of network connections are their channel and network addresses and other parameters affecting the operation of the network layer.

Each computer in the Internet network (they are usually called **hosts**) has addresses of two levels: channel and network.

The channel address of the host is determined by the technology used to connect it to the Internet . For machines connected to Ethernet local networks , this is the so-called MAC address (Media Access Control) of the network adapter, which is assigned by the equipment manufacturer and is unique. For existing LAN technologies, the MAC address has a 48-bit format (6 bytes):

- The first bit indicates: a frame is assigned to a single (0) or group (1) addressee;
- The next bit indicates whether the MAC address is globally (0) or locally (1) administrative ;
- The next 22 bits are the manufacturer's company identifier;
- The lower 3 bytes are uniquely assigned by the manufacturer. MAC addresses are usually represented in the 16-bit system, for example, 00-E0-4C-78-23-FD. The FF-FF-FF-FF-FF-FF address is broadcast.

As the network address of the host Internet uses IP addresses (Internet Protocol Address), which characterizes not a separate computer or router, but one network connection. When communicating via the Internet, the global uniqueness of the address is required, which is provided by the recommendations of the special Internet division InterNIC (Network Information Center). Internet service providers obtain address ranges from InterNIC units and then distribute them to their subscribers. In the case of a local network isolated from the Internet, the uniqueness of the network address is necessary only within its boundaries, while IP addresses must be selected by the administrator from blocks of "closed" addresses specially reserved for such networks.

In the most common fourth version of the Internet Protocol (IP.v4), an IP address is a 32-bit binary number written as four decimal numbers (values from 0 to 255) separated by dots (for example, 192.168.0.1). The address consists of two logical parts - the network number and the host number in the network.

With the class model of address formatting, the values of the first bits of the address determine which part of it refers to the network number, and which part refers to the host number , as shown in the table. 2.6.

Table 2.6 – Class model of address formatting

Class	IP address										Address range
	31	30	29	28	27	25	24	23 16	15 8	7 0	
A	0	No. network						No. network			0.1.0.0–126.0.0.0
B	1	0	Network number						host no		128.0.0.0–191.255.0.0
C	1	1	0	No.,network						host no	192.0.1.0–223.255.255.0
D	1	1	1	0	multicast group address						224.0.0.0–239.255.255.255
E	1	1	1	1	0	reserved					240.0.0.0–247.255.255.255

A number of network and subnet addresses are special:

- If the entire IP address consists only of binary zeros, then it indicates the address of the host that generated this packet;
- If all binary bits of the host's IP address are equal to 1, then the packet with this destination address is broadcast, that is, it must be sent to all hosts on the same network as the source of this packet;
- If all the binary digits of the host IP address are 0, then this address does not represent an individual address, but the entire network;
- The address 127.0.0.1 means forwarding within the same host (used for offline debugging of network software);
- Addresses of closed networks (private network, Internet network) are in the ranges 10.0.0.0-10.255.255.255, 172.16.0.0-172.31.255.255, 192.168.0.0192.168.255.255.

In order to more economically distribute IP addresses between users, the class model is replaced by a classless one, in which the allocation of bits in the address allocated for network numbering is specified by a special four-byte code - the subnet mask. The bits of the mask used for numbering networks have single values. For example, the mask 255.255.255.240 (code 11111111.11111111.11111111.11110000 in the binary system) indicates that 28 high digits are used for network numbering, and only 4 low digits of the corresponding IP address are used for host numbering. IP address entry of the type 192.96.10.0/28 is often used. The number after the slash means the number of single digits in the subnet mask.

IP addresses for specific computers can be set manually by the network administrator, which is very difficult. To automate the process of assigning IP addresses to local network hosts, a special DHCP protocol (Dynamic Host Configuration Protocol) is used, which provides static or dynamic assignment of IP addresses. Address assignments are formed by the DHCP server based on requests from DHCP client programs installed on individual hosts.

In the automatic static method, the DHCP server assigns an IP address and other configuration parameters to the client from a pool (set) of available IP addresses without operator intervention. The limits of the pool of assigned addresses are set by the administrator when configuring the DHCP server. Between the client's ID and its IP address, there is a constant correspondence between the client's ID and its IP address, as before, as with manual assignment. It is set at the moment of initial assignment of the client's IP address by the DHCP server. With all subsequent requests, the server returns the same IP address.

With dynamic allocation of addresses, the DHCP server assigns an address to the client for a limited time, which makes it possible to later reuse IP addresses by other computers.

Computers use numerical IP addresses to communicate, while humans are more comfortable working with verbal names. In order for verbal names to be used in network applications, a name-to-IP address conversion mechanism is required, which is implemented by the DNS (Domain Name System) domain name service, a distributed database that supports a hierarchical name system for identifying hosts on the Internet.

The DNS service is designed to automatically look up an IP address using a known symbolic host name. DNS servers store a part of the database on the correspondence between symbolic names and IP addresses. This database is distributed across the administrative domains of the Internet. Clients of the DNS server know the IP address of the DNS server of their administrative domain and, using the IP protocol, send a request in which they report a known symbolic name and ask to return the IP address corresponding to it.

If data about the requested match is stored in the database of this DNS server, then it immediately sends a response to the client, if not, then it sends a request to a DNS server of another domain, which either processes the request itself or forwards it to another DNS server. All DNS servers are connected hierarchically, according to the hierarchy of Internet domains.

The DNS database has a tree structure called **a domain namespace** , in which each domain (tree node) has a name and can contain subdomains. The domain name identifies its position in this database in relation to the parent domain, with periods in the name separating the parts that correspond to the domain hosts.

Top-level domains are assigned on a country-by-country basis as well as on an organizational basis. The domain name is made up of words separated by dots and containing Latin letters, numbers and a minus sign (-). Domain names can contain up to 63 characters and are case-insensitive, meaning uppercase and lowercase letters are considered the same.

The InterNIC organization, which manages the entire Internet address space, as well as the entire name space, delegates to some organizations the right to maintain first-level domains, which include the following "organizational" zones (**com** - commercial, **edu** - educational, **gov** - government, **int** - international, **mil** - military, **net** - organizations that ensure the operation of the network, **org** - non-profit organizations, **biz** - the same as **com** , **info** - information resources), as well as more than two hundred "geographic" domains (**ru** and **su** - Russia, **uk** - Great Britain, **de** - Germany, **fr** - France, **ua** - Ukraine, etc.).

The owner of the domain zone can organize any subdomains in it and delegate the functions of administration of these subdomains to other organizations. A subdomain is created by appending another dot-separated word to the domain name on the left. Each domain has a unique name, and each subdomain has a unique name within its own domain. Each host on the Internet is uniquely identified by its full domain name, which includes the names of all domains from the host to the root. An example of a full DNS name: alice.pnzgu.ru.

2.3 Network diagnostics system utilities

Ipconfig utility is designed to verify the correctness of the TCP/IP configuration for the Windows operating system. Returns values for the current configuration of the TCP/IP stack: MAC and IP addresses, subnet mask, default gateway address, WINS (Windows Internet Naming Service) and DNS server addresses, DHCP usage.

When troubleshooting a TCP/IP network, you should first check the correctness of the configuration using the ***ipconfig utility*** .

Syntax utilities : ***ipconfig [/ all] [/ renew [adapter]] [/ release [adapter]]*** .

Parameters (optional parameters are indicated in square brackets hereafter):

- ***all*** displays the entire list of parameters, without this key only the IP address, mask and default gateway are displayed;
- ***renew [adapter]*** renews the DHCP configuration parameters for the specified network adapter named ***adapter*** ;
- ***release [adapter]*** releases the allocated DHCP IP address.

Thus, the ipconfig utility (Fig. 2.34) allows you to find out whether the configuration is initialized and whether the IP addresses are not duplicated:

- if the configuration is initialized, the IP address, mask, and gateway appear;
- if the IP addresses are duplicated, the network mask will be 0.0.0.0;

- if the computer could not get an IP address when using DHCP, then it will be equal to 0.0.0.0.

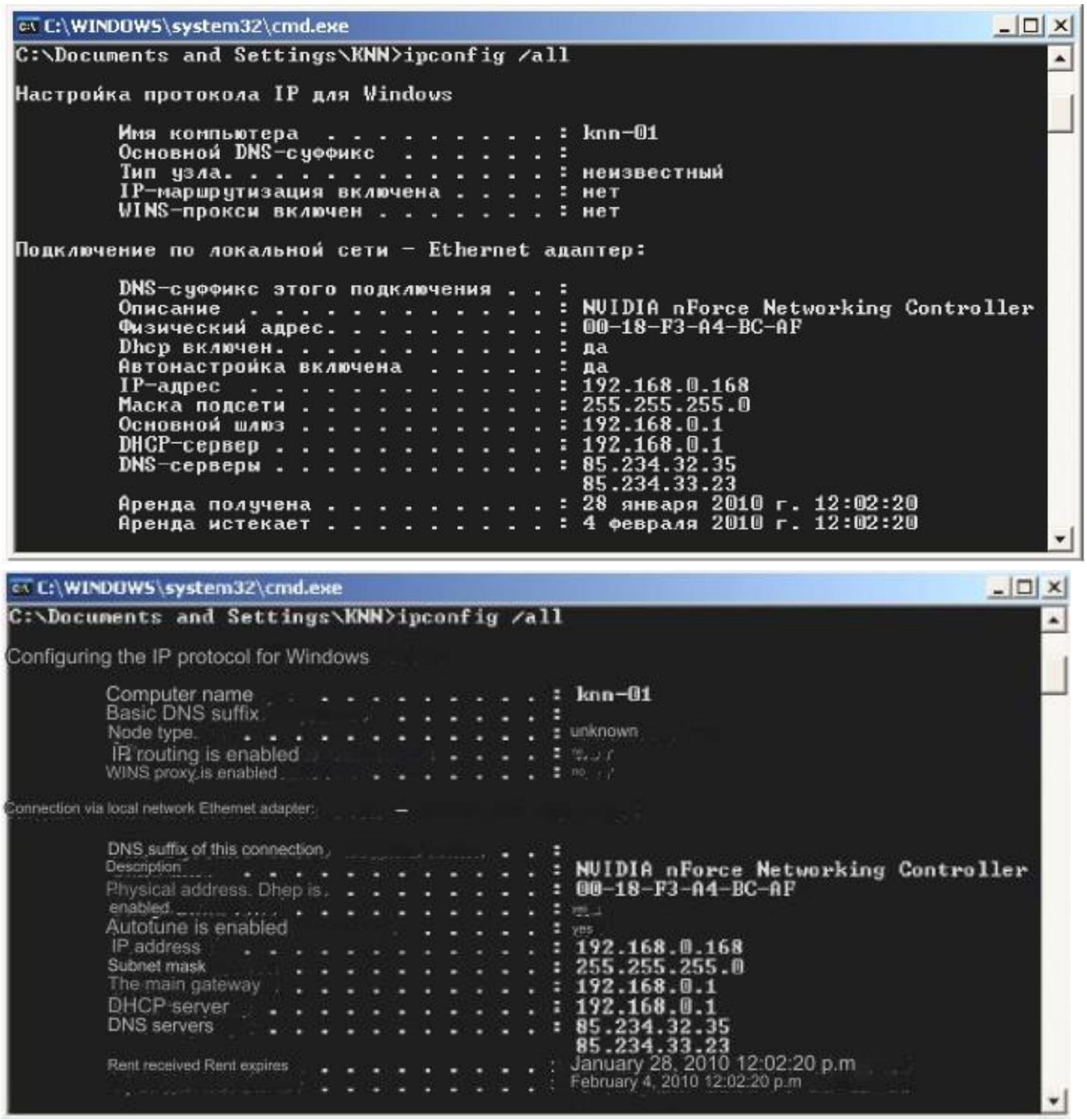


Figure 2.34 – Display of network configurations installed on the computer by the **i *pconfig* *utility***

The ping (*Packet Internet Grouper)* utility is used to check the TCP/IP configuration and diagnose connection errors. It determines the availability and functioning of a specific host - any network device that exchanges information with other network devices via TCP/IP. Using ***ping*** is the best way to verify the existence of a route between a local computer and a network host.

ping command checks the connection with a remote host by sending *Internet Control Message Protocol* (ICMP) echo packets to it and listening for echo responses. ***Ping*** displays the number of transmitted and received packets. Each received packet is checked against the transmitted message. If communication between hosts is poor, ***ping*** messages will show how many packets are lost.

By default, four 32-byte echo packets are transmitted, representing a sequence of uppercase alphabetic characters. ***Ping*** allows you to change the size and number of packets, specify whether the route it uses should be recorded, what the lifetime value can be set, whether the packet can be fragmented, etc. When receiving a response, the field determines how long (in milliseconds) the sent packet reaches the remote host and turns back Since the default value for waiting for a response is 1 s, all values of this field will be less than 1000 ms. If the "Timeout Interval Exceeded" message is issued, it is possible that increasing the response timeout will allow the packet to reach the remote host.

When using the ***ping utility*** , you should remember:

- the delay, which is determined by the utility, is caused not only by the bandwidth of the data transmission channel to the checking machine, but also by the load of this machine;
- some servers may not send echo responses for security purposes, as a hacker attack may start from the ***ping utility.***

Ping can be used to test both a host's domain name and its IP address. If the IP address is ***pinged*** successfully and the name fails, it means that the problem is in the resolution of the address and name, not in the network connection.

Syntax : ***ping [-t] [-a] [-n count] [-l length] [-f] [-i ttl] [-v tos] [-r count] [-s count] [[-j host -list | [-k host-list]] [-w timeout] destinationlist*** . Parameters:

- ***-t*** executes the ***ping command*** until it is interrupted (**Ctrl-Break** - see statistics and continue, **Ctrl-C** - interrupt command execution);
- ***-a*** allows you to determine the domain name of the remote computer by its IP address;
- - ***n count*** sends the number of *Echo packets* specified by ***the count parameter*** (by default, four requests are sent);
- ***-l length*** sends packets of length ***bytes*** (maximum length 8192 bytes);
- ***-f*** sends a packet with the "Do not fragment" flag set, prohibiting fragmentation of the packet on transit routers;
- ***-i ttl*** sets the lifetime of the packet to the value ***of ttl*** (each router reduces ***ttl*** by one, that is, the lifetime is a counter of passed routers (hops));
- ***-v tos*** sets the value of the "service" field, which sets the priority of packet processing;
- ***-r count*** records the path of the outgoing packet and the returning packet in the path entry field, ***count*** - from 1 to 9 hosts;

- ***-s count*** sets the maximum possible number of transitions from one subnet to another (hops);
- ***-j host-list*** routes packets using the list of hosts specified by ***the host-list parameter*** .), the maximum number of hosts is 9;
- ***-k host-list*** routes packets through the list of hosts specified in ***host-list*** , and the specified hosts cannot be separated by intermediate routers (hard static routing);
- ***-w timeout*** indicates the waiting time for a response ***timeout*** from the remote host in milliseconds (default - 1s);
- ***-destination-list*** specifies the remote node to which ***ping*** packets should be directed , can be a hostname or machine IP address.

In practice, options are most often used in the command format
-t and ***-n*** .

An example of the operation of the ***ping utility*** is shown in Figure 2.35.

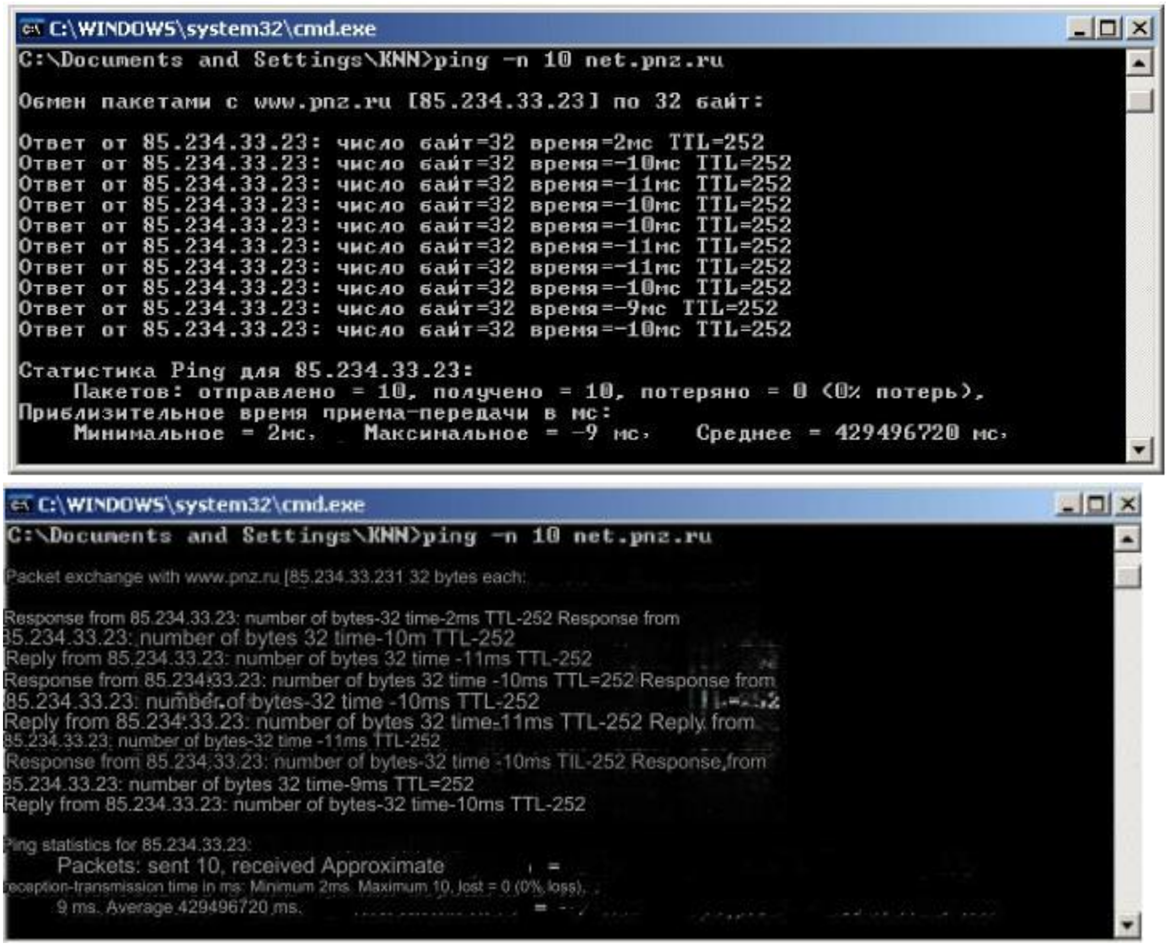


Figure 2.35 is an example of using the ***ping utility***

Ping utility can be used in the following ways:

1. To verify that TCP/IP is installed and configured correctly on the local computer, the loopback address is specified in the ***ping command: ping 127.0.0.1*** .

If the test is passed successfully, you will receive the following response:

Reply from 127.0.0.1: number of bytes = 32 time <1ms TTL = 128
Reply from 127.0.0.1: number of bytes = 32 time <1ms TTL = 128
Reply from 127.0.0.1: number of bytes = 32 time <1ms TTL = 128
Reply from 127.0.0.1: number of bytes = 32 time <1ms TTL = 128

2. To make sure that the computer is correctly added to the network and the IP address is not duplicated, the IP address of the local computer is used: ***ping IP-address_local_host*** .

3. To check that the default gateway is functioning and you can establish a connection with any host on the local network, the IP address of the default gateway is set: ***ping gateway_IP_address*** .

4. To check the possibility of establishing a connection through the router, the IP address of the remote host is specified in the ***ping command: ping IP_address of the remote host*** .

The tracert (*trace route)* utility allows you to discover the sequence of routers through which an IP packet passes on its way to its destination by examining ICMP messages sent back by intermediate routers.

The tracert utility works as follows: I send three test ICMP protocol echo packets with TTL = 1 to the destination node, the first router will send an ICMP "Timeout" message to the source computer. The TTL is then incremented by 1 in each subsequent packet until the packet reaches the destination host or the maximum possible TTL value is reached (default is 30).

The machine name can be the hostname or IP address of the machine. The output is a list of hosts starting with the first gateway and ending with the destination. At the same time, the waiting time for a response to each packet is displayed on the screen.

In those cases where the remote node cannot be reached, using the **tracert utility** is more convenient than ***ping*** because it can be used to locate the area of the network in which there are communication problems.

If there are problems, the utility displays asterisks (*) or messages such as "The specified network is not available", "Time out".

It should be remembered that some routers simply destroy packets with an exhausted TTL and will not be visible to the ***tracert utility*** .

Syntax utilities : ***tracert [-d] [-h maximum_hops] [-j host-list] [-w timeout] destination-list*** . Parameters:

- ***-d*** indicates that addresses for hostnames are not to be resolved;
- ***-h maximum _*** **hops** indicates the maximum number of hops (by default - 30);
- ***-j host-list*** specifies non-rigid static routing according to ***hostlist*** ;

- *-w timeout* indicates that you need to wait a specified number of ms for a response to each echo packet;
- ***-destination-list*** specifies the remote node to which ***ping packets should be directed*** .

tracert utility is shown in Fig. 2.36.

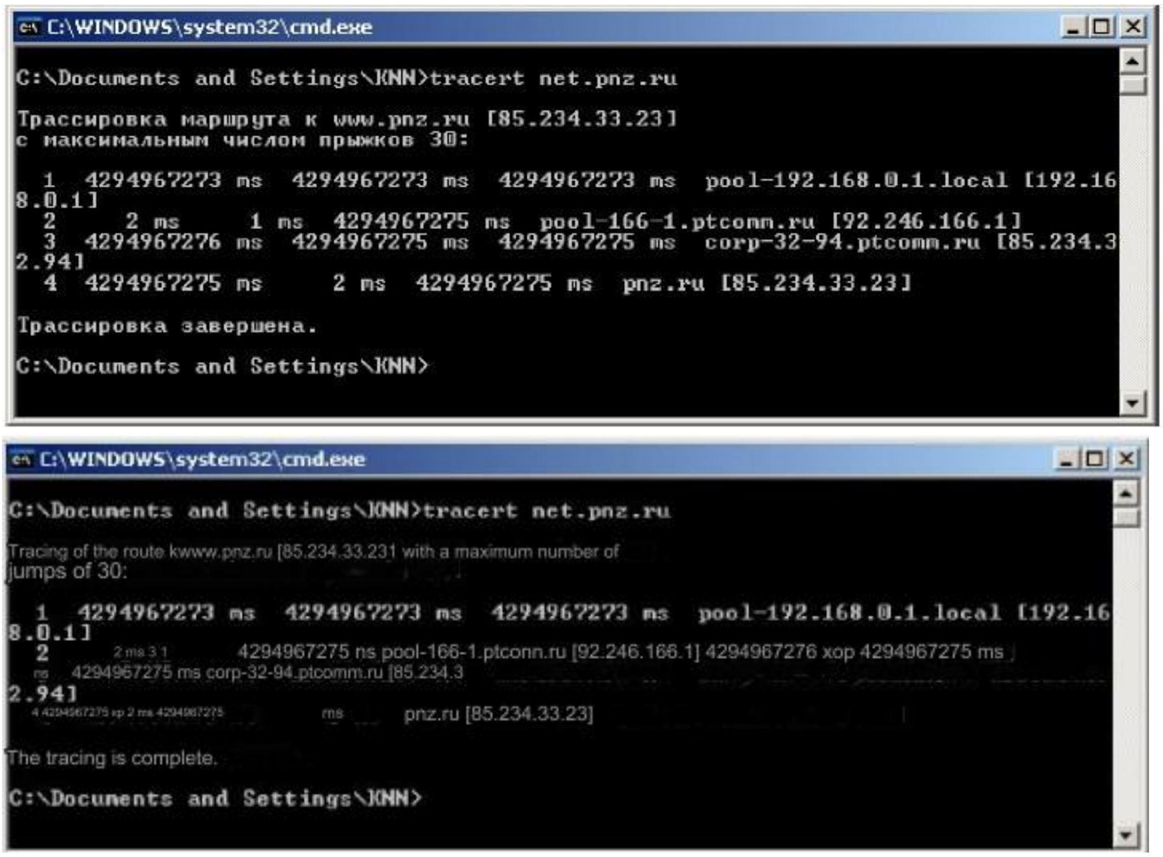


Figure 2.36 – An example of using **the tracert utility**

rp (*Address Resolution Protocol)* utility allows you to manage the so-called ARP cache - a table used to translate IP addresses into corresponding local addresses. Entries in the ARP cache form the ARP protocol. If the necessary entry in the table is not found, then the ARP protocol sends a broadcast request to all computers on the local subnet, trying to find the owner of the given IP address.

The cache can contain two types of entries: static and dynamic. Static records are entered manually and stored in the cache permanently. Dynamic entries are cached as a result of broadcast requests. For them, there is a concept of life time. If the entry was not needed for a certain time (by default, 2 minutes), it is deleted from the ARP cache.

Syntax utilities : ***arp [-s inet_addr eth_addr] [-d inet_addr] [-a]*** .

Parameters:

- ***-s inet_addr eth_addr*** enters a static record with the specified IP address and MAC address into the cache;
- ***-d inet_addr*** deletes an entry for a specific IP address from the cache;
- ***-a*** scans the cache contents for all network adapters on the local computer, as shown in Fig. 2.4.

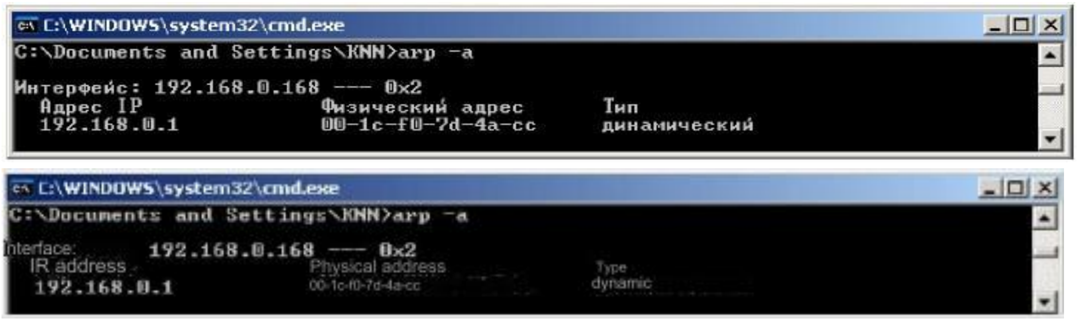


Figure 2.37 – An example of using the *arp utility*

The netstat utility displays protocol statistics and current TCP/IP connections and has the following syntax: ***netstat [-a] [-e] [-n] [-S] [-p name] [-r] [interval]*** . Parameters:

- ***-a*** displays complete information on all connections and ports on which the computer is waiting for a connection;
- ***-e*** displays Ethernet statistics (this key can be used in conjunction with the ***-s*** key);
- ***-n*** displays addresses and port numbers in numeric format, without converting them into symbolic DNS names and into the name of network services, which is done by default ***t*** ;
- ***-p name*** specifies the display of information for the ***name*** protocol (valid values ***of name*** : ***tcp*** , ***udp*** or ***ip***) and is used together with the ***s*** key ;
- ***-r*** displays the contents of the route table (routing table);
- ***-s*** displays detailed protocol statistics. By default, data is output for TCP, UDP, and IP. The ***p*** key allows you to set the data output according to a certain protocol, the ***interval*** key initiates the repeated output of statistical data after the interval specified in seconds (in this case, to stop the data output, press the ***Ctrl + C*** keys).

The result of executing the command is a list of active connections, which includes established connections and open ports (Fig. 2.38).

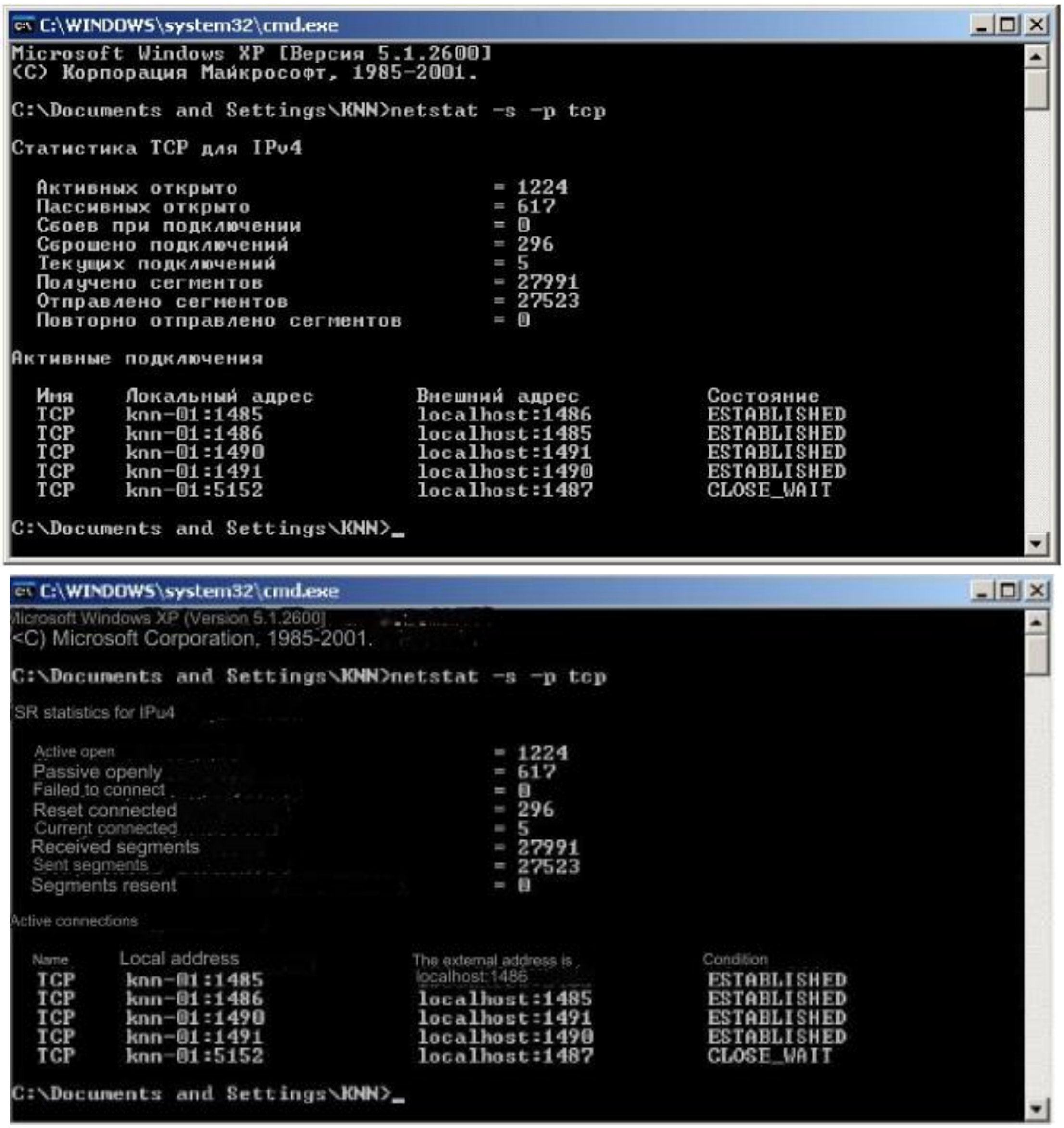


Figure 2.38 – An example of displaying the TCP connections established on the computer by the ***netstat utility***

Open TCP ports are marked in the "Status" column with the line **LISTENING** - passively open connections ("listening" sockets) or **ESTABLISHED** - established connections, that is, already used by network services. Some of the ports are related to Windows system services and are displayed not by number, but by name - ***epmap*** , ***microsoft-ds*** , ***netbios-ss*** , etc. Ports that do not belong to standard services are displayed by numbers. UDP ports cannot be in different states, so the special **LISTENING** flag is not used for them. Like TCP ports, they can be displayed by name or by number.

nslookup utility is designed to query DNS servers to resolve names to IP addresses and, in a simple case, has the following syntax: ***nslookup [host [server]]*** . parameters:

- ***host*** - the domain name of the host, which should be converted into an IP address;

- ***server*** - the address of the DNS server that will be used to resolve the name. If this parameter is omitted, then DNS server addresses from the TCP/IP protocol configuration parameters (displayed by the ***ipconfig utility***) will be used.

The results of the ***nslookup command*** are shown in Fig. 2.39.

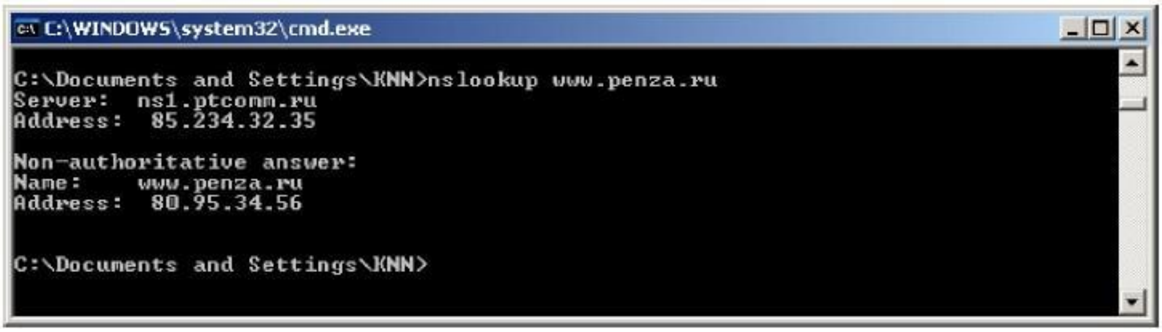


Figure 2.39 – An example of display by the ***nslookup utility***

The first two lines of the response contain the name and IP address of the DNS server that was used to resolve the name. The following lines contain the real domain name of the host and its IP address and the indication ***Nonauthoritative answer*** , which means that the answer was not received from the DNS server responsible for the ***penza.ru zone*** . An ***Aliase*** string may also be present , which contains alternative names for the server being searched for.

When tracing routes or checking the availability of a host on the Internet, it is often necessary to determine the IP address of the host of its legal owner and the contact details of its administrator.

Regarding second-level domains, this information becomes freely available to any Internet user through the ***Whois service*** . On-line service ***Whois*** can be obtained through the form on the website page http://www.nic.ru/whois .

2.4 Studying the configuration of ETHERNET networks

The Ethernet network (IEEE 802.3 standard) became the most widespread among local computer networks. The standard defines multiple access to a "bus" type monochannel with conflict detection and transmission control (in English CSMA / CD - Carrier - Sense Multiple Access / CollisionDetection - an access method with carrier control and collision detection).

The main characteristics of the IEEE 802.3 standard are as follows: topology - "bus", transmission speed - 10 Mbit/s, access method - CSMA / CD, narrowband transmission (monochannel). Transmission is in packets of variable length. Individual, group and broadcast addressing is provided.

In addition to the standard topology of the "bus" type, topologies of the "passive star" and "tree" types are also used. At the same time, the use of repeaters and passive concentrators connecting different parts (segments) of the network is assumed (Fig. 2.40).

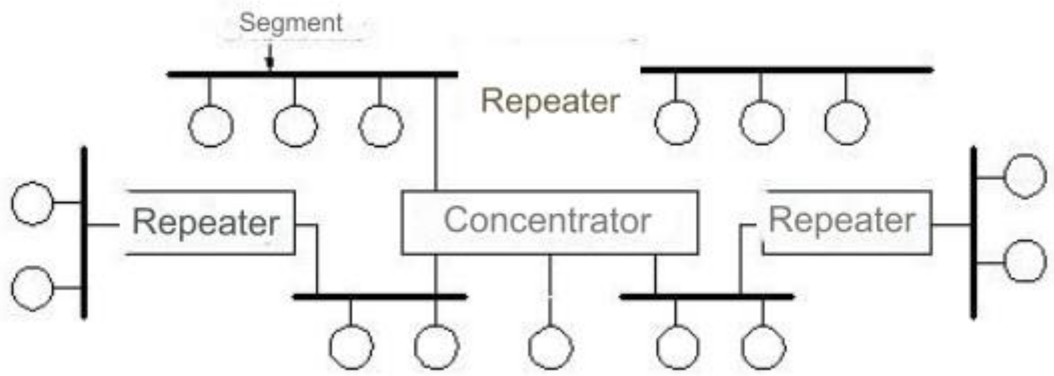


Figure 2.40 – An example of using repeaters and hubs

A single subscriber can act as a segment. The main thing is that there are no closed paths (loops) in the resulting topology. In fact, it turns out that the subscribers are all connected to the same "bus", since the signal from each of them spreads immediately in all directions and does not return back.

For the Ethernet network, the standard defines four main types of transmission media:

- 10 BASE 5 ("thick" coaxial cable);
- 10 BASE 2 ("thin" coaxial cable);
- 10 BASE - T (twisted pair);
- 10 BASE - F (optical fiber cable).

The designation of the transmission medium includes three elements: the number "10" means a transmission speed of 10 Mbit/s, the word BASE means transmission in the main frequency band (that is, without modulation of the high-frequency signal), and the last element means the permissible segment length: "5 "- 500 meters," 2 "- 200 meters (more precisely, 185 meters) or the type of communication line: "T" - twisted pair (from the English "twisted - pair", "F" - optical fiber .

10 BASE 5 equipment ("thick" cable)

10 BASE 5 hardware is shown in fig. 2.41, and the connection diagram of the adapter to the "thick" cable - in fig. 2.42.

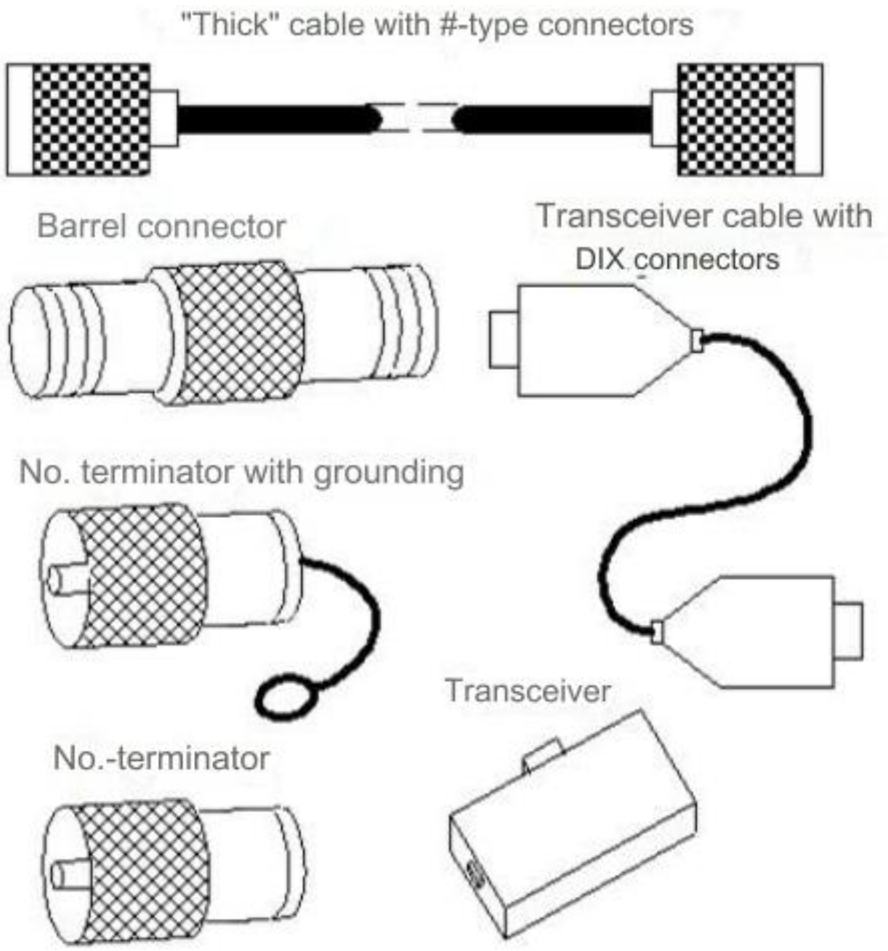


Figure 2.41 - 10 BASE 5 hardware

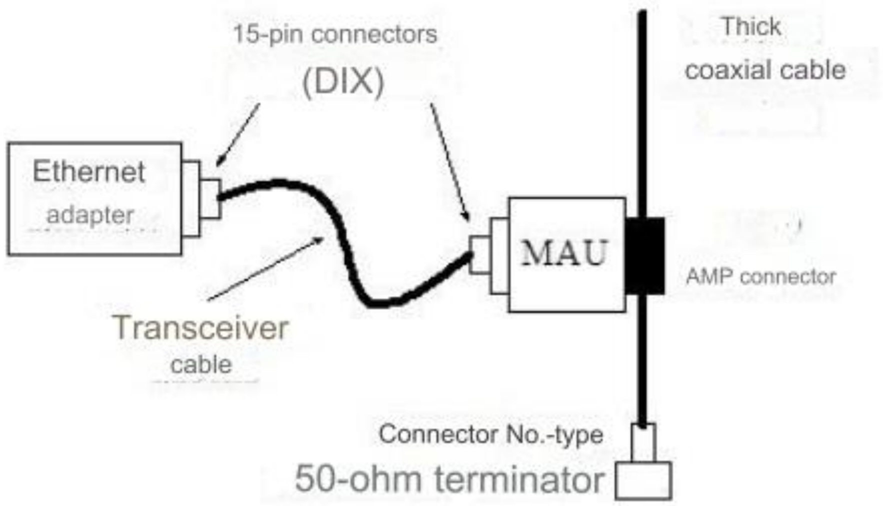


Figure 2.42 – Connection diagram of the adapter to the "thick" cable

"Thick" coaxial cable has a diameter of 0.5 inches (about 1 cm) and is characterized by high rigidity, which leads to great difficulties in installing equipment. The wave resistance of a "thick" coaxial cable is 50 ohms. The maximum length of the segment is 500 meters (without repeaters). "Thick" cables of the RG-8 and RG-11 type are widely used.

N-type connectors are used to connect pieces of "thick" coaxial cable and connect terminators to it. Two N-type connectors are connected using Barrel connectors.

At the ends of the segment cable, 50-ohm N-type terminators must be installed, one of which must be grounded.

An AMP connector is most often used to connect transceivers to a "thick" cable.

A special transceiver (or MAU - Medium Attachment Unit) is placed directly on the cable, which is connected to the network adapter by means of a flexible multi-conductor transceiver cable AUI (about 1 cm in diameter), consisting of 4 twisted pairs, which has 15-pin connectors at the ends (DIX connectors of the "plug" type). The length of an ordinary transceiver cable can reach 50 m, and a thinner and more flexible office variant of the transceiver cable - up to 12.5 m. The transceiver is powered by a computer power source.

A transceiver (transmitter + receiver = transceiver) is a part of a network adapter that performs the following functions:

- reception and transmission of data from cable to cable;
- determination of collisions on the cable;
- electrical separation between the cable and another part of the adapter; - cable protection against incorrect operation of the adapter.

It is allowed to connect no more than 100 transceivers to one segment, and the distance between the transceiver connections should not be less than 2.5 m. The connection diagram of the computers of the network segment on the "thick" cable is shown in Fig. 2.43.

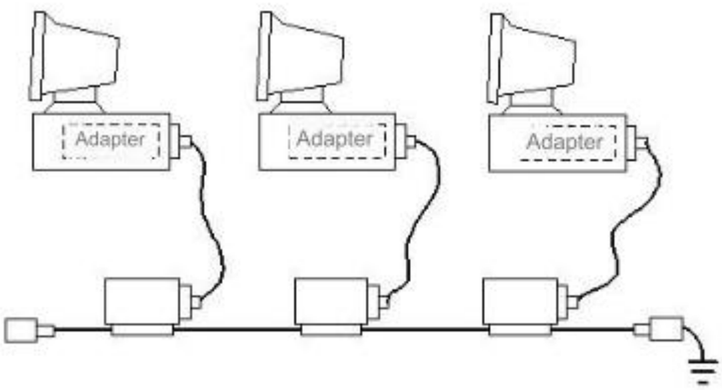


Figure 2.43 – Diagram of connecting computers of a network segment on a "thick" cable

A network adapter working with a "thick" cable must have an external 15-pin AUI connector (DIX type "socket" connector).

The standard allows the use of no more than 4 repeaters (repeater hubs) and, accordingly, no more than 5 cable segments in the network. This gives a maximum length of 10 BASE 5 network equal to 2500 meters. Only 3 segments out of 5 can be loaded, that is, those to which computers are connected. There must be unloaded segments between the loaded segments, so that the maximum network configuration is two loaded end segments that are connected by unloaded segments to one more central loaded segment.

The rule for using repeaters (repeater concentrators) in the network

Ethernet 10 BASE 5 is called the "5-4-3 rule": 5 segments, 4 repeaters (repeater hubs), 3 loaded segments.

Each repeater (repeater hub) is connected to a segment with its own transceiver, so no more than 99 computers can be connected to loaded segments. The maximum number of computers in a 10 BASE 5 network is 99.3 = 297 computers.

The minimum set of equipment for a single-segment network on a "thick" cable includes the following elements:

- network adapters (by the number of connected computers);
- "Thick" cable with N-type connectors at the ends, the total length of which is sufficient to connect all computers in the network;
- transceiver cables with 15-pin connectors at the ends of the length from the computer to the "thick" cable (according to the number of network adapters);
- transceivers (by the number of network adapters);
- two N-type barrel connectors for connecting terminators at the ends of the cable;
- one N-terminator without grounding;
- one N-terminator with ground.

10BASE2 hardware ("thin" cable)

A "thin" coaxial cable differs from a "thick" one by a smaller thickness - a diameter of about 0.5 inches (5 mm), greater flexibility, great ease of installation, and lower cost. "Thin" cable has an impedance of 50 ohms and requires 50 ohm termination. The maximum length of the segment is 185 meters (without repeaters).

The biggest disadvantage of the "thin" cable is the shorter permissible length of the segment (up to 185 m). The most common types of "thin" coaxial cable are RG -58 / U, RG -58 A / U, RG -58 C / U. 10 BASE 2 hardware is shown in fig. 2.44, and the connection diagram of the adapter via a "thin" cable - in fig. 2.45.

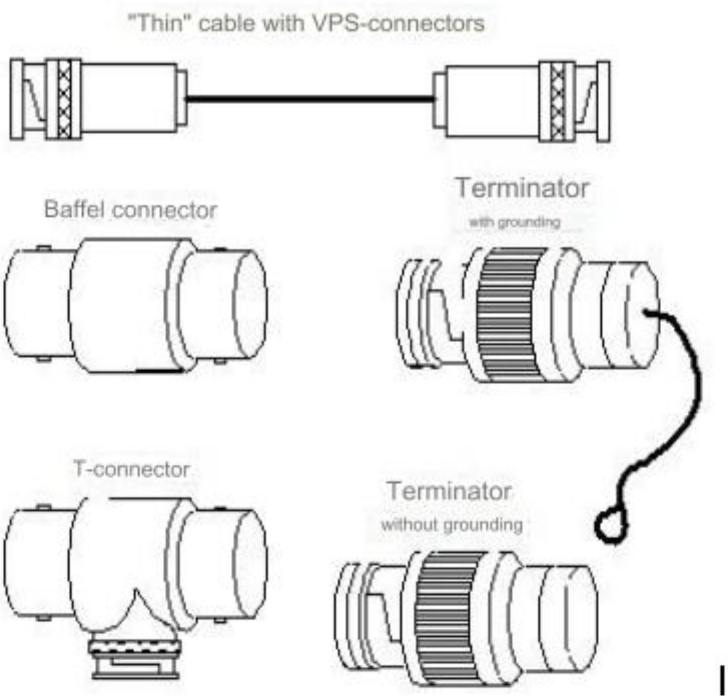


Figure 2.44 - 10 BASE 2 hardware

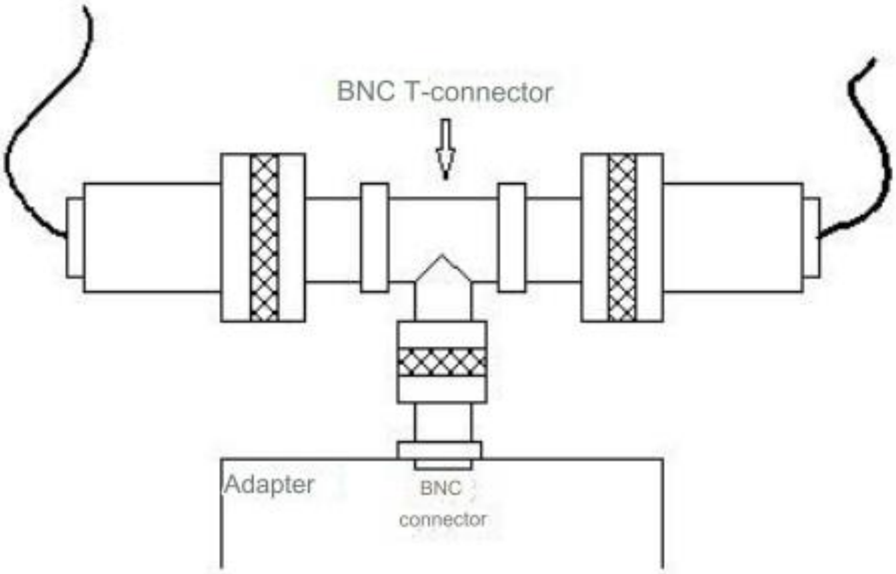


Figure 2.45 – Connection diagram of the adapter via a "thin" cable

If the entire network is performed on a "thin" cable, then, according to the standard, the number of segments should not exceed five (the total length of the network will be 925 m, four repeaters will be required). At the same time, there should not be more than 30 subscribers on one segment, including repeaters, that is, the total number of computers in the network based on a "thin" cable cannot be more than (30-1)*3 = 87. The minimum distance between computers - 1 m.

The 10 BASE 2 standard provides for the use of repeaters (repeater concentrators), the use of which must also comply with the "rule 5-4 - 3".

The minimum set of equipment for a single-segment network on a "thin" cable should include the following elements:

- Network adapters (by the number of computers connected to the network);
- lengths of cable with BNC connectors on two ends, the total length of which is sufficient to connect all computers;
- BNC T-connectors (by the number of network adapters); - one BNC terminator without grounding; - one BNC terminator with grounding.

10BASE-T hardware (twisted pair)

In an Ethernet network based on a twisted pair (UTP cable, Unshielded Twisted - Pair Cable), signal transmission is carried out over two twisted pairs of wires, each of which is transmitted only in one direction (one pair is transmitting, the other is receiving). Each of the subscribers of the network is connected by a cable to the hub, the use of which is mandatory.

The length of the connecting cable between the adapter and the hub should not exceed 100 m. The cable used is flexible, with a diameter of about 6 mm. The most common type of cable is EIA / TIA category 3 telephone cable.

Cables are connected by 8-pin RJ-45 type connectors, in which only four contacts are used. Hubs sometimes also use 50-pin Telco connectors.

The standard defines the maximum number of hubs between two network stations, namely 4. This rule is called the "4-hub rule". When creating a 10 BASE-T network with a large number of stations, hubs can be connected to each other in a hierarchical way, forming a tree-like structure.

Loop connections of hubs in the 10 BASE-T standard are prohibited. Reservation of connections (creation of parallel communication channels between important hubs to reserve connections in case of failure of a port, hub or cable) is possible only by transferring one of the parallel connections to an inactive (blocked) state.

The total number of computers in the network is 10 BASE-T-1024, the maximum length of the network (the maximum distance between two computers in the network) is 500 m.

The minimum set of equipment for a twisted pair network includes the following elements:

- Network adapters (by the number of computers connected to the network) with RJ-45 connectors;
- cable segments with RJ-45 connectors at the ends (by the number of computers to be joined);

- One hub that has as many UTP ports as it is necessary to connect computers.

10BASE-FL equipment (optical fiber cable)

The use of an optical fiber cable in Ethernet, in addition to providing full galvanic isolation of network computers, allowed to increase the length of the segment and significantly increase the stability of the transmission.

Information is transmitted over two fiber optic cables that transmit signals in different directions.

The 10 BASE FL standard provides communication between two computers, between two repeaters or between a computer and a repeater. The standard guarantees the length of the fiber optic connection between repeaters up to 1 km with a total network length of no more than 2500 m. The maximum distance between a computer and a hub is 2000 m. The maximum number of repeaters (repeater hubs) between any computer by network computers - 4. The maximum length of the 10 BASE - FL fiber optic cable connecting repeater hubs (repeaters) with computers should not exceed 400 meters. Computers can be connected to all segments.

10 BASE - FL equipment is similar to both 10 BASE 5 equipment (external transceivers connected to the transceiver adapter cable are used) and 10 BASE - T equipment (passive star topologies and two unidirectional cables are used). The network adapter and hub connection diagram is shown in Fig. 2.46.

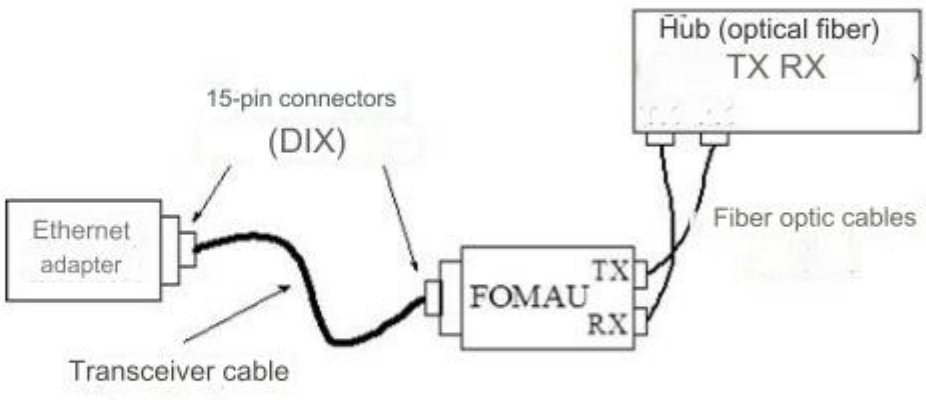


Figure 2.46 – Network adapter and hub connection diagram

The minimum set of equipment for connecting two computers with a fiber optic cable includes the following elements:

- two network adapters with transceiver connectors;
- two optical fiber transceivers (FOMAU);

- two transceiver cables;
- two fiber optic cables with ST-connectors at the ends.

Independent work. Selecting an Ethernet configuration

Adherence to the numerous restrictions established for various standards of the physical layer of Ethernet networks guarantees the correct operation of the network.

The rules of "5-4-3" for coaxial networks and "4-hubs" for networks based on twisted pair and optical fiber not only guarantee network performance, but also leave a large "safety margin" of the network.

For networks consisting of mixed cable systems, for which the rules on the number of repeaters are not calculated, additional calculations must be made.

In order for an Ethernet network consisting of segments of different physical nature to work correctly, four basic conditions must be met:

- the number of computers in the network is no more than 1024;
- the maximum length of each physical segment is not more than the value defined in the corresponding physical level standard;
- the time of double signal turnover between the two most distant computers of the network is no more than 575 bit intervals;
- reduction of the inter-frame interval when passing a sequence of frames through all repeaters should be no more than 49 bit intervals.

Compliance with these requirements ensures correct operation of the network even in cases where simple configuration rules, which determine the maximum number of repeaters and the total length of the network of 2500 m, are violated.

Calculation of the time of double turnover of the signal (PDV-Path Delay Value or RDT - Round Trip Delay)

The model used to estimate the Ethernet change is based on calculating the time characteristics of a given configuration. It uses two calculation systems: one involves the calculation of the double (circular) time of the signal passing through the network, and the other - checking the admissibility of the received (interframe) time interval. At the same time, calculations in both calculation systems are conducted for the worst case.

The first system of calculations uses concepts such as "initial segment", "intermediate segment" and "final segment". Note that there may be several intermediate segments, and the initial and final segments may change places in different calculations. The delay values presented in Table 2.9 are used for calculations.

Table 2.9 – Values of delays

Segment type Ethernet	Max. length, m	Initial segment		Initial segment		Initial segment		Initial segment
		t0	tm	t0	tm	t0	tm	t1
10BASE5	500	11.8	55.0	46.5	89.8	169.5	212.8	0.0866
10BASE2	185	11.8	30.8	46.5	65.5	169.5	188.5	0.1026
10BASE-T	100	15.3	26.6	42.0	53.3	165.0	176.3	0.1130
10BASE-FL	2000	12.3	212.3	33.5	233.5	156.5	356.5	0.1000
FOIRL	1000	7,8	107.8	29.0	129.0	152.0	252.0	0.1000
AUI (> 2 m)	2+48=50	0	5.1	0	5.1	0	5.1	0.1026

Note. Delays are given in bit intervals.

procedure is reduced to the following:

1. The path of the longest length is distinguished in the network;
2. If the length of the segment is not maximum, then the double (circular) travel time in each segment of the selected path is calculated according to the formula: ts= L*t1+t0, where L is the length of the segment in meters (in this case, the type of segment: initial, intermediate or final must be taken into account);
3. If the length of the segment is maximum, then the delay value tm is taken from the table for it;
4. The total amount of delays of all segments of the allocated path should not exceed 575 bit intervals;
5. Then it is necessary to perform the same actions for the reverse direction of the selected path (that is, considering the final segment as the initial one, and vice versa);
6. If the delays in both cases do not exceed 575 bit intervals, then the network is operational.

If in your chosen network configuration the path of the longest length is not so obvious, then similar calculations must be made for all paths claiming the greatest signal delay. In any case, the double transit time according to the standard is not enough to make a final conclusion about the performance of the network.

Calculation of the reduction of the interframe interval (PVV - Path variability Value)

In order to recognize the network configuration as correct, it is also necessary to calculate the reduction of the inter-frame interval by repeaters (repeater hubs).

This value must not be less than 49 bit intervals. The concepts of initial segment and intermediate segment are also used for calculations here (the final segment does not contribute to shortening the interframe interval, since the packet reaches the receiving computer through it without passing through repeaters and repeater concentrators).

To calculate the reduction of the interframe interval, you can use the values of the maximum values of the reduction of the interframe interval when passing repeaters (repeater concentrators) of different physical environments given in table 2.10.

Table 2.10 - Physical environments

Segment type	Initial segment	Intermediate segment
10BASE5	16	11
10BASE2	16	11
10BASE-T	10.5	8
10BASE-FL	10.5	8

By summing up the reductions of the interframe interval for the largest path in the selected configuration and comparing the sum with the limit value of 49 bit intervals, we can draw a conclusion about the performance of the network.

The same calculations are carried out for the return direction along the same path.

Procedure for performing independent work

1. Familiarize yourself with the theoretical part before the laboratory work.
2. According to the given option, design the local computer network of the organization.
3. Prepare a specification for the equipment and materials of the designed local computer network of the organization (APPENDIX 3.2). An example of work performance is given in APPENDIX 3.3.

Address types of the TCP/IP stack

There are three types of addresses used in the TCP/IP stack:

- local (also called hardware)
- IP addresses
- symbolic domain names

Local addresses

A local address in TCP/IP terminology is a type of address that is used by the underlying technology to deliver data within a subnet, which itself is an element of a composite internetwork.

In different subnets, different network technologies and different protocol stacks are permissible, therefore, when creating a TCP/IP stack, the presence of different types of local addresses was already assumed in advance.

If the subnet of the internet is a local network, then the local address is **the MAC address** assigned to the network adapters and network interfaces of the routers.

MAC addresses are assigned by equipment manufacturers and are unique because they are managed centrally. For all existing LAN technologies, **the MAC** address has a 6-byte format, for example 11-AO-17-3D-BC-01.

It should be noted that since the IP protocol can also work on higher-level protocols. In this case, the local addresses for the IP protocol will accordingly be the addresses of the corresponding higher-level protocols.

It should be taken into account that a computer in a local network can have several local addresses even with one network adapter. Conversely, some network devices do not have local addresses at all. For example, such devices include global router ports designed for point-to-point connections.

IP addresses are the main type of network layer addresses

Based on IP addresses, the network layer transmits packets between networks:

IP addresses consist of 4 bytes (32 bits).

IP addresses are assigned by the administrator during the configuration of computers and routers.

An IP address consists of two parts: a network number and a node number.

Network number	Node (host) number

The network number can be chosen by the administrator arbitrarily, or assigned based on the recommendation of a special Internet unit (Internet Network Information Center, InterNIC), if the network must work as a component of the Internet. Typically, ISPs obtain address ranges from InterNIC units and then distribute them to their subscribers.

The node number in the IP protocol is assigned regardless of the node's local address.

By definition, the router enters several networks at once. Therefore, each port of the router has its own IP address (Fig. 4.1).

190.15.67.1 190.15.40.1190.15.40.2185.30.155.1 (Мережа - Network)

Figure 2.47 – An example of irrational use of the IP address space

Before sending the packet to the next network, the router must determine its local address based on the found IP address of the next router. For this, the IP protocol, as shown in Fig. 4.2, refers to the address resolution protocol (ARP).

An endpoint can also belong to multiple IP networks. In this case, the computer must have several IP addresses, according to the number of network connections.

Thus, an IP address does not characterize a single computer or router, but a single network connection.

Symbolic names

domain names in IP networks .

Domain names are built on a hierarchical basis. A full symbolic name in IP networks consists of several components, which are separated by a dot. They are listed in the following order (from left to right): name of the node group, name of the end name of the larger node group. (for example, the name of the . (subdomain) of the organization)

The domain is indicated according to the geographical principle: UA - Ukraine, RU - Russia, UK - Great Britain, SU - USA)

An example of a domain name can be the name base2.sales.zil.ru. There is no correspondence between the domain name and the IP address of the node, so it is necessary to use some additional tables or services so that the Internet node can be uniquely identified in the network, both by the domain name and by the IP address.

IP addresses. Classes of IP addresses

IP address structure

IP addresses are not assigned to the nodes of the component network, but to the network interfaces of the nodes of the component network.

Most computers on an IP network have a single network interface (and as a result, a single IP address). But computers and other devices can have several (if not more) network interfaces - and each interface will have its own IP address.

Thus, a device with 6 active interfaces (for example, a router) will have + 6 IP addresses - one for each interface in each network to which it is connected.

Therefore, the IP address uniquely determines the network and the node that is connected to this network. The length of the IP address is 4 bytes (4 by 8 bits), this gives a total of 32 bits of available information.

To improve readability, the IP address is written as four numbers separated by periods:

Binary form: **XXXXXXX. XXXXXXX. XXXXXXX. XXXXXXX** X= bit state, 0 or 1

XXXXXXXXX - byte
Decimal form: **YYY. YYY. YYY. YYY** YYY= a number between 0 and 255

For example, **128.10.2.30** is the decimal form of the address representation - 4 (decimal) numbers separated by dots (.), and **10000000 00001010 00000010 00011110** - binary representation of the same address.

Binary system	7-bit	6-bit	5-bit	4-bit	3-bit	2-bit	1-bit	0-bit
Decimal system	$2^7=128$	$2^6=64$	$2^5=32$	$2^4=16$	$2^3=8$	$2^2=4$	$2^1=2$	$2^0=1$
The sum of all numbers in the decimal number system within one byte $2^7+2^6+2^5+2^4+2^3+2^2+2^1+2^0=255$								

Since each of the four numbers is a decimal representation of an 8-bit byte, each number can take values from 0 to 255 (gives 256 unique values - remember, zero is also a value).

The decimal form of recording the IP address is used mainly in operating systems, as it is the most convenient for configuration.

In addition to the binary form, there is a hexadecimal form of the IP address record: **C0.94.1.3**

Using 32-bit binary numbers allows you to create **4294967296** unique IP addresses - more than enough for any private intranet.

The IP address consists of two logical parts - **the network number and the node number in the network** (Fig. 2.48) (in general, 32 bits are allocated for the IP address, and of these, N-bits are used to identify the node, and 32-N are used to identify the network number) .

32 - N bits	**N - bit**
Network number	Node number

Figure 2.48 – IP address structure

Classes of IP addresses

Of course, the question immediately arises: how to determine in one address where the network number is, and where the node number is? You can agree to use, for example, the first 8 bits of the address for the network number, and the rest for the node numbers in that network, or the first 16 bits, or the first 24 bits. But in this case, the addressing turns out to be completely flexible, we will have either many small networks and few large ones, or vice versa.

In order to more rationally determine the size of the network and at the same time distinguish which part of the IP address belongs to the network number, and which part belongs to the node number, it was agreed to use a class system. The class system uses the value of the first bit of the address.

But, in such a way that the values of these first bits of the address are indications of which class this or that IP address belongs to. Figure 2.49 shows address classes.

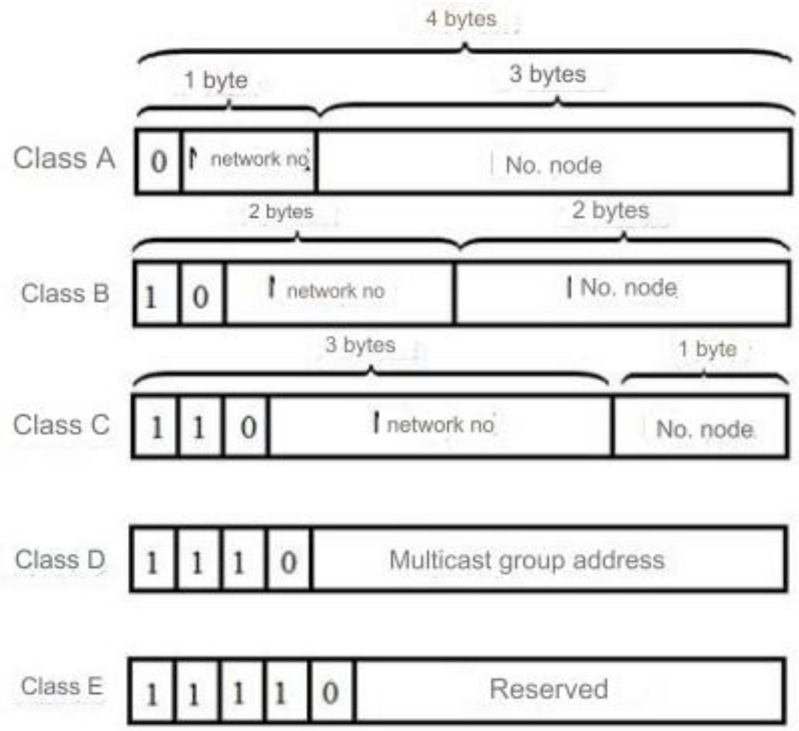


Figure 2.49 – Classes of addresses

A separate table lists the ranges of network numbers and the maximum number of nodes corresponding to each class of networks:

Table 4.1 – Network number ranges and maximum number of nodes

Class	**The first bits**	**The shortest network address**	**The longest network address**	**Maximum the number of nodes**
A	**0**	1.0.0.0	126.0.0.0	2^{24} (16 777 216-2)
B	**10**	128.0.0.0	191.255.0.0	2^{16} (65536-2)
C	**110**	192.0.1.0	223.255.255.0	2^{8} (256-2)
D	**1110**	224.0.0.0	239.255.255.255	Multicast

E	**11110**	240.0.0.0	247.255.255.255	reserved

If the address begins with the sequence 1110, then it is a class D address and denotes a special, group address - **multicast** .

If a class D address is specified as the destination address in the packet, then such a packet must be received by all nodes assigned this address.

If the address begins with the sequence 11110, it means that this address belongs to class E. Addresses of this class are reserved for future applications.

Thus, it can be clearly determined that: large networks receive class A addresses, medium ones - class B, and small ones - class C (Fig. 2.51).

Figure 2.51 - Assignment of classes of IP addresses

Depending on which class (ABS) the address belongs to, the network number can be represented by the first 8, 16, or 24 digits, and the host (node) number by the last 24, 16, or 8 digits.

There are some values of IP addresses that are reserved in advance, that is, there are IP addresses that are reserved for special purposes:

1) If all IP addresses consist of only binary zeros, then it indicates the address of the node that generated this packet

0	0	0	0	………………		0	0	0	0

this mode is used only in some ICMP ICMP messages.

2) If the network number field contains zeros, then by default it is assumed that the destination node belongs to the same network as the node that sent the packet.

0	0	0	0	………………	0	Node number

An IP address with a host number of zero is used to address the entire network. For example, in a class C network with the number 199.60.32, the IP address 199.60.32.0 represents the network as a whole.

3) If all the binary digits of the IP address are equal to 1, then the packet with this destination address must be sent to all nodes on the same network as the source of this packet.

1	1	1	1	………… ……	1	1	1	0

Such a mailing is called a limited broadcast message .

4) If there are only ones in the destination node number field, the packet with this address is sent to all network nodes with the given network number. For example, a packet with the address 192.190.21.255 is delivered to all nodes on the 192.190.21.0 network.

Networ k number	1	1	1	………… ……	1	1	1	1

Such a mailing is called a broadcast message (**broadcast**), that is, the data stream is intended for reception by all sections of the network (within one network segment (Fig. 2.52).

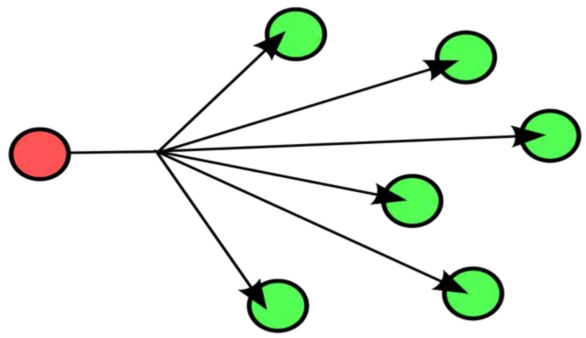


Figure 2.52 – Wide-language transmission scheme

Suppose, for example, that one of the hosts on a Class C network with a network address of **199.60.32.0** is going to send a message to all other hosts on the same network. In this case, the message should be sent to the address **199.60.32.255** (the last byte 255 is broadcast).

Thus, neither the network number nor the node number can consist of only one binary ones or only one binary zeros. It follows that the maximum number of nodes, which is given in table 4.1 for networks of each class, should be reduced by 2 (broadcast + node numbers) in practice.

The IP address, the first octet (byte) of which is equal to 127 and is reserved for testing programs and the interaction of processes within the same machine, has a special meaning.

When the program sends data to the IP address **127.0.0.1** , a "loop" is formed, that is, the data is not transmitted over the network, but is returned to the upper-level modules as soon as they are received.

Therefore, in an IP network, it is forbidden to assign IP addresses to machines starting with 127. This address is called **loopback** .

You can assign the address 127.0.0.0 to the internal network of the routing module of the node, and the address 127.0.0.1 to the address of this module on the external network.

In fact, any network address 127.0.0.0 serves to indicate its routing module, not just 127.0.0.1, such as 127.0.0.3.

In the IP protocol, there is no concept of broadcast in the sense in which it is used in channel-level protocols of local networks, when data must be delivered to absolutely all nodes.

Both the limited broadcast IP address and the broadcast IP address have their limits of distribution in the intranet - they are limited either to the network to which the source node of the packet belongs, or to the network whose number is specified in the destination address. Therefore, partitioning the network by means of routers localizes the broadcast storm to the boundaries of one of the components of the common network of parts simply because there is no way to address the packet simultaneously to all nodes of all the networks of the component network.

Multicast IP addresses mean that this packet must be delivered at once to several nodes that form a group with the number specified in the address field.

Nodes identify themselves, which means they determine which group they belong to. The same node can belong to several groups. Members of any **multicast group** do not necessarily have to belong to the same network. In the general case, they can be distributed over completely different networks, located from each other on an arbitrary number of hops (transit section of the computer network).

The group address is not divided into the network and node number fields and is handled by the router in a special way.

The main purpose of **a multicast address** is to distribute information according to the "one-to-many" scheme.

Figure 2.53 - **Multicast technology**

It works as follows: a host that wants to transmit the same information to many subscribers, using a special protocol IGMP (Internet Group Management Protocol), reports the creation of a new multicast group with a certain address in the network.

Routers that support multicasting distribute information about the creation of a new group in the networks connected to the ports of this router.

Hosts that want to join a newly created multicast group report this to their local routers, which forward this information to the host that initiated the creation of the new group.

In order for routers to be able to automatically distribute packets with a multicast address over a complex network, it is necessary to use special modified routing information exchange protocols in the end routers.

In general, group addressing was intended for economic distribution on the Internet or a large corporate network of audio or video programs intended for a large audience of listeners or viewers at once.

It must be said that if such tools find widespread use (now they represent mainly small experimental areas in the general Internet), then the Internet will be able to create serious competition for radio and television.

So, an IP address can mean one of three things:

1. Network IP address (a group of IP devices that have access to a common transmission medium - for example, all devices in an Ethernet segment). A network address always has the interface (host) bits of the address space set to 0 (if the network is NOT subnetted);

2. The IP network's broadcast address (the address to "talk" to all devices on the IP network). Broadband addresses for a network always have the host bit of the address space set to 1 (unless the network is subnetted).
3. Interface address (for example, Ethernet - adapter or PPP interface of the host, router, print server, etc.). These addresses can have any value of the host bits, excluding all zeros or all ones - not to be confused with network addresses and broadcast addresses.

For a class A network ...

(One byte of network subaddress, three bytes for host number)

10.0.0.0 is a class A network because all host bits are 0.

10.0.1.0 is the host address on this network

10.255.255.255 is the broadcast address of this network because all network bits are set to **1** For a Class B network...

(Two bytes for the network address, two bytes for the host number)

172.17.0.0 class B network

172.17.0.1 is the host address on this network

172.17.255.255 network broadcast address For Class C network.

(Three bytes for the network address, one byte for the host number) **192.168.3.0** Class C network address

192.168.3.42 host address on this network

192.168.3.255 network **broadcast address** Not all available network IP addresses belong to class C.

Masks in IP addressing

So, the traditional IP address distribution scheme for network number and node number, which is based on the concept of class, is considered. The class is determined by the values of the first few bits of the address. Now, for example, we can determine that since the first byte of the address 185.23.44.206 falls into the range 128-191, then this address belongs to class B, which means that the network number is the first two bytes, supplemented by two zero bytes 185.23.0.0, and the number node - 0.0.44.206.

It is obvious that the determination of network numbers by the first bytes of the address is also not a completely flexible mechanism for addressing. And what if we use some other sign, with the help of which it would be possible to more flexibly set the boundary between the network number and the node number?

As such a sign, masks have now become widespread.

The mask is a 32-bit number that looks like an IP address. The mask is used in a pair with the IP address, but does not match it.

The principle of separating the network number and the number of the network node using a mask is as follows: the binary entry of the mask contains *ones* in those digits that should be represented as a network number in the IP address and *zeros* in those digits that are represented as a host number.

Mask (overlaid on IP address)	
111…..1111	000…..000
Defines the network	Specifies the host (node)

Each class of IP addresses (A, B and C) has its own mask, which is used by default.

Since the network number is an integer part of the address, the ones in the mask must also represent a continuous sequence. Thus, for standard classes of networks, masks have the following values:

Class A	**11111111. 00000000. 00000000. 00000000**	**255.0.0.0**
Class B	**11111111. 11111111. 00000000. 00000000**	**255.255.0.0**
Class C	**11111111. 11111111. 11111111. 00000000**	**255.255.255.0**

For example:

If the address 185.23.44.206 **is assigned a mask of** 255.255.255.0 **(** 11111111.1111111.1111111.0000000 **), then the network number will be** 185.23.44.0 **, and not**

185.23.0.0 , as defined by the rules of the class system:

AN D	10111001.00010111.00101100.11001110	**185.23.44.206**	IP address
	11111111.11111111.11111111.00000000	**255.255.255.0**	Mask
	10111001.00010111.00101100.00000000	**185.23.44.0**	Chain

Other formats are used to record **masks ,** for example, it is convenient to interpret the value of a mask written in hexadecimal code: **FF.FF.00.00** - mask for Class B addresses.

The following designation is often found: IP address / network prefix. For example, **185.23.44.206/16** - this entry says that the mask for this address contains 16 units (network prefix), or that in the specified IP address **16** binary digits are assigned to the network number :

Figure 2.54 – Mask in the binary number system

Network prefix notation is also known as Classless Interdomain Routing (CIDR).

Thus, it is very easy to abandon the concept of classes of addresses, by giving each IP address an arbitrary (not necessarily a multiple of 8), thereby making the IP addressing system more flexible.

Example: assign a mask to the IP address 129.64.134.5
255.255.128.0, which in binary form will look like this:

IP address - 129.64. 134.5	**10000001.01000000.1 0000110.00000101**
Mask - 255.255.128.0	**11111111.11111111.1 0000000.00000000**

Here, the first 17 consecutive units in the mask are "superimposed" on the IP address according to the "AND" principle (that is, two units will be one, and zero and one will be zero), and determine the network number:

The IP address of the node is 129.64.128.0	**10000001. 01000000. 10000000. 00000000**

and 15 zeros determine the node number:

0000110.00000101 or **0.0.6.5.**

The mechanism of masks is very widespread in IP routing, and masks can be used for a variety of purposes. With their help, the administrator can structure his network without requesting additional network numbers from the service provider.

Based on the same mechanism, service providers can combine the address spaces of several networks by introducing so-called "prefixes" in order to reduce the volume of routing tables, and thereby increase the performance of routers.

Masks during recording are always "inseparable" from the corresponding addresses, subnet mask IP addresses - this is how we will now describe the address of any network host.

Procedure for assigning IP addresses. Autonomous IP addresses. Automation of IP address assignment

In the situation shown in the example (Figure 2.55), for a dedicated network formed by a channel connecting the ports of two adjacent routers, it is necessary to allocate a separate network number, although there are only 2 nodes in this network.

(Мережа - network, Пограничні маршрутизатори - border routers, Вироджена мережа - dedicated network)

Figure 2.55 – An example of a dedicated network

Let's consider another situation: what IP addresses can the administrator use if the Internet service provider has not assigned any address to him? If, for example, we know for sure that the network we administer will never connect to the Internet in the future (works in "offline mode"), then we can use any IP addresses, observing the rules for their assignment, which were discussed in the speech above. For simplicity, you can use class C addresses: in this case, you do not have to calculate the value of the subnet mask and calculate the address for each host.

In this case, we would simply have to assign each segment of our local network its own Class C network number.

If all segments of our local network have their own class C network numbers, then 254 host numbers can be created in each segment.

However, if there is even a small chance that our network may be connected to the Internet at some point in the future, we should not use such IP addresses. They may conflict with other addresses on the Internet. To avoid such conflicts, you should use IP addresses reserved for private networks.

For this purpose, several blocks of IP addresses are specially reserved, which are called autonomous.

Autonomous addresses are reserved for use by private networks. They are usually used by organizations that have their own large private network - intranets (local networks with the architecture and logic of the Internet), but small networks often find them useful.)

These addresses are not processed by Internet routers under any circumstances. These addresses are selected from different classes:

Class	From the IP address	To the IP address	Total address nodes in the range
A	10.0.0.0	10.255.255.255	16,777,216-2
B	172.16.0.0	172.31.255.255	65 536-2
C	192.168.0.0	192.168.255.255	256-2

These addresses are reserved for private networks. Thus, if in the future we decide to connect our network to the Internet, then even if the traffic from one of the hosts in our network gets into the Internet in any way, there should not be a conflict between the addresses. A router on the Internet is programmed not to broadcast messages sent from or to reserved addresses.

It must be said that the use of autonomous IP addresses also has disadvantages, which are that if we connect our network to the Internet, we will have to re-configure the hosts connecting to the Internet.

Subnetting can be said to be a method of taking a network IP address and breaking it up locally so that one network IP address can actually be used in multiple interconnected local networks.

One network IP address can only be used for one network. The most important thing: division into subnets is a local setting, it is not visible "from the outside". Dividing one large network into subnets significantly relieves the overall traffic and allows you to improve the security of the entire network as a whole.

Algorithm for dividing the network into subnets:

1) We establish physical connections (network cables and network connectors - such as routers);

2) We decide how big/small subnets you need, based on the number of devices that will be connected to them, that is, how many IP addresses need to be used in each network segment.

3) We calculate the corresponding network masks and network addresses;

4) We give each interface in each network its IP address and the corresponding network mask;

5) We configure each router and all network devices;

6) **6)** We check the system, correct errors.

Now our task is to figure out how to perform the 2nd and 3rd steps.

Example 1

Suppose we want to divide our network into subnets, but we only have one network IP address:

IP address of the network	**210.16.15.0**

Solution:

Class	**C** (defined by address range)
Default mask	**255.255.255.0** (depending on the class)
Maximum number of hosts	**254** - network address - broadcast address = **252**
Network address	**210.16.15.0** (mask applied to the address)
Broad address	**210.16.15.255** (last host address)

1) First step: determine the "size" of the subnet.

There is a relationship between the number of created subnets and "spent" IP addresses.

Each individual IP network has two addresses that are not used for interfaces (hosts):

- IP address of the network itself - Broadband address.

When dividing into subnets, each subnet requires its own unique network IP address and broadcast address - and they must be correctly selected from the range of IP addresses of the network we are dividing into subnets.

So, when dividing the IP network into subnets, each of which has two network addresses and two broadcast addresses, it should be remembered that each of them will reduce the number of used interface (host) addresses by two.

We must always take this into account when calculating network numbers.

2) The next step is to calculate the subnet mask and network numbers.

The netmask is what does all the logical manipulation of dividing an IP network into subnets.

There are standard network masks for all three classes of IP networks:

- **Class A** (8 network bits): **255.0.0.0**
- **Class B** (16 network bits): **255.255.0.0**
- **Class C** (24 network bits): **255.255.255.0**

To create **a subnet** , you need to change the subnet mask for a given address class.

The subnet number can be set by borrowing the amount of digits required for subnet numbering in the host number:

<table>
<tr><td>XXXXXX.XXXXXXX</td><td>XXX</td><td>XXXXX</td></tr>
<tr><td>For example: network area X - bit state, 0 or 1</td><td colspan="2">The range of hosts to be subnetted</td></tr>
<tr><td>In this example: 24 bits for network, 3 bits for subnet and 4 bits for hosts
The subnet, hosts, and network range in an IP address may be different for different networks</td><td>Borrowing of the region hosts for subnet identification</td><td>A range of hosts that remain when dividing into subnets</td></tr>
<tr><td colspan="3">The input mask in the given example:
1111111.1111111.1111111.00000000
The newly created mask for identifying the subnet in the given example:
1111111.1111111.1111111.11100000
In the last byte, 3 high-order bits are added to identify subnets</td></tr>
</table>

To do this, the left (higher) digits of the host number are taken, in the mask the self-taken digits are filled with ones to show that these digits now number NOT the node, but the subnet. The values in the bits of the subnet mask remain zero; this means that the remaining bits in the host number in the IP address must be used as the new (smaller) host number.

For example, to split a network address into two subnets, we must borrow one host bit by setting the corresponding bit in the network mask of the first host bit to 1.

If we need four subnets - we use two host bits, if eight subnets - three bits, etc. It is clear that if we need five subnets, then we will use three host bits. The subnet mask changes accordingly:

The procedure for determining the number of bits allocated to the identification of N subnets is shown in Fig. 2.56.

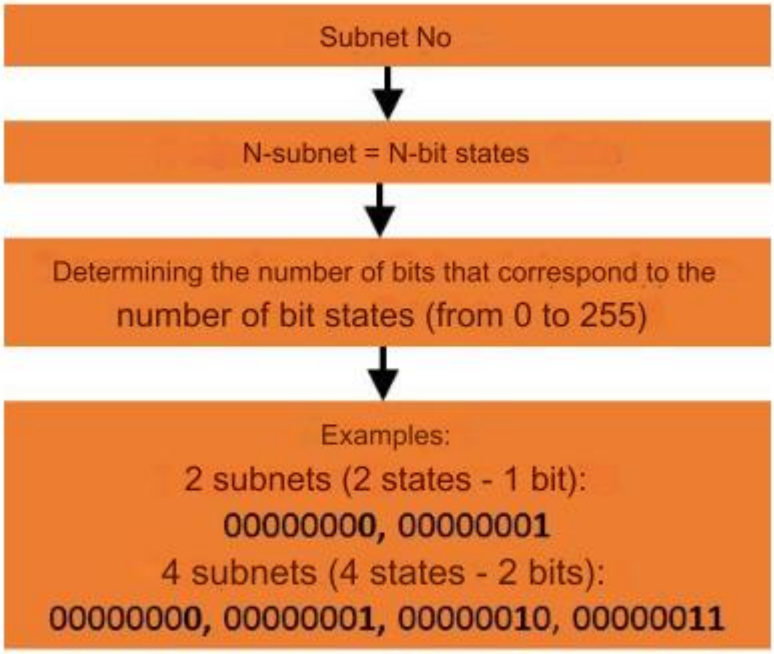


Figure 2.56 – Algorithm for determining the number of bits to identify N subnets

For **class C** addresse**s** , when divided into 2 subnets, this gives a mask - **11111111.11111111.11111111.10000000** or **255.255.255.128**

when divided into **4 subnets,** the mask is in binary form - 11111111.11111111.11111111.11000000 or in decimal 255.255.255.192 etc.

For our class C network address **210.16.15.0** , the following several methods of subnetting can be defined.

Table 2.11 – Subnetting methods

Number of subnets	Number of hosts	Network mask
2	126	255.255.255.128 (11111111.11111111.11111111.10000000)
4	62	255.255.255.192 (11111111.11111111.11111111.11000000)
8	30	255.255.255.224 (11111111.11111111.11111111.11100000)
16	14	255.255.255.240 (11111111.11111111.11111111.11110000)
32	6	255.255.255.248 (11111111.11111111.11111111.11111000)
64	2	255.255.255.252 (11111111.11111111.11111111.11111100)

Now you need to resolve the issue of network addresses and broadband addresses, and the range of IP addresses.

Again, taking into account only class C network addresses, and specifying only sequential (host) addresses, Table 4.3 is obtained.

From Table 2.12, it is immediately clear that increasing the number of subnets reduces the total number of available host addresses. Based on this information, you can assign host and network IP addresses and network masks.

Table 2.12 – Address structure

Network mask	Subnet	Chain	Broadcast	minIP	maxIP	hosts	Total hosts
128	2	0	127	1	126	126	252
		128	255	129	254	126	
192	4	0	63	1	62	62	248
		64	127	65	126	62	
		128	191	129	190	62	
		192	255	193	254	62	
224	8	0	31	1	30	30	240
		32	63	33	62	30	
		64	65	65	94	30	
		96	97	97	126	30	
		128	129	129	158	30	
		160	161	161	190	30	
		192	193	193	222	30	
		224	225	225	254	30	

Example 2.

Let's determine how many subnets are needed for our Class C network to break it up into subnets of 10 hosts each.

Solution:

A Class C network can support a total of 254 hosts plus a network address and a broadcast address.

For addressing 10 hosts, 3 bits are not enough, so 4 bits are needed. So, of the eight possible for class C, we need only 4 bits to address 10 hosts, the others can be used as network bits to address subnets. Each subnet reduces the number of possible host addresses by a factor of two.

4 bits must be used to address 16 subnets. So, let's now count the number of nodes in each of the 16 subnets: $2^4-2 = 14$ hosts. This quantity more than satisfies the condition of the problem. Let's calculate the subnet mask, in this case it looks like this:

11111111.11111111.11111111.11110000 or 255.255.255.240

We will need to specify this mask when configuring each host on our network (regardless of which subnet the host is on).

Now, for example, we can say the address **192.168.200.246** with mask

255.255.255.240 - means network number **192.168.200.240** and node number **0.0.0.6** . Example 3.

Now, for all three classes, we will determine the subnet masks, respectively, and the maximum possible number of nodes in each of these subnets, if it is necessary to divide the class A network, class B network, and class C network into 4 separate subnets, respectively.

Solution:

For a class A network.

The maximum number of nodes is 16,777,216. 2 bits (00000010) are needed to address 4 subnets, so 22 bits remain for addressing hosts. Thus, each of the four subnets is capable of serving 2^{22} -

2=4194302 hosts in each of the subnets.

Number of subnets	Number of hosts	Network mask
4	4,194,302	255.192.0.0 (11111111. 11000000.00000000.00000000)

For a class B network.

The maximum number of nodes is **65536** . To address **4** subnets in a **class B** network address , you also need to use **2 bits** , but now **14 bits** remain free . Thus, each of the subnets can serve **2^{14}-2 =16 382** hosts.

Number of subnets	Number of hosts	Network mask
4	16,382	255.255.192.0 (11111111.11111111.1000000.00000000)

Example 3.

Divide the IP network 192.168.0.0 with mask 255.255.255.0 into 4 subnets. Specify the broadcast address for the subnet.

Solution:

Class C network. Total number of hosts **2^{8}-2 =254** .

Mask 255.255.255.0 allocates 24 high bits for network identification and 8 bits for host identification:

192.168.0.0	**11000000.10101000.00000000.**	**0000000**	network address
255.255.255.0	**11111111.11111111.11111111.**	**0000000**	mask
	Network (24 bits)	hosts (8 bits)	

The number of 4 subnets must correspond to 2 states of bits in the order of their increase from 0 to the fourth state. That is, 4 states 00000000, 00000001, 00000010, 00000011 correspond to the number of bits that will be allocated to identify subnets.

The two most significant bits of the host name are allocated to identify the subnet by creating a new subnet mask:

192.168.0.0	**11000000.10101000.00000000.**	**00**	**000000**	network address
255.255.255.192	**11111111.11111111.11111111.**	**11**	**000000**	Subnet mask
	Network (24 bits)	Subnets (2	hosts (6 bits)	

The address change step is equal to the value of the lower bit of the subnet, i.e. 64, i.e.: 0 - the beginning of the first subnet, 0+64=64 - the beginning of the second subnet, 64+64=128 - the beginning of the third subnet, 128+64=192 - the beginning of the fourth subnet Accordingly addresses are divided into subnets:

192.168.0.0-192.168.63.255 - 1st subnet

192.168.64.0-192.168.127.255 - 2nd subnet

192.168.128.0-192.168.191.255 - 3rd subnet

192.168.192.0-192.168.255.255 - 4th subnet

Each subnet has 256 addresses from 0 to 255, of which 254 are available to hosts, as 0 identifies the subnet:

192.168.0.0

192.168.64.0

192.168.128.0

192.168.192.0, and 255 is the broadcast address:

192.168.63.255

192.168.127.255

192.168.127.255

192.168.127.255

Since the assignment of **IP addresses** to network nodes, even with a small network size, is a very difficult procedure for the administrator, therefore as the second step in **IP addressing** the developers decided to automate this process.

For this purpose, the **Dynamic Host Configuration Protocol** was developed **(DHCP)** , which frees the administrator from these problems **by automating the process of assigning IP addresses** .

DHCP can support a method of automatic dynamic address allocation, as well as simpler methods of manual and automatic static address assignment. The DHCP protocol works according to the client-server model.

During system startup, a computer that is a DHCP client sends a broadcast request to the network to obtain an IP address. DHCP - the server responds and sends a response message containing an IP address. It is assumed that the DHCP client and DHCP server are on the same IP network.

With dynamic allocation of addresses, the DHCP server issues addresses to the client for a limited time, it is called lease duration. This makes it possible to later reuse this IP address to assign to another computer.

The main advantage of DHCP is the automation of the administrator's routine work on the configuration of the TCP/IP stack on each computer. Sometimes the dynamic division of addresses allows you to build an IP network, the number of nodes of which exceeds the number of IP addresses available to the administrator.

In the manual procedure for assigning static addresses, the administrator takes an active part, who provides the DHCP server with information about the correspondence of IP addresses with physical addresses or other client identifiers. The DHCP server, using this information, always issues the address assigned by the administrator to a certain client.

In the automatic static method, the DHCP server assigns an IP address from a pool of available IP addresses without operator intervention. And the limits of the assigning address pool are set by the administrator when configuring the DHCP server.

The address is given to the client from the pool for permanent use, that is, with an unlimited rental period. Between the client's ID and its IP address, there is a constant correspondence, as before, as with the manual one. It is set when the client's IP address is first assigned by the DHCP server. In all subsequent requests, the server returns the same IP address.

DHCP provides a reliable and simple way to configure a TCP/IP network, ensuring no duplication of addresses by centrally managing their distribution.

In this case, the administrator can only control the process of assigning addresses using the "lease duration" parameter, which determines how long the computer can use the assigned IP address before requesting it again from the DHCP server for lease.

Cloud Internet technologies are now more and more setting the tone for using the Internet and storing information on the network. Worldwide social networks such as Facebook, Twitter and others work with them. The "cloud" principle has been developed for a long time, it is a convenient environment for storing and using information that combines hardware, software, communication channels and technical support. With the help of this Internet service, the user has access to his own information, and at the same time he does not have to take care of the infrastructure with which he works.

Often, the concept of cloud or distributed technologies refers to the entire Internet network. In fact, it is an updated version of IT services, or servers, available over the Internet. The technology allows you to expand the IT capabilities of the enterprise, while not requiring additional investments in the creation of new infrastructure, the involvement of additional employees and the retraining of already working personnel.

Fiber optic Internet technology implies high-speed data transmission. Optical waveguides are used to connect fiber-optic Internet, the signal travels along them at the speed of light. At the moment, electronic equipment is used to receive and transmit information, so converters of electronic signals into optical signals and vice versa are needed. Such converters, or fiber optic modems, have long been developed and widely used.

Fiber optic technologies made it possible to get high-speed Internet and use it in large areas. The optical signal in the fiber optic cable is practically not distorted and does not weaken during transmission over long distances. When using fiber optic Internet, you are protected from unauthorized access to transmitted information - induction reading, hacking and other dangers. The technology makes it possible to connect interactive television, IP telephony, video surveillance, security systems, etc. Quartz is the material for the manufacture of optical fiber cable, it is very light, has a long service life, is not exposed to atmospheric influences and is fire-resistant. Currently, the number of users who prefer fiber-optic Internet far exceeds those who use cable Internet.

Modern network technologies provide more and more opportunities both for ordinary Internet users and for business development and advertising, they bring progress in the transmission of systematized data and processing of data arrays. They have their advantages and disadvantages and nevertheless bring tangible benefits to society.

SECTION 3 . USE OF DISTANCE EDUCATIONAL ENVIRONMENT AND INTERNET RESOURCES

3.1. Modern universal and designer and online tools for creating educational websites and blogs

Due to the rapid development of information technologies, when the Internet is added to mass media, which allows working with information at a higher level, the role of educational Internet resources is growing. If a website of an educational institution is created, it helps to improve its image, becomes its business card, advertising tool that works around the clock. Most educational institutions use new information technologies in both educational and extracurricular activities. An educational resource on the Internet is an opportunity to demonstrate your achievements, post relevant information for those who are interested (parents, applicants, schoolchildren, teachers, students, lecturers, colleagues, etc.), inform society about educational services, publish your assets, materials, research results, implement exchange of experience, consultations, etc.

In his works, H. Stetsenko singles out the following types of educational sites [1]:

1. Official websites. These are the sites of governing bodies that host the following educational web resources: government documents, regulations, laws (for example mon.gov.ua – official website of the Ministry of Education and Science of Ukraine; kmu.gov.ua – Government portal).

2. Websites of educational institutions. Accordingly, these sites differ in size (sites of higher educational institutions: nubip.edu.ua - site of the National University of Life and Environmental Sciences of Ukraine).

3. Cultural and educational sites. These include: virtual libraries (nbuv.gov.ua – National Library of Ukraine named after V.I. Vernadskyi); reference websites of libraries (zntu.edu.ua – website of the library of the Zaporizhia National Technical University); collections of abstracts and other scientific works (site of Ukrainian-language abstracts; virtual magazines and newspapers (educational electronic Internet publication for teachers "Informatics and information technologies"), virtual

museums (/scH544/museum - virtual museum of informatics).

4. Sites for online learning. Centers of online education: atutor.tu.edu.te.ua - online learning server of Ternopil State Technical University; Electronic textbooks: /vcg/useful_ukr.html – electronic textbooks on computer science.

5. Reference sites: encyclopedias (open Ukrainian wiki-encyclopedia) are electronic pages with texts and graphic images of a classic encyclopedic nature; dictionaries - an electronic database of definitions from a certain field of knowledge or in several areas; catalogs – contain a list of web addresses of sites by subject; information and reference resources (olymp.vinnica.ua - All-Ukrainian Center for School Olympiads on the Internet) - sites containing reference information about conferences, competitions, seminars, grants , etc.

6. Thematic sites. A site on a certain topic or field of knowledge.

7. Personal sites. The site of an individual person, which contains general information about this person, what he does, what interests he has, etc. For example, pedagogika.at.ua is the website of Nadiya Mykolaivna Stetsenko.

8. Portals. One of the most effective ways to accumulate large amounts of information. (for example: .ua – educational portal)

9. Means of communication. Teleconferences, chats, forums, methodical associations of teachers serve for the exchange of opinions, information, and cooperation with colleagues from other regions. (For example: ki.ifmion.npu.edu.ua/forum - forum of the Department of Informatics of Drahomanov NPU).

It should be noted that over ten years of our research of the Ukrainian segment of the Internet, the situation with Ukrainian-language educational Internet resources has changed for the better. High-quality resources of various educational topics are appearing, using new technologies for the development and functioning of web resources. New Internet services that can be used by educators are being developed.

In the Ukrainian segment of the Internet, we distinguish the following types of Internet resources according to the type of information resource:

1) catalogs — sets of links to web resources with a brief description of them,

structured by appropriate sections, which can be ranked by various features (by quotation index, by date of addition, by alphabet, etc.);

2) ratings — sites, the purpose of which is to evaluate web resources according to various criteria (by attendance, by the quotation index, by the results of user voting, etc.);

3) search engines — online services that provide the ability to search for information on the Internet thanks to the implementation of the site indexing mechanism by the search robot;

4) portals — a multi-level combination of various resources designed to provide integrated information or provide users with various interactive services (search, forums, blogs, news, discussions, mail, file storage, etc.);

5) sites - web nodes, a set of web pages physically located on the same server, united by the same design, theme and navigation;

6) personal pages — web pages or small sites dedicated to information about the professional activity of one person;

7) blogs - websites, the main content of which are records, images or multimedia, which are regularly added by users of blogs through a convenient visual interface;

8) forums - Internet resources, which are a means of communication on the Internet of many users with the help of a certain online service, which provides for the presence of rules for posting, editing and deleting information;

9) social Internet networks - an Internet service that facilitates the creation and maintenance of social circles and networks, communication and establishing connections between people using a set of web tools.

The classification of educational resources according to other characteristics is presented in the study of V. Osadchyi "Educational possibilities of the Internet" [1].

Modern site builders are amazingly simple services that allow you to create your own site in the browser without having any special skills. The results of our analysis of popular services for creating websites are presented in the table. 3.1.

Table 3.1.

Universal services for creating web pages

Service	Jimdo.com	Google sites	Weebly	Yola
Link	http://ru.jimdo.com	https://sites.google.com/site/sites	http://www.weebly.com	http://www.yola.com
Cyrillic interface	available	available	available	available
Website address	mysite.jimdo.com	sites.google.com/site/mysite	mysite.weebly.com	mysite.yolasite.com
The site is on a separate domain	in the paid version	+	+	in the paid version
Storage space	500 MB	100 MB	not limited	1 GB
HTML editor	+	+	+	+
creating a blog	+	—	+	+
restricting access to the site	in the commercial version	+	in the commercial version	+
Optimizing for mobile devices	+	+	+	in the paid version
Peculiarities of service	Dropbox integration	Other google services integration, free project	Multi-user site management interface	Online editing of images

In late June, Domo published an infographic showing the minute-by-minute activity of 2.1 billion Internet users. According to this data, every minute 571 new sites are created on the Internet. And this means that thousands of people ask the question "How to make your web resource?" every day.

Fig. 3.1. – Domo infographics showing the minute-by-minute activity of internet users

The answer to this question can be very different. You can entrust the creation of the site to a team of web developers, or you can choose one of the free or paid CMS, buy hosting and create the site yourself. Another relatively inexpensive (and in some cases, completely free) option is to use a site builder. On the one hand, it saves a technically untrained user from the need to deal with FTP server settings and make changes to configuration files, and on the other hand, it gives an opportunity to creatively work on your own site to your satisfaction.

There are different types of site builders: both those that can be used to create sites of almost any orientation, and specialized ones, which means, focused only on certain types of web resources (business card sites, portfolios, and others). In this review, we will pay attention only to universal designers.

Jimdo.com . The Jimdo.com project was originally created for small companies, and its goal was to create a site management system so simple that employees of the organization could create and update the site themselves, without contacting webmasters.

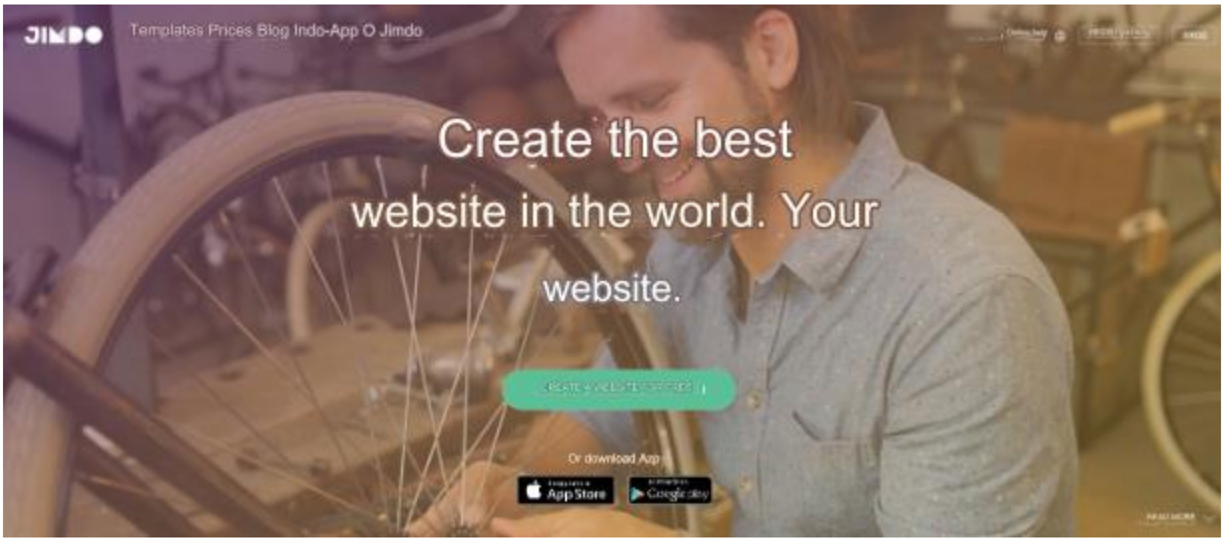


Fig. 3.2. – Home page for creating a Jimdo web resource.

When such a CMS was created, the project was opened to a wide audience. It turned out that Jimdo is suitable not only for portfolios of organizations, but also for blogs, educational pages, photo galleries, online stores and many other types of sites. After registration, each Jimdo user receives 500 MB of space for free file storage, as well as a mysite address .jimdo.com. The ability to link your own domain is one of the paid functions of the service.

The site is completely controlled from the browser. On the title page there is a link to login as an administrator. After logging in, all blocks of the site become editable: it is possible to make changes to them, delete them, as well as add new ones.

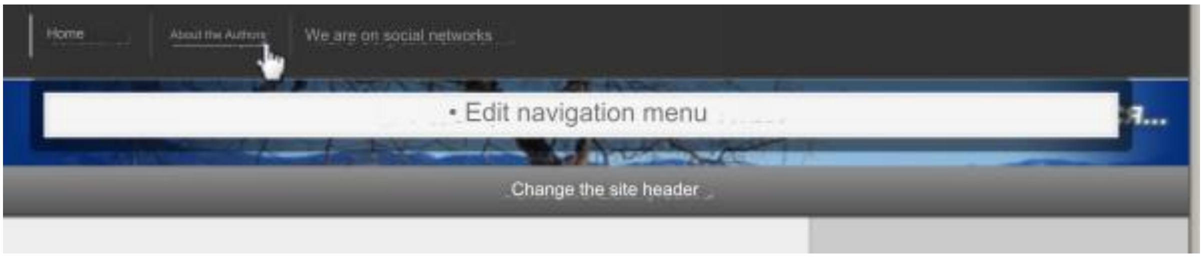


Fig. 3.3. – Edit navigation menu in Jimdo pages

Blocks range from plain text to tables, text, galleries, map embeds, Flickr photos, Twitter feed, guestbook, file download links, RSS feeds, and more .

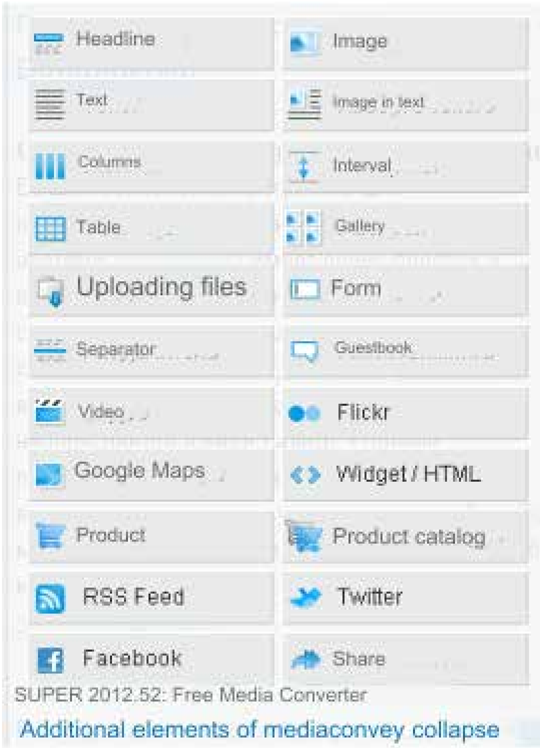


Fig. 3.4. – Toolbar in the Jimdo editor

For a page with information about the site or about the author, it is convenient to use the "Image in text" block, with which you can place the text, the accompanying picture on the page and set the image wrapping parameters. Files can be uploaded to the site not only from the hard drive, but also from the Dropbox online storage - Jimdo integrates with this service. This is convenient, for example, when creating a gallery. By the way, the image gallery can be created both on the basis of HTML and Flash tools with flipping animation transition effects and others. Jimdo also has a unit for playing Flash videos (SWF files).

You can quickly add a "Like" button to the site to promote the page on

Facebook, as well as a "Share" block so that visitors can post links to the page on their Facebook profiles , VKontakte and other social sites.

To edit the page layout or change the site structure, you need to use the special navigation panel that appears on the right side of the screen (Fig. 3.5) .

(Шаблон - Template, свернуть - collapse)

Fig. 3.5. – Jimdo editor navigation panel

Basic options for changing the design include uploading a custom image for the site header, choosing a template from a large library, setting the colors of headers, links, menus and page backgrounds. More advanced users can download their own template and edit it using HTML and CSS editors.

Many site settings that can be found in the admin panel work only in the paid version of the service. For example, users of free accounts cannot change links in the footer of the site, protect pages with a password, set meta tags for pages, hide links for entering the administration panel, do newsletters.

Jimdo is well suited for creating an online store. True, it is worth keeping in mind that in the free version the number of products is limited to five, and payment is accepted only through Paypal, so the store can only work fully for users of Pro accounts.

Creating a store is as automated as possible: products can be presented in the form of a list or gallery, for more convenient organization, not only categories, but also labels are used. The store owner can change the standard letters that are sent to those who placed an order, set the cost of delivery to different regions, choose the countries to which the product is delivered.

"Google Sites" . Google has its own website creation tool . You can make your project with the help of this service absolutely free of charge and in a matter of minutes. The site is assigned a pretty tasteless name like https://sites.google.com/site/mysite, but you can also link the site to your own domain. In addition, you should not forget that you are dealing with Google, which means that the chance that there will be any problems with hosting is minimal.

Fig. 3.6. – Start page for creating a Google web page

The site is created in a few simple steps: you need to specify its name, description, choose a template and design theme.

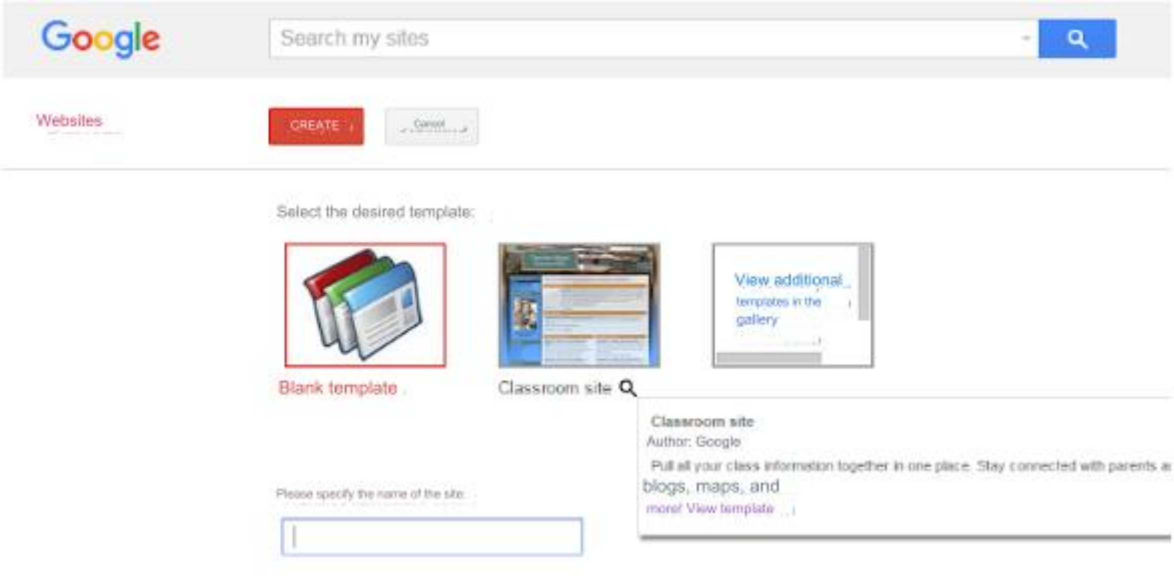


Fig. 3.7. – The first step of creating a Google website

By default, the site is available to everyone, but if you wish, you can prohibit its indexing by search engines or limit access to it altogether by manually specifying those people who will be able to access the site. The last option makes sense if you need to post paid lessons or other content intended for a limited number of users.

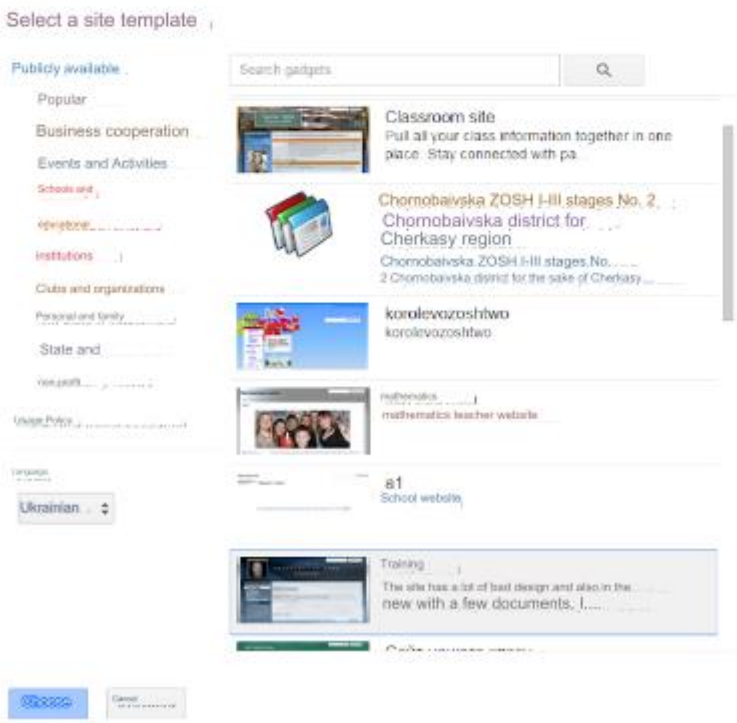


Fig. 3.8. – Choosing a Google website template

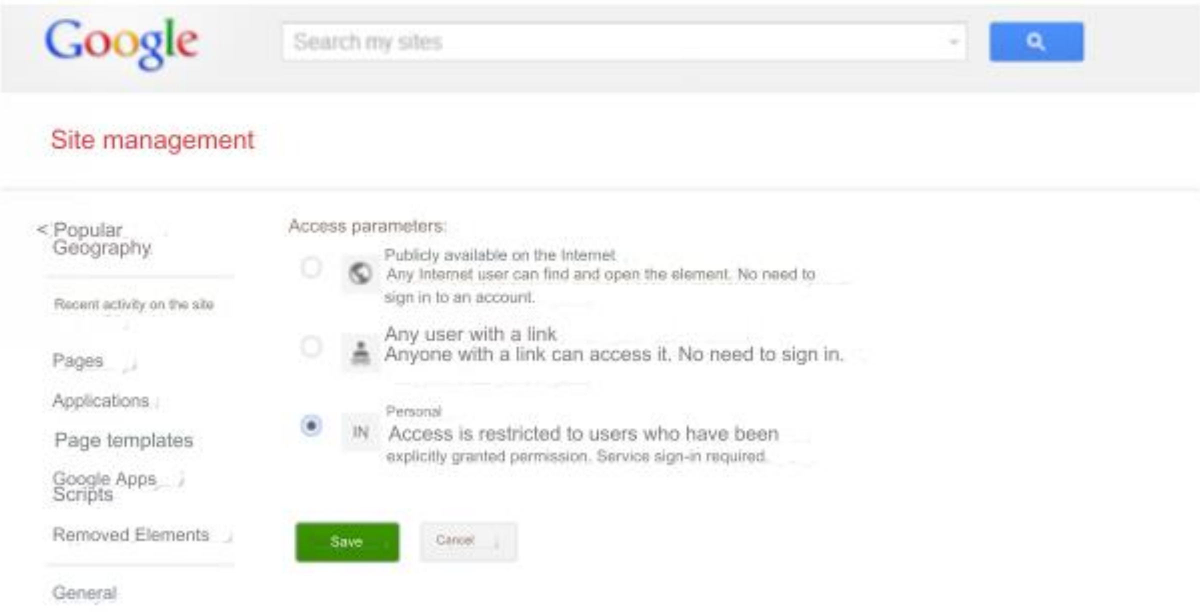


Fig. 3.9. – Selection of site access parameters

The site can contain any number of pages. Their structure can be managed by dragging the page names in a tree-like list with the mouse. The service offers several templates for quickly creating pages, including a standard page with information, a blog with announcements, files, a repository, and presenting information in the form of a list. You can create templates yourself, and later use them for new pages.

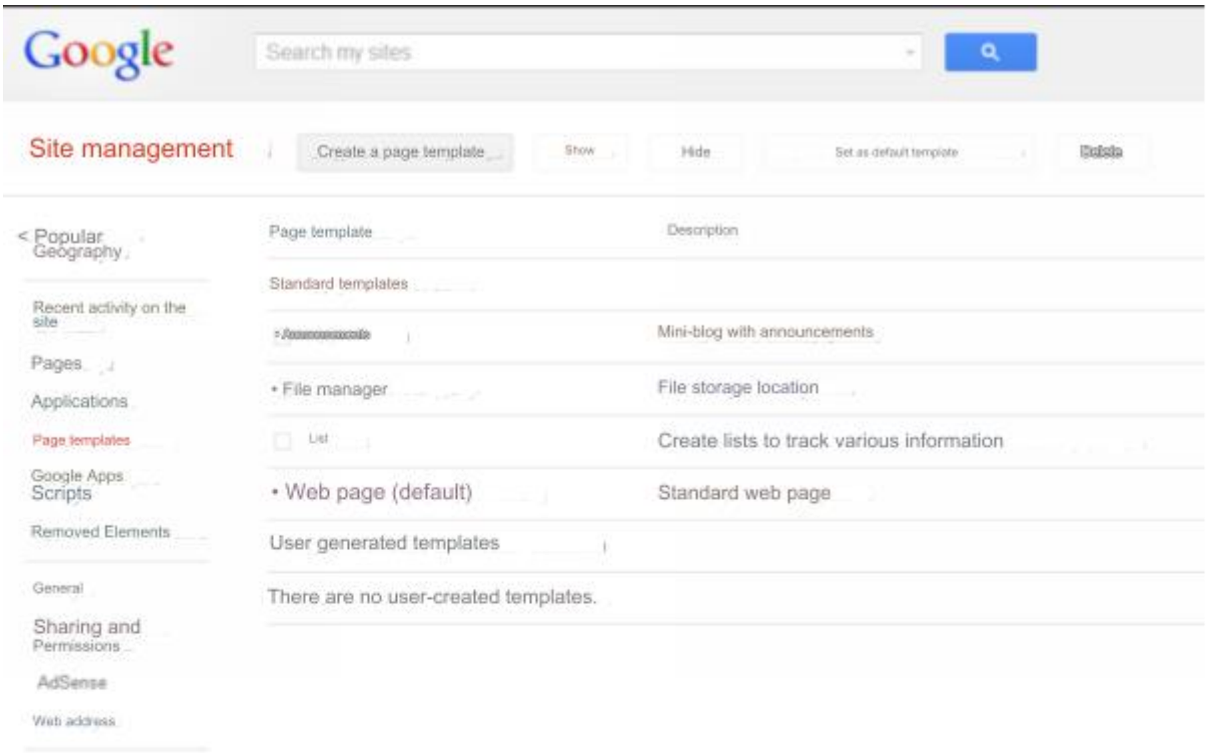


Fig. 3.10. – Google Website Control Panel

Pages are edited using a visual editor. Pages can contain a wide variety of blocks, including, for example, recently added files, recent messages, content, a list of subpages, etc. Among the available blocks (in Google Sites they are called gadgets) there are many that are related to other services of the Internet giant. For example, you can insert a document stored in Google Drive, a slide show based on photos from Picasa web albums, a video from YouTube, an AdSense ad block, etc. Note, however, that the site creation service has apparently not been updated for a long time, as here you can find a block for the now defunct Google Wave and Google Video services. At the same time, there is no hint of integration with the currently actively promoting social network Google+.

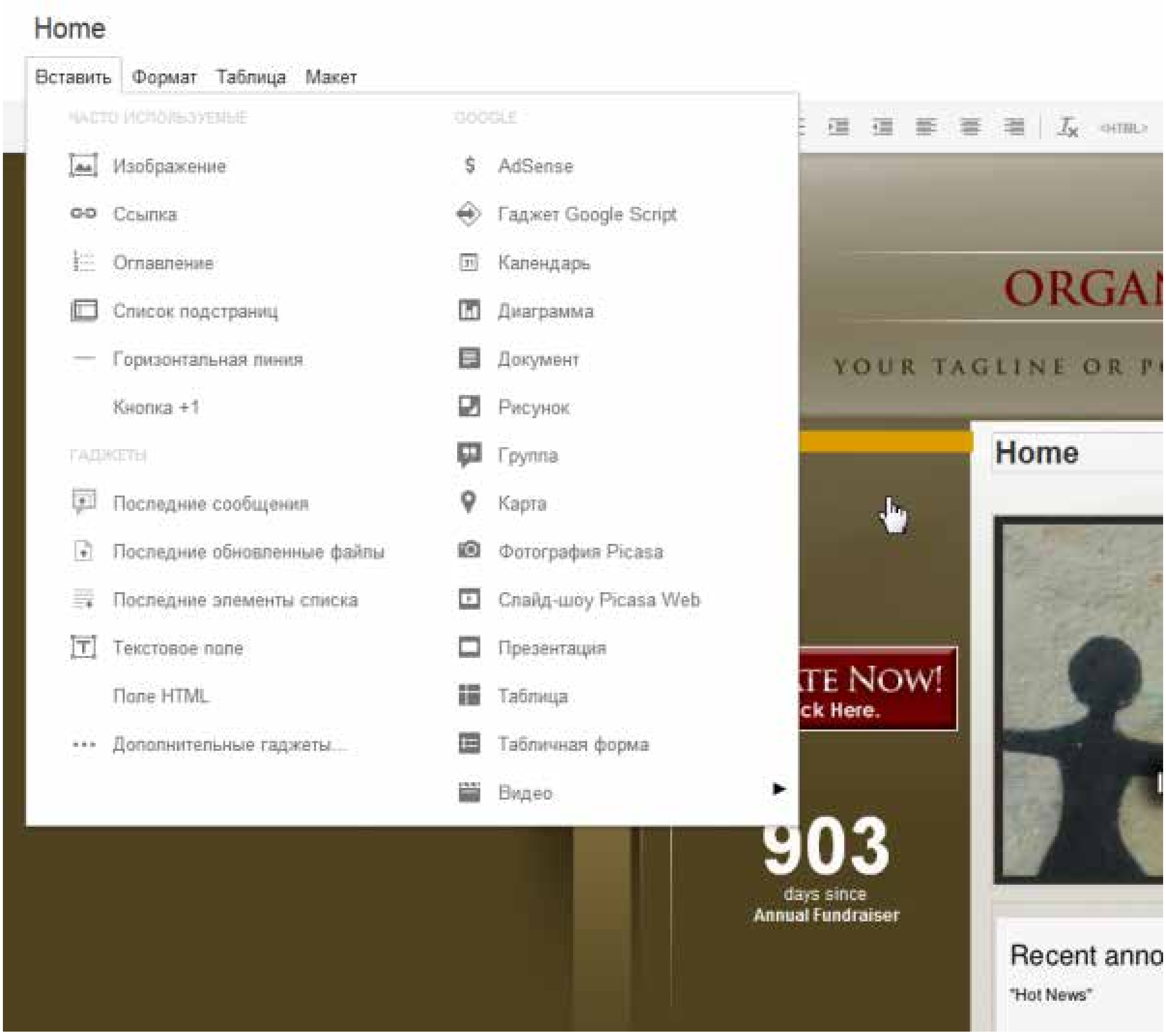


Fig. 3.11. – Mode for inserting a picture into a Google web page

The service also integrates with other Google projects for webmasters: Google Analytics statistics and Google Webmaster Tools, designed for search engine optimization of the site. It is also worth noting the automatic creation of a version of the site intended for viewing on mobile devices.

100 Mbytes of disk space is allocated for storing files related to the site. You can manage downloaded data using a special section of the admin panel. Here you can find file location, size, download date are displayed.

Weebly . The Weebly site builder does not have Russian localization, so if this is a problem for you, it is better to look for another service. However, for those with at least a high school curriculum level of Shakespeare, Weebly may definitely be of interest. The service is not completely free, but it allows you to create sites on your own domains as part of a basic account.

There are practically no ads on free Weebly sites - just a small link in the bottom of the page. The disk space allocated to the site is not limited, but the size of one file cannot exceed 5 MB.

Fig. 3.12. – Weebly web editor home page

Since it is assumed that after signing up with Weebly, the user will start creating the site right away, the number of mouse clicks that he needs to make to do this is kept to a minimum. Immediately after registration, a window appears where you need to enter the name of the site and specify the category, which it belongs to. Then the user must choose which domain he will host the site: on his own or on the third-level domain mysite.weebly.com.

After that, you can immediately proceed to work on the title page. A visual editor is used to change the content: first, on the settings panel, elements are selected for insertion on the site, then you can edit each block by calling the settings by clicking on it. Since there are quite a lot of types of blocks, they are divided into categories: basic, multimedia, income generation, others.

Fig. 3.13. – Control panel in Weebly web editor

In particular, you can add slideshows, photo galleries, flash videos, Google maps, videos from YouTube, links to download files, a form for contacting the administration, multi-column text, polls, and RSS feeds. There is also the insertion of custom blocks of HTML code. But the ability to play video and audio files uploaded to the site in the player is the prerogative of premium users. Pro-account gives an opportunity to add various documents (.doc, .pdf, .xls, .ppt) to the site, which are opened directly in the browser window. The premium options also include password protection of the site and individual pages and uploading a site icon (favicon).

Weebly offers its users to place AdSense advertising blocks on their sites, but it is worth keeping in mind that site owners receive only half of the income from advertising - the service takes the other half.

It is also very easy to edit page properties and manage the site structure: you can create the required number of pages, including those that will lead to external sites, set titles, descriptions and meta tags, place the code in the title or at the very bottom of the page, determine which pages will be hidden in the navigation menu, hide the site from search engines, enable optimization for mobile devices.

In the page settings, you can also find a button to add a blog to the site. Date and time settings, as well as comments, are offered for the blog. You can set pre-moderation of comments before publication, and turn on notification of new comments by email. A convenient window is used to manage comments, in which you can view all received messages, approve them, delete them, and mark them as spam.

Weebly even implements the possibility of multi-user site management. The owner of the resource can add editors and define their roles: for example, some users are given the right to delete comments, others can edit some pages, left users can give full access to change the site. However, it is worth keeping in mind that only administrators with unlimited powers can be added to a free account (Fig. 3.14).

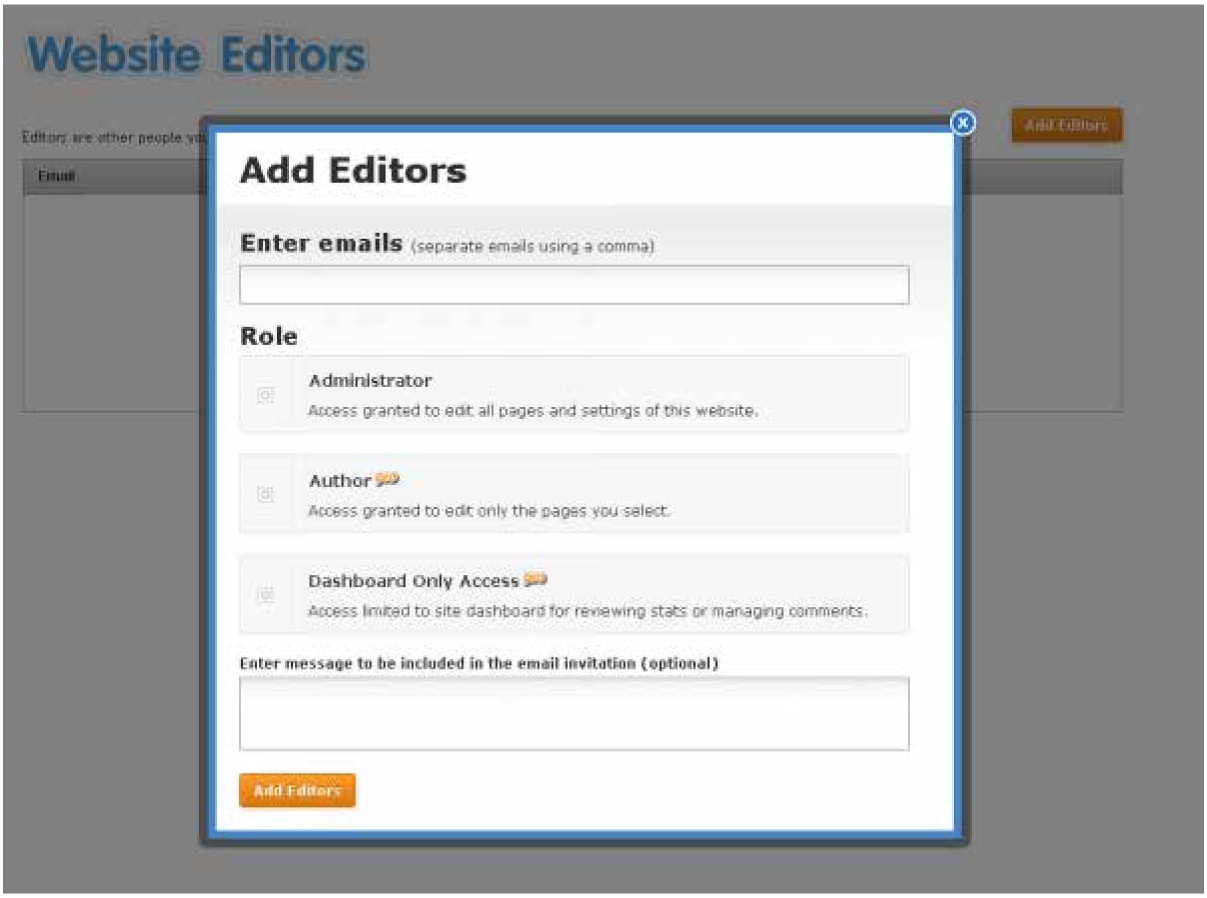


Fig. 3.14 – Adding administrators with unlimited powers

The site created in the Weebly constructor appears on the Web only after clicking the Publish button, so before presenting the project to the world, you can collectively work on it in closed mode.

Yola . Yola is an English-language site builder that is suitable for web projects of the most different orientations (Fig. 3.15). One of the interesting features of the service is the automatic selection of a template based on the site's theme.

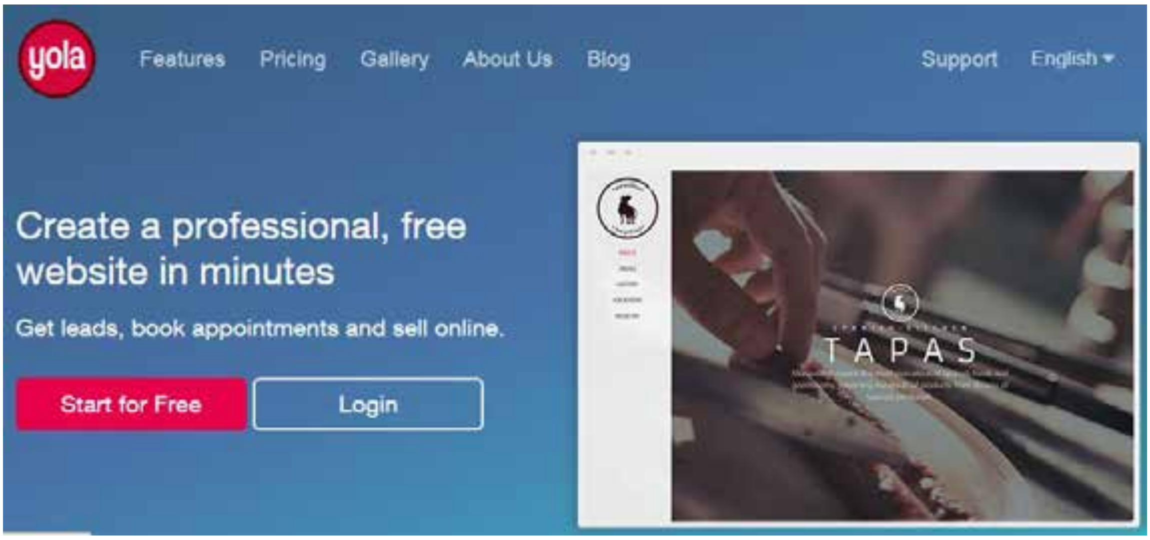


Fig. 3.15. – The start page of the English-language site builder Yola

Immediately after registration, it is suggested to specify the name of the site and inform the service of the nature of the content to be placed on it. For example, if you inform them that the site will be dedicated to mechanisms, Yola immediately selects a suitable template for it.

As in other site builders, adding elements is done by simply dragging blocks from the settings panel to the page area. You can add videos from YouTube, photos from Flickr, upload flash videos and audio files for playback on web pages, and any file up to 5 MB. At the same time, up to 1 GB of disk space is allocated for the site. It is also very easy to add social buttons to the Yola website: Google +1, "Facebook comments", "Like", "share on Twitter" and others.

Working with Yola, the user has the opportunity not only to choose a template, but also to change the layout of the page. After the markup is defined, hints appear in those areas of the site that are not yet filled with content. Images uploaded to the service can be edited online thanks to the integration of Yola with the Aviary editor (Fig. 3.16).

Fig. 3.16. – editing of pictures and drawings by the Aviary editor

In addition, the service offers integration with the Fotolia photo store, thanks to which you can choose, buy, upload a photo and place it on the site without leaving the designer page. You should also pay attention to the free clipart from Yola.

Like Jimdo, the Yola service allows you to create an online store on the site, but this is a paid option. By the way, the store module was developed by the Russian company Ecwid, located in Ulyanovsk. The store supports integration with popular payment systems, social functions and a mobile version.

As part of a free account, you can create a third-level domain name like mysite.yolasite.com. Using your own domain name is again a paid option. The premium features of the service also include CSS editing, the use of additional styles, and the removal of the Yola advertising block in the "basement" of the site.

Thus, it should be emphasized that without deep comprehensive studies of the experience of developing educational web resources, without studying their pedagogical orientation and opportunities in education, it is impossible to talk about the effective use of educational Internet resources in the learning process. During development, pedagogical goals and tasks of its creation are outlined, methods of its use in the educational process are designed, stages and technologies of its development and implementation are chosen.

Modern site builders have nothing in common with the tools that ten years ago were offered for creating home pages on free hosting. These are full-fledged CMSs, with the help of which you can create quite decent educational sites for a variety of purposes: and web resources of educational organizations, thematic blogs, photo galleries. And paid editions of site designers should not be ignored either, because the pFig includes not only additional opportunities for creating web resources, but also not very expensive hosting.

3.2 The method of using a distance learning environment as a factor in the training of engineering specialists

The improvement of the professional training of future specialists in the economic direction occurs thanks to the use of information and communication technologies and a distance learning environment in the educational process, which contributes, in particular, to the development of personality. The essence of the concept of "distance learning environment" as an informational and educational space built on the informational integration of computer and telecommunication technologies (virtual libraries, distributed databases, an optimally structured educational and methodological complex) and aimed at self-development of the individual is revealed. The educational situation in such an environment is designed as a dynamic process of subject interaction of all participants of the educational process, mediated by computer technologies.

The problems of development and use of remote and computer-oriented learning tools are studied in the works of V. Bykov, A. Gurzhii, M. Zhaldak, Yu. Zhuk , N. Morse, N. Tverezovska, and others. Psychological-pedagogical and methodical aspects of this issue are reflected in the works of E. Mashbits. The main competence of the teacher is his renewed role in the conditions of the distance learning environment - the role of a guide of knowledge, a kind of "navigator" who helps to learn and navigate in the bottomless ocean of information. The task of a modern teacher is to teach the optimal choice of an individual educational route and methods of its passage, i.e. "navigation in education". However, it can be concluded, and this is confirmed by numerous studies and observations, that not all teachers are prepared to fulfill their updated role [69, p.330].

The widespread introduction of computer-oriented environments in the educational process is restrained by two factors: the lack of subject-oriented methods of using ICT tools in educational activities; insufficient number of scientifically based educational software tools.

More and more scientists are coming to the conclusion of the expediency of presenting teaching and methodical materials in electronic form. Therefore, we consider the creation of a structural and logical scheme of a distance learning environment according to our methodology and the use by the teacher of a structural and logical scheme of a distance learning environment to be a priority task of modern education, which will allow to create in the future a single informational and methodological educational space of the informatized educational and educational process of any institution of higher education as indicated in fig. 3.17.

E -learning courses are classified by:

−a functional feature (they can be classified as educational publications);

−submission form (belong to the category of electronic publications);

−creation technology (software products).

Therefore, monitoring of the quality of electronic training courses (hereinafter, ENC) should be multi-level, taking into account their classification.

ISO 9000 standards (a series of quality management standards) are considered the main quality standards today. In the field of software - the ISO/IEC 9126 standard (attributes and methods of software quality requirements) and the set of ISO/IEC 14598 standards (regulates methods of evaluating these characteristics). IN totality they form model quality SQuaRE (Software Quality Requirements and Evaluation). Therefore , when developing ENK quality criteria, we also manage this model .

Based on the theory of the step-by-step formation of mental actions (P.

Halperin, N. Talizina) [2, p. 78], the sequence of work in the distance learning environment for students' assimilation of the necessary information of modern scientific knowledge in the field of marketing, economic cybernetics, electronic commerce is determined and built structural and logical scheme of the algorithm of work in the environment.

Within the framework of the SQ ua RE model, the following main characteristics and qualities are distinguished:

– *Functionality* (accuracy, consistency, interoperability, security, usability).

– *Reliability* (stability, completeness, renewability).

– *Accessibility* (learning efficiency, ergonomics, comprehensibility).

– *Efficiency* (resources and time).

– *Support* (ease of analysis, changeability, stability, verifiability).

– *Portability* (adaptability, compliance with standards and regulations, installation flexibility, replaceability).

Evaluation of the quality of electronic educational materials should be comprehensive. A comprehensive assessment of the quality of electronic educational materials means an assessment of the quality of a set of parameters: *content, technical-technological, didactic, methodical and design- ergonomic.*

Central Components:

- **Student (СТУДЕНТ):** The core of the model, representing the learner.
- **Instructor (ВИКЛАДАЧ):** The teacher or facilitator responsible for guiding the learning process.
- **Information Resources:** A wide range of materials, likely including textbooks, online resources, and multimedia content, used by both the student and instructor.

Key Processes:

- **Development of Teaching Methodology:** The instructor's role in creating and adapting teaching methods to suit the distance learning environment.

- **Technology for the Phased Learning Process:** The use of technology to support the various stages of learning, from initial information reception to knowledge accumulation and application.
- **Control of the Learning Process:** Mechanisms to monitor and evaluate student progress, including assignments, quizzes, and feedback.

Components of the Learning Environment:

- **Theoretical Block:** Likely referring to foundational knowledge and concepts.
- **Practical Block:** Application of theoretical knowledge through exercises, assignments, or projects.
- **Independent Work:** Tasks completed by the student outside of direct instruction.
- **Glossary of Terms:** A reference resource for definitions and explanations.

Additional Elements:

- **Sequential Presentation of Teaching Material:** The structured organization of content.
- **Types of Educational and Control Tasks:** The different kinds of assignments and assessments.
- **General and Specific Didactic Principles:** Guiding principles for effective teaching and learning.
- **Principles of Distance Learning Environment Functioning:** The underlying rules and guidelines for the distance learning system.

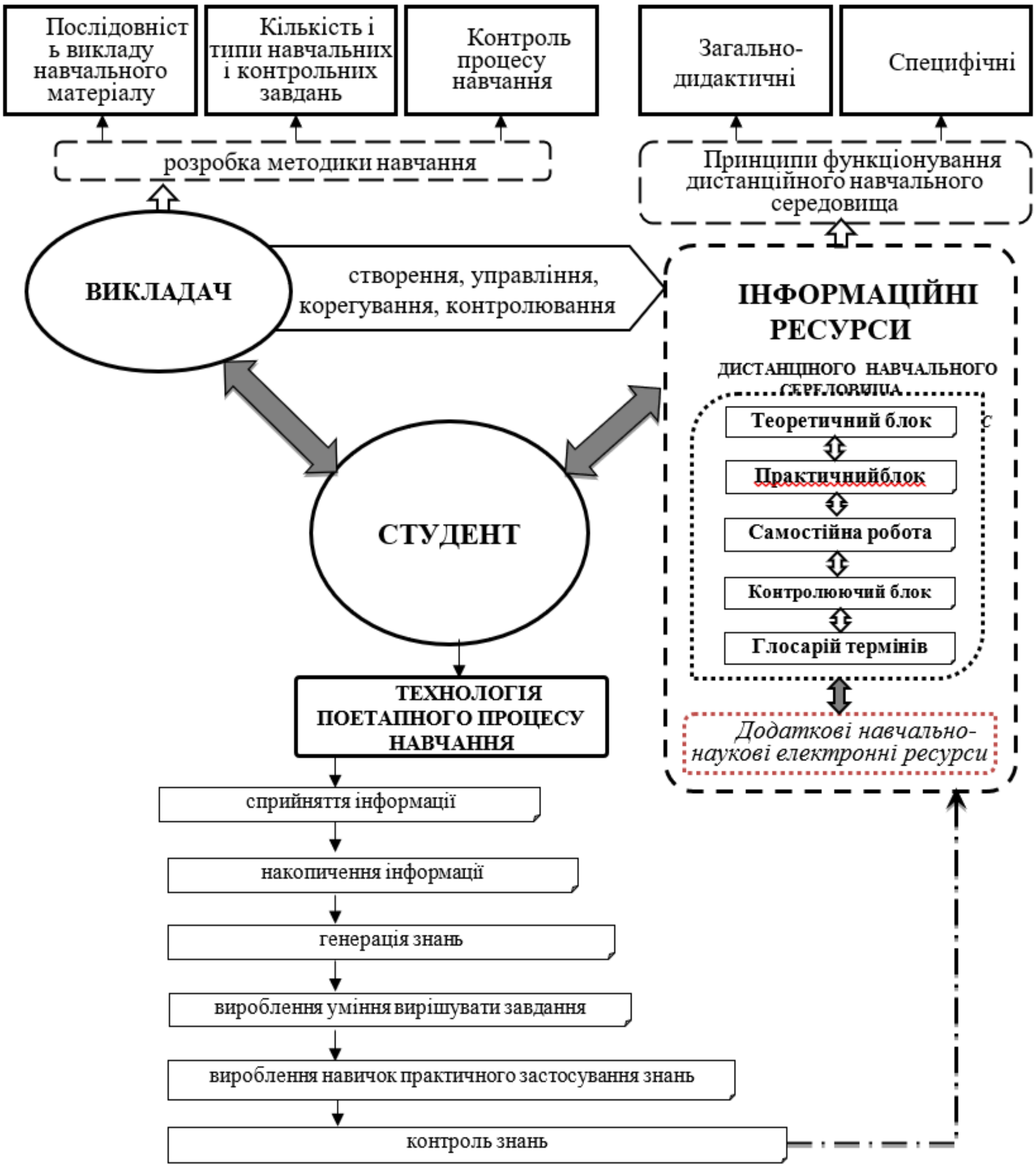


Fig. 3.17. C structural and logical scheme of the distance learning environment in the preparation of future specialists in the engineering profile

The set of didactic and methodical support, implemented with the help of material and technical means of education, intended for use in the educational process of training future engineers, will be called a distributed distance learning environment. Note that the experiment was conducted in the discipline "Agricultural machines", which used a traditional form of education using personal computers without a network and environment (control group), and the experimental group studied in a distance learning environment on the Moodle platform using an electronic training course .

Fig. 3.18. - Algorithm of the student's work with an electronic educational course in a distance learning environment

The content management of the distance learning environment is performed using the freely distributed software product P hP and the Moodle platform. We developed and presented the algorithm for working in such an environment as shown in fig. 3.18.

Therefore, there is a certain inconsistency between the need to use the advantages of computer-oriented learning environments in the training of highly qualified engineers and the lack of pedagogically and methodologically sound software, methods of using these tools in educational activities.

Having analyzed the classical model of Internet learning, we compared it with electronic training courses created by teachers based on the Moodle information and communication learning environment. On the basis of the initial data, we created an alternative model taking into account the peculiarities of the compilation and use of electronic training courses in the above-mentioned software environment.

The main requirement for the distance education shell is that it does not become "tight" for the organization of the virtual learning environment, that is, the shell must contain a sufficient number of tools to fully support the process of training engineers, marketers and others.

On the basis (knowledge, problems) of the presented educational materials and tools (presentations, chat, tasks, tests, virtual conferences, forum, etc.), training is conducted in a computer-oriented environment in the shell of the platform Moodle.

In order to check the effectiveness of the method used by economics students in a distance learning environment, we have created an electronic training course on the discipline "Agricultural machines". Therefore, in order to start classes in the environment, the student must first go to the educational and informational portal of the National University of Bioresources and Nature Management of Ukraine.

The next step of the student in the environment is to find an educational unit (department) and choose an electronic educational course specified by the teacher.

After the student has made a choice of discipline, the process of authorization in the electronic course takes place. It should be noted that enrollment (registration) of students can take place in two ways:

- forced (a student or a group of students is enrolled by the teacher);
- independently (with appropriate course settings, the student has the opportunity to independently register for the course).

Once on the electronic course, the student sees the shell created by means of a computer-oriented environment on the Moodle platform , as shown in Fig. 3.19.

From the moment the student enrolls in the course, he has the opportunity to familiarize himself with general information (curriculum, evaluation criteria, calendar plan, news, schedule, etc.).

Fig. 3.19. – Title page of the electronic training course in the discipline "Agricultural machines" for agricultural engineers, where:

pp. 1-3 are available to the teacher and are invisible to students

1 – a navigation bar where the abbreviated name of the site and the open course is indicated;

2 - the "activity" block is used for: filling in the dictionary of terms in the form of a glossary, reviewing and entering the solutions to tasks sent by students, conducting and the results of surveys and questionnaires, filling in and reviewing the resources located on the course, reviewing the results of tests and slices of knowledge, etc.;

3 – the "control" block is intended for editing and setting course parameters by the teacher;

paragraphs 4-6 – make up the substantive part of the course and are open resources:

4 – general information includes the work program, calendar plan, student evaluation criteria, glossary, forums, questionnaires, news, etc.;

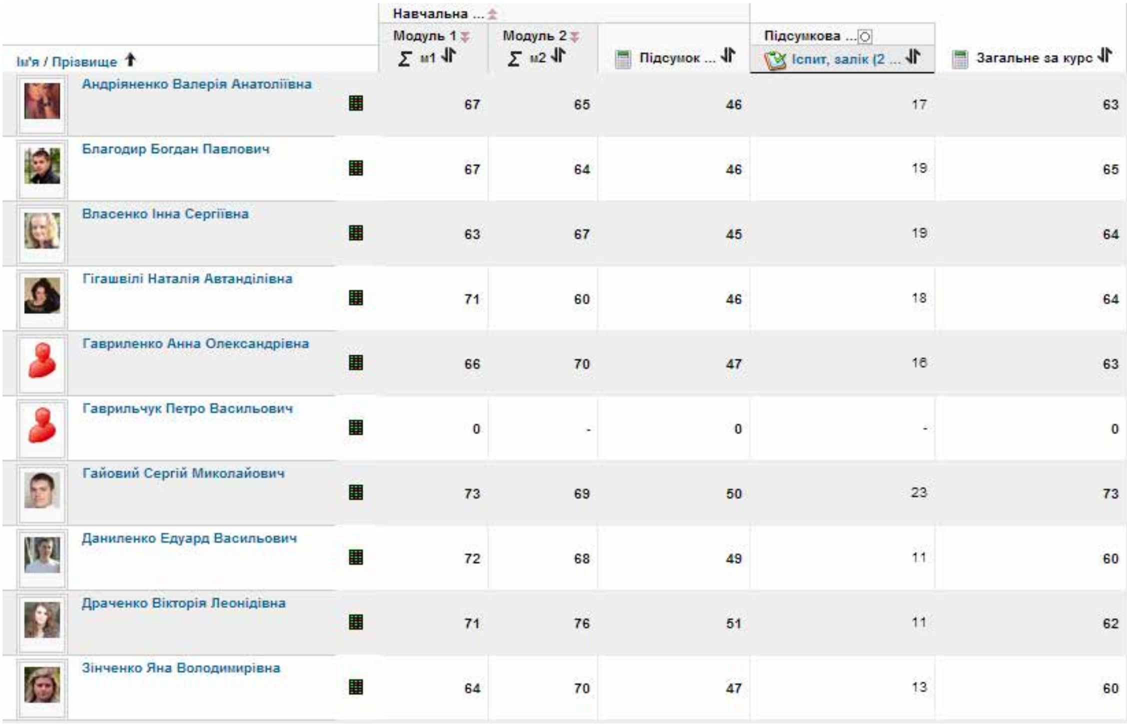
5 – the first (and other, if any) meaningful module, which consists of theoretical and practical parts, independent work, intermediate certification for the first and second modules in the form of an electronic test;

6 – final attestation, which includes an exam or assessment in a test form;

7 - block of recent events in the electronic training course made by course users.

While studying in a computer-oriented environment, students acquire knowledge and skills. In the process of learning, students acquire theoretical knowledge and perform practical (laboratory exercises), which are sent to a remote server for checking by the teacher. The teacher can observe the student's activities in the distance learning environment, check the sent laboratory works and evaluate them. After studying a certain meaningful module, the teacher conducts an intermediate test control to check the consolidation of the student's theoretical knowledge. The grade for the meaningful module includes the accumulated grade for the laboratory work assigned by the teacher and the grade assigned to the student by the environment during the module test. Evaluating the student's practical activity, the teacher can comment on the student's work. If necessary, by means of a distance learning environment, the teacher can conduct virtual communication with the student to clarify his knowledge or other information. The same connection can be made by a student in relation to a teacher or another student.

The use of the electronic journal of student evaluations, as shown in Fig. 3.20, deserves special attention. The evaluation journal is always an open resource, which can be used by both the student and his parents for orientation in the process of studying the discipline. The structure of the electronic journal was developed in accordance with the requirements of the Ministry of Education and Science of Ukraine for examination information.



Ім'я / Прізвище	Навчальна ... Модуль 1 Σ м1	Навчальна ... Модуль 2 Σ м2	Підсумок ...	Підсумкова ... Іспит, залік (2 ...	Загальне за курс
Андріяненко Валерія Анатоліївна	67	65	46	17	63
Благодир Богдан Павлович	67	64	46	19	65
Власенко Інна Сергіївна	63	67	45	19	64
Гігашвілі Наталія Автанділівна	71	60	46	18	64
Гавриленко Анна Олександрівна	66	70	47	16	63
Гаврильчук Петро Васильович	0	-	0	-	0
Гайовий Сергій Миколайович	73	69	50	23	73
Даниленко Едуард Васильович	72	68	49	11	60
Драченко Вікторія Леонідівна	71	76	51	11	62
Зінченко Яна Володимирівна	64	70	47	13	60

Fig. 3.20. – A window of the student's electronic evaluation journal, which is available for viewing by every participant of the educational process during the entire academic period/semester.

Therefore, the distance learning environment allows the most complete realization and control of the components and stages of learning, building models of both the learning process itself and its subject and object, that is, the student [7, p.43].

Distance learning environment includes the following structural components:

1. Educational and methodological complex of the discipline.

2. Information banks of the discipline, which must be constantly updated.

3. Modular rating pedagogical technology (a means of optimizing the educational process, adapted to the individual characteristics of students).

4. Implementation of creative projects, including collective or group projects. Creative projects have a detailed structure of the joint activities of the participants.

5. Student scientific and practical conferences, public defense of creative projects and presentation of the results of their activities on the Internet (a means of forming reflective and communicative skills).

6. Automated knowledge control system (facilitates the work of teaching staff

and promotes openness, objectivity and impartiality of student assessment).

7. Selection of information resources (optimal combination of electronic and traditional educational resources). In this regard, information projects are aimed at collecting information about any object, phenomenon, at familiarizing project participants with this information, its analysis and generalization of facts [1, p.15].

The given structural components have technological features and perform certain didactic tasks. Let's dwell on some of them.

The electronic training course of the discipline may contain the following elements:

- electronic textbooks, including theoretical material, a glossary, as well as topics of seminar, laboratory and practical works;
- plans for theoretical and laboratory-practical classes;
- virtual laboratory complexes;
- synopsis-presentations of theoretical classes and lectures;
- tasks for laboratory-practical works;
- educational tasks for independent work and requirements for them;
- questions and tasks for the final certification;
- a description of the information tools and technologies necessary for the performance of educational tasks;
- methodical instructions for using this complex;
- electronic banks of questions and tests;
- links to additional information resources on the discipline on the Internet ;
- additional educational materials (textbooks, manuals, etc.) [4, p.81].

The presented educational and methodological complex is provided to students on printed media or is freely distributed through the local network of the educational institution and the global Internet.

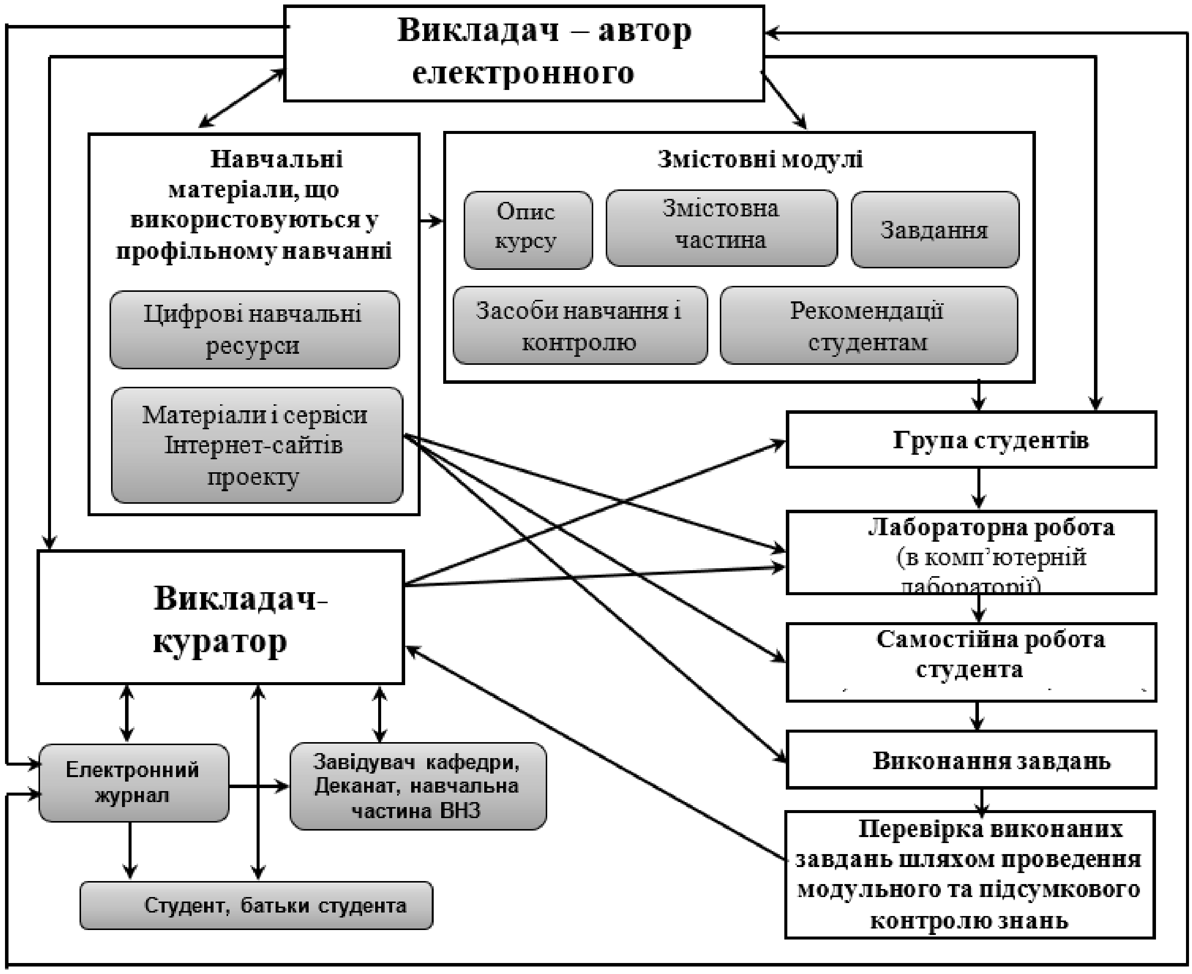


Fig. 3.21. The learning process in the Moodle software environment

In the process of preparing a teacher for the use of computer - oriented learning environments, two stages can be distinguished: 1) the formation of the teacher's information competence in general, 2) his ability to implement the latest tools in his professional field, that is, to be not only a user of ready-made software products, but to a greater extent act as a creator, developer of own educational and methodological tools as shown in Fig. 3.21.

At the first stage, the teacher's professional training in the use of computer-educational environments is usually carried out in professional development courses. This, as a rule, ends the process of professional training of teachers, and the second stage appears as a problem that must be solved on one's own, at best at the level of self-education.

Management of students' project activities with the use of information technologies is a separate type of work that does not always coincide with the requirements of methodical support of the class. The main task, as is known, is to increase students' motivation, their interest in the subject being studied, the development of productive thinking and the practical application of acquired knowledge and skills - in other words, this is the side of the method that mainly "works" on students. An example of the practical application of the results of students' project activities can be the use of software products in the educational process. From this point of view, a project as a demonstration material of a lesson, used by a teacher or submitted by a project group of students is a positive aspect of project activity that can be useful for the teacher in .

However, this type of work is not always productive and convenient for the teacher: not all topics and approaches needed by the teacher for classes may be understandable to students, especially if the topic is new or difficult enough, strict time frames can also reduce the effectiveness of the created software product [9 , p.262]

In our opinion, the development of an electronic educational course for student preparation should contribute to the involvement of students in project activities for the creation of a project in distance learning environments.

The proposed course is implemented in two stages :

1) setting and solving the task of mastering information technologies at the level of an active student (working with various software environments) regardless of the subject of study;

2) setting and solving the task of training a future economist as an expert and user of ready-made software products; training of an e-commerce specialist as a creator of own software products that meet specific goals and tasks.

Creation of an electronic training course of the discipline requires the teacher to be both an expert and user of ready-made software products, as well as a developer of own software products with multimedia support.

Training courses in remote environments must have a number of necessary components:

1) work program and course schedule. The ratio of theoretical and practical

parts of the course,

2) information and reference materials (repositories, encyclopedias, directories, etc.);

3) electronic books,

4) educational films in compressed format,

5) libraries of electronic visual aids and databases,

6) methodological materials on electronic media (development of lessons, methodological recommendations, modular tests and other materials);

7) Internet resources;

8) educational and methodical software tools for accompanying foreign language classes (demonstration materials, presentations, lesson plans, etc.);

9) combined informational means of learning (educational programs, electronic textbooks, collections of exercises and educational games);

10) means of monitoring the student's mastery of the studied material (electronic tests or exams).

In the process of working on the structure and content of the course, the author should proceed from a number of key provisions that allow the student to successfully master and further creatively apply the acquired knowledge and skills in his future professional activity. The peculiarity of the interaction between a teacher and a student is that they communicate during the learning process as colleagues - current and future. Therefore, the level of training of a student as a future specialist in the field of information and post-information society largely depends on the level of use of computer-oriented learning environments by the teacher [7 , p.337]

When modeling the educational process, part of which will be carried out taking into account the use of information technologies, the teacher must take into account the following criteria and ways of integration between them:

1) general educational possibilities of information technologies and implementation of didactic principles based on them;

2) the correlation of key educational competencies with the possibilities of

integrating information technologies into the educational process, as a way of presenting and processing educational material using a computer in class.

During the development of the course, the following were taken into account:

–computer-oriented learning methods (used as a kind of tutor, which organizes mostly independent development of skills through repeated repetitions, self-monitoring and obtaining reference information of an educational nature);

–developed functions of the distance learning environment (allowed to create the effect of "immersion" of students in the learning environment and interaction between themselves and the teacher in an interactive mode);

–demonstration functions of the distance learning environment (the principle of visibility was raised to a new level, which allowed students to observe phenomena both statically and dynamically, use a large number of illustrations and moving images, as well as display a large amount of information on the screen);

–controlling functions of the distance learning environment (allowed to determine the level of knowledge and the degree of formation of students' abilities and skills in a fast, accessible and reliable way);

–diagnostic functions of the distance learning environment (allowed to quickly and effectively carry out diagnostics and monitoring of various components of the educational process - curriculum, subject program, content of educational material, monitoring of student activity in order to optimize the allocation of educational time, etc.).

–reference and information functions of the distance learning environment (it greatly facilitated access to sources of information of various nature due to rationally organized information search and output systems (encyclopedias, directories, the Internet, etc.);

–combined functions of the distance learning environment (most fully implemented in electronic teaching aids of various purposes, levels and approaches, including those created by the teacher himself) [8, p. 84].

Among the conditions that determine the effectiveness of the use of remote and computer-oriented learning environments, we included:

–basic computer literacy of teachers and students;

–a sufficient number of educational software;

–availability of subject-oriented methods.

Achieving these conditions ensured a significant increase in the quality of the educational process in the process of training both agricultural engineers and specialists in any other field of knowledge.

As mentioned above, Moodle is presented in the form of a website, the elements of which are hypertext links that can be opened in almost any browser.

Therefore, as a result of studying under the credit-module system on the Moodle platform , it is more convenient for the student to prepare for lectures and tests, perform laboratory and independent work. During the entire training, he can follow the electronic journal of his grades, study the educational material. In turn, the teacher can more perfectly and clearly see which aspects of the discipline are being mastered by a group of students to one degree or another. By creating a survey resource or a forum, the teacher has the opportunity to keep in touch with students, not in real, but virtual contact, which sometimes gives frankly interesting results. The use of the Moodle platform requires the teacher to have knowledge and skills in the use of information and communication technologies, but it repeatedly returns the efforts spent in mastering and applying the credit-modular system of education [3, p. 175].

An important task of our pedagogical research in the learning process was to identify and establish the order of regularities in the training of students of agricultural engineers by methods of information and communication technologies in education.

It will not be superfluous to note that in modern conditions of total informatization of society and society, future specialists in the agrarian industry feel the need to use the latest information and communication technologies of learning, which allow more extensive and qualitative self-improvement throughout life.

3.3. Properties of the computer-oriented environment as a component of information and communication technologies in engineering education

A computer-oriented learning environment provides an opportunity for self-realization of an individual who possesses the necessary professional qualities. Such a servant environment is the foundation for the organization of the modern educational process [50, p. 32].

Let's reveal the property and characteristics of a computer-oriented educational environment.

Scalability and extensibility . The architecture of the system and technological solutions must take into account its functions and changes in the number and quality of services, and the availability of productive processing of external requests from users of a computer-oriented educational environment . From a technical point of view, the properties of a computer-oriented learning environment are ensured by using the larger capacity of platform architectures and their capabilities. This is the basis for scaling the computer-oriented learning environment [55, p. 73].

Portability and modularity . Software of a computer-oriented educational environment is usually built according to the principle of modularity, individual modules of which can be located on different hardware and software platforms. This makes it possible to provide the necessary scaling of the computer-oriented educational environment , to use powerful computing clusters in the event of a change of platforms . These signs of portability cause the redistribution of the functions of maintenance of individual services of specific computer -oriented educational environments , which are used within a single educational space .

Reliability . Regarding the external student , all computer-oriented educational environments operating within a single educational space must guarantee the necessary technical characteristics of the reliability of their functioning [54, p. 77].

Multilevel client-server architecture of a computer-oriented educational environment . A generally recognized way of structuring the environment of open systems is the use of the so-called reference model, in the framework of which the information system contains three levels, namely: the core (computing and information resources), the shell (a set of standardized interfaces) and telecommunications (that is, the network and the standard protocols involved in it). Based on this, the TVS imposes certain restrictions on the choice of the general architecture of building a computer-oriented educational environment that functions within the framework of a single educational space - computer - oriented educational environments are mainly built in the environment of a multi-level client-server architecture .

Parameters of the computer-oriented interaction profile educational environment in a single educational space . Computer-oriented interaction profile educational environment is an agreed set of mandatory basic standards necessary to solve a specific task or a series of tasks. There are three main groups of standards:

- data transfer protocols (telecommunications level);
- software interfaces for the interaction of elements of a computer-oriented educational environment (shell level, i.e. document formats, metadata, interaction protocols and services);
- linguistic and organizational support (level of information resources) [55, p. 98].

Further, relevant proposals and justifications for each of the groups of standards are presented for determining the profile of a computer-oriented educational environment, on the basis of which the formation of a single educational space will be carried out.

The general scheme of information interaction of the portals of the unified educational space and data exchange between the corresponding computer-oriented educational environments is mainly implemented in a fully automated synchronous (on-line) mode. To ensure the specified synchronous exchange, it is necessary to use a standardized data transmission protocol, as such the basic protocol of the global network http :// is used . On the other hand, at the initial stage of the formation of a unified educational space, there is a real need for interaction with already existing computer-oriented educational environments that do not have http :// oriented interfaces. Therefore, in some cases, the optional use of the standard asynchronous protocol - smtp:// is provided . It is important to note that in both synchronous and asynchronous modes of telecommunication, the choice of these standard protocols is determined by the following factors:

- the possibility of using protected modes of data transmission, including the use of the electronic digital signature mechanism;
- the practical absence of restrictions on the use of various data transfer formats;
- a high degree of reliability of server applications using these protocols [55, p. 105].

Any of the portals is a means of searching and selecting high-quality Internet resources of a certain topic with a certain quality guarantee. That is, the portal is not just a recommended list of resources that is usually placed on the servers of various organizations, but a bibliographic tool that meets a whole set of requirements, including the scientific and pedagogical value of the document.

Let's highlight the following characteristic features of the portal:

- formulation and observance of the thematic framework of the subject, which determine which resources should be included in the recommended list;
- formulation and observance during the selection of resources and quality criteria for thematic sites, databases or individual documents;
- a certain form of description or annotation of each of the included resources;
- indexing and cataloging of the collection of resources that the portal recommends to its students;
- announcing and ensuring the system of responsibility of portal compilers for its creation, filling and constant updating [49, p. 112].

In their content and principle, portals are very different from search engines such as Google , and from directories such as Yandex. In it, the entire work of selecting resources, describing them, annotating and cataloging relies on a person whose experience and knowledge will help compensate for some of the defects that arise in the case of the use of automated means.

The portals do not limit the support of their users' professional activities to bibliographic services. They offer their students a whole range of web services, such as online conferences or forums, hosting for teams or authors working in a related field, sending special newsletters, etc. Educational portals contain electronic versions of lectures, teaching and methodical manuals, organize testing and computer-oriented learning environments for students. That is, the portal covers network sources of a certain field of knowledge, and can perform the functions of an information and educational environment for specialists and students.

The selection of sources for the portal is always based on two basic criteria: relevance to the topic and quality of the resource. As a result, the portal covers a relatively small volume of network documents, but at the same time guarantees a selection adequate to the student's professional needs, correct and fairly complete annotation, and a cataloging system that corresponds to the specifics of one or another field of knowledge or activity.

One of the quality criteria is the resource's belonging to certain defined categories. The specific selection of criteria depends on the subject field, the circle of users the portal is aimed at, and the selection technology adopted by the compilers. For example, one of the sections of the educational portal may be limited to the following types of documents:

− electronic magazines (reports and articles);
− mailing lists and archives;
− educational software;
− bibliographic, factual or full-text databases;
− graphic and multimedia documents;
− electronic news;
− bibliographies;
− leading pages of general educational institutions and innovative teachers [103].

It is more difficult with substantive quality assessment, which is difficult to formalize. A resource can be considered high-quality if the information it offers is accurate, up-to-date and comes from reliable and authoritative sources. Developers of portals and authors studying their experience identify a whole range of signs by which it is possible to establish whether a resource is of sufficient quality to be included in a collection. For example, the following criteria can be identified:

- completing the site in accordance with the announced goals;
- reliability and reputation of the source of information and its independence;
- accuracy of documents;
- completeness, level of detail of the source;
- uniqueness of the material;
- quality of composition and presentation of the material;
- ease of navigation;
- student support, availability of instructions, explanations;
- use of recognized standards;
- relevance of information at the moment [104 , p. 3 1].

In addition, to the selection of high-quality resources, the portal is subject to a number of requirements, in particular, mandatory annotation or description of resources, as well as support for some system of their cataloging. The description of the resource located on various portals has a wide range of differences in scope and form: from a simple abstract to a detailed informative summary of the content with an indication of keywords. The only common thing is that portal developers carefully avoid the use of automatically generated descriptions compiled by search engines. The keyword system is used when organizing a thematic search for documents on a certain site. Full-text search using index files and using algorithms based on methods of structural linguistics is also used.

Standards for the development of portals neither in the classification system nor in the used search tools have yet been developed, and this leaves a wide field for the independent creativity of designers, taking into account the specifics of the subject field and the intended range of users.

The most important feature of a quality portal is the presence of a permanent team or organizational structure that is responsible for its work. Just so can provide:

– high level of expertise during the selection, description and classification of resources;

– constant renewal of the collection of portal sources in accordance with the appearance of new documents in the network, changes on the sites, elimination of resources, etc. [112 , p. 14].

In most cases, information content management tools provide centralized management of accumulated data, separate content from presentation (that is, from site design or its application), and automate the life cycle of information content by different students for different tasks.

Based on the presented principles and means, the National University of Bioresources and Nature Management of Ukraine created a number of electronic information resources and network technologies, a number of sites and portals that form the electronic educational space of the university: an educational and informational portal and a scientific library portal (Fig. 3.22, 3.23) .

The content management of the portal of the National University of Bioresources and Nature Management of Ukraine is performed using the freely distributed PHP software product (PHP: Hypertext).

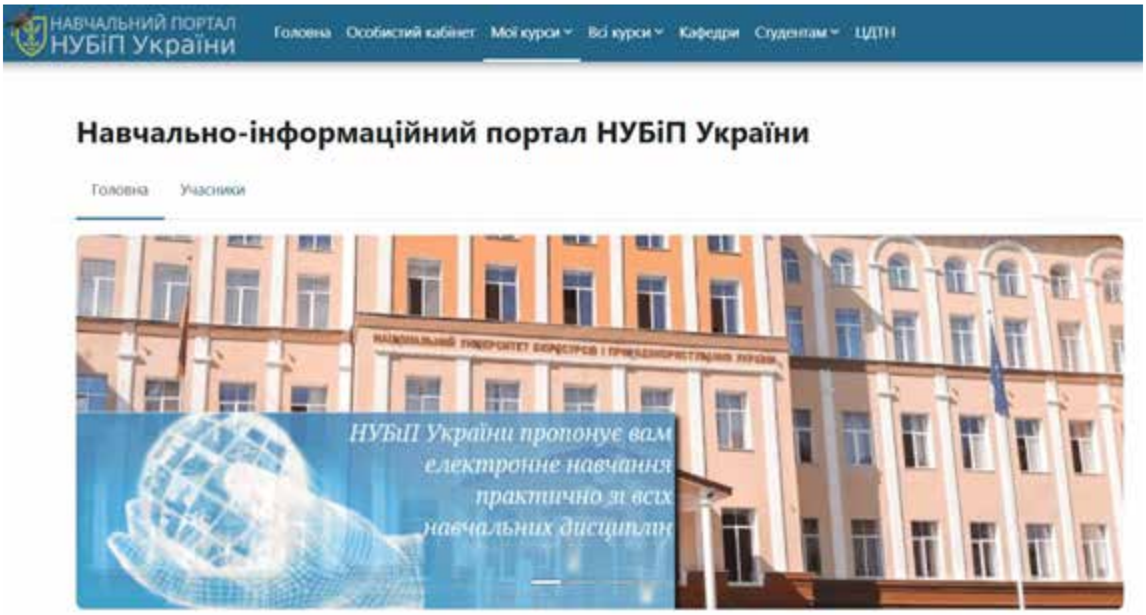


Fig. 3.22. Educational and informational portal of NUBiP of Ukraine

Achieving the goals of unification, and as a result, achieving the maximum practical effectiveness of individual means of information and communication technologies, which are developed for the purpose of further use in the system of open education, must take place in strict accordance with the specifications of the description of information resources produced for a specific system of open education.

Preprocessor; first Personal Home Page Tools - "Tools for creating personal web pages").

Developing a unified policy on the development and application of information and communication technologies in open education is the most difficult problem, which is further complicated by the fact that the formation and functioning of the open education system can be distributed in space and time thanks to the advantages of modern means of communication.

Appropriate ICT tools are developed at different times by different creative teams, after which the finished products are integrated within the framework of the open education system by sending data through telecommunication channels. Teachers and students, as the main users of information and communication technologies, get lost in a large amount of heterogeneous information of various types, the basis of which are structuring based on various criteria, and the principles of its transmission, processing and presentation are subject to various technological techniques.

There are frequent cases when the participants of the educational process have to master new additional methods of operating information and telecommunication equipment and software for each individual ICT tool used in open education.

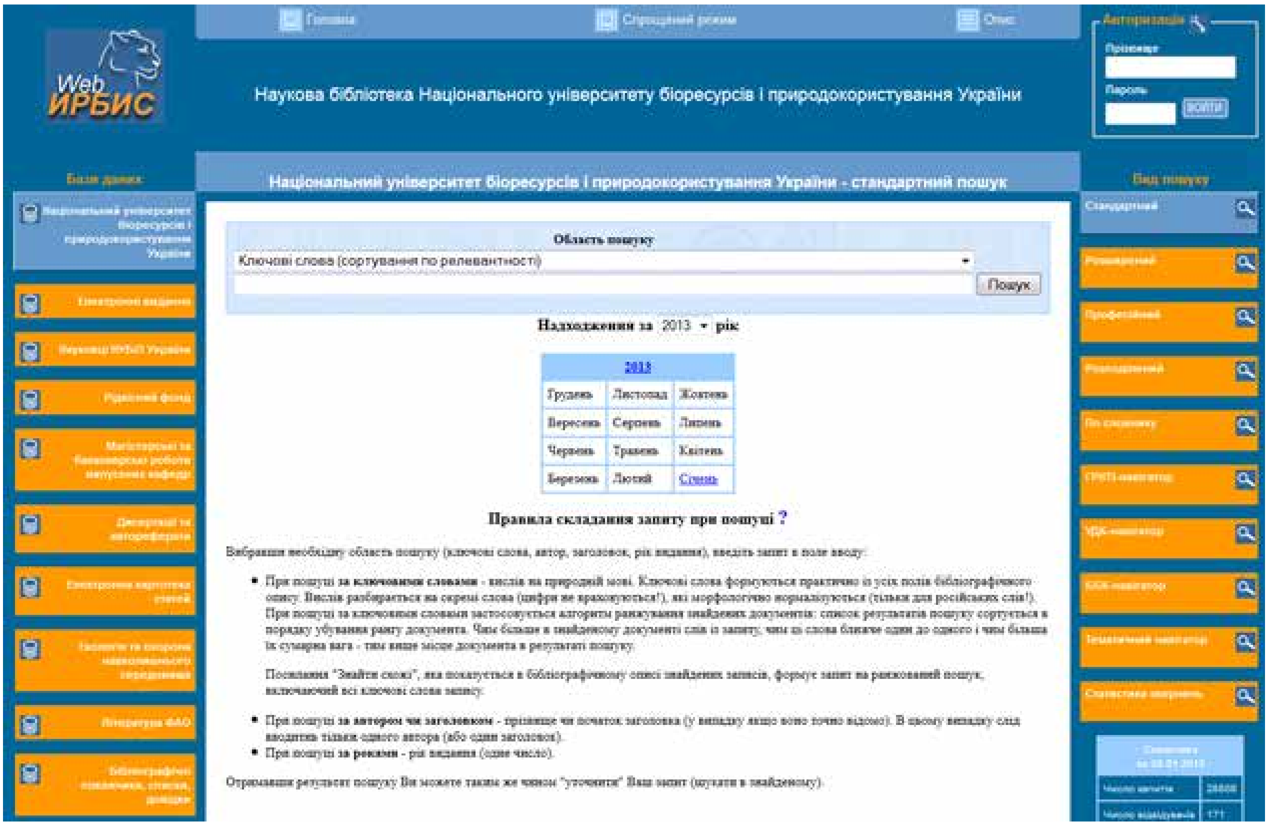


Fig. 3.23 . The portal of the scientific library of NUBiP of Ukraine

Let's highlight the trends in the use of a computer-oriented educational environment:

1. Development and distribution of computer-oriented learning tools included in the environment. This trend is manifested in the creation of resource centers that are engaged in the distribution of modern computer educational resources and tools via the Internet, their collection, registration, systematization, and provision of methodical and methodological recommendations for their use. This method of introducing computer-oriented learning tools provides openness to the learning environment, which acquires flexibility and mobility, the range of use and the possibilities of choosing tools depending on the learning goals are expanded. With the development of this trend, it can be predicted that eventually the so-called "closed" computer-oriented educational environment, in which the use of a computer is reduced to the operation of one or another individual tool, will become a thing of the past.

2. Changing the role and purpose of educational computer systems , in

particular, with elements of artificial intelligence, as part of the environment. If earlier educational assignment systems were created with the aim of performing some functions of a teacher and managing education, then in the conditions of an open environment their goals change. The priority is the student's independent study, in which the teacher will provide him with the necessary support and direction. Therefore, the role of artificial intelligence systems is also changing. They are used to support learning in its various aspects - to search for information, master a new subject area, evaluate, improve qualifications, etc. To some extent, artificial intelligence systems are turning from learning management tools into communication and self-learning support tools.

3. The growing role of specialization in the process of creating and using educational computer systems. Computer-oriented tools are becoming more specialized, their use is becoming systematic. For example, the environment may include: a program that monitors the progress of the student's reasoning based on his model, provides and corrects the performance of educational tasks; one or more knowledge bases; a knowledge control system that can be used both by the student for self-testing and by the teacher to control the student's knowledge; the system is a pedagogical agent that provides recommendations for solving problems, finding the necessary material, and answering questions; a "microcosm" type program for modeling; exercise program and others. All these programs can be localized in different ways both on the server of the educational institution, where the teacher is located, and on the student's computer, on remote computers that the student accesses during the study process , etc.

4. The growing role of integration in the creation of computer-oriented teaching aids. There is a tendency to create integrated tools that combine the functions of several tools of different types. For this purpose, separate modules are used, which can be part of both one and several different teaching aids [122]. Based on the modules, it is possible to create various configurations of the learning environment, taking into account a specific educational goal. Such environments will contain, for example, a model of the subject area together with powerful means of presentation

and representation of objects of study, including visualization, virtual reality capabilities, means of simulating an experiment; subsystem of computer support for establishing new patterns; interactive mastery of concepts and symbols; formulation of statements, their further generalization and systematization; a subsystem for fixing problem situations, setting and solving problems; as well as evaluation of learning outcomes.

5. Increasing effectiveness and multi-levelness of used knowledge models. Knowledge models underlying computer systems for educational purposes are becoming more powerful and detailed. This leads to the creation of more effective models of student and teacher activity. Thanks to the improvement of student models, computer programs become more individualized, adapt to the peculiarities of the student's thinking and personality. Modern models of the teacher provide opportunities for communication in ordinary language, procedural and contextual assistance, monitoring of plans and strategies of student reasoning, etc. [123].

6. Development of interactive learning environments. The concept of an interactive learning environment is undergoing changes. Previously, this term meant, as a rule, educational programs that provide tools for independent student work and have an appropriate system of methodological instructions and recommendations (for example, " microworld " programs , hypertext textbooks, etc.) [59, p. 44]. Now environments of this type acquire an open character, when the ideas about the interactivity of working with them change. It is assumed not only the work of one student with this environment, but the communication of a group of students or students and teachers in the learning process.

7. Formation of virtual learning communities. A characteristic feature of learning in an open computer-oriented learning environment is the formation of learning communities united by interests in the process of implementing an educational project, solving a problem, etc. This trend indicates that the participants of the educational environment do not necessarily belong to a certain educational class or educational institution, they may not belong to educational institutions or their networks at all. It can be any person - students, teachers, experts, specialists

who are interested in solving some question, scientific problem, whose sphere of interest concerns the environmental field. In this way, learning truly becomes open in the sense that it is not limited to educational institutions, but involves free communication and the search for new ideas [130].

8. The emergence of powerful banks and libraries of expert knowledge. The improvement of knowledge presentation methods will lead to the creation of much more powerful hierarchical, multi-level knowledge bases, combining them into libraries or banks of expert knowledge from various scientific fields and their subdivisions. The use of such banks enables the student to attract information from several related disciplines to solve, for example, an open problem.

Thus, the goal of education is not only mastering a certain amount of knowledge (a person can be replaced by an expert system in many cases), but directing the acquired knowledge in order to solve actual practical and theoretical problems.

Educational portals play an important role in the creation and development of an open computer-oriented learning environment . which perform various functions - creation, transfer, control of knowledge, confirmation of received qualifications, provision of information services, etc. [124].

Although a large number of new tools are created, their use often does not have a sufficiently systematic character. This problem is especially relevant in the conditions of Ukraine, where there are practically no servers of educational computer resources. This work is just beginning. Information about available resources, possibilities of their use, terms of distribution can be displayed in the portal.

Educational portals in this context are not only a means of providing information, but also a means of conducting scientific research. For example, the compilation of lists of teaching aids and their classification can be carried out on the basis of data placed on the Internet, and which are displayed in an integrated form in the content of the portal. Even such information as the number of calls and copies of a particular tool to a certain extent indicates the effectiveness of its use, and such data, as a rule, are displayed on the servers of educational services. There is also the possibility of conducting Internet surveys on the effectiveness of using certain tools, which could indicate their "viability" and popularity among students and teaching staff.

The development of requirements and expert evaluation of computer-oriented tools is quite difficult in connection with the development of evaluation criteria. It is not always possible to predict in sufficient detail what types of learning activities will occur when working with the tool, the developers themselves cannot always predict this [128]. The issue of creating appropriate conceptual grounds for testing and approving means remains important. The results of expert evaluation can also be displayed in the portal.

Creation of educational and computer-oriented educational environment, virtual Internet-centers that would provide methodological support to teachers regarding the use of certain computer tools, answers to questions, recommendations regarding the organization and use of a computer-oriented environment, conducted training on searching necessary resources and navigation in the Internet space.

Creation of appropriate resources that would provide the student with the results of scientific research, foreign experience in organizing a computer-oriented environment, definition and classification of types of environment, formulation of requirements for the composition of the environment, information on the latest computer-oriented learning tools, opportunities and results of their application.

Collection, analysis and dissemination of advanced pedagogical experience in the use of computer-oriented learning tools and learning environments, which could take place through the holding of forums on this topic, the creation and distribution of relevant resources, which will ultimately be manifested in the formation of virtual communities interested in the development of this issue .

In recent years, the composition of the funds has changed significantly, in particular, a significant part of the library funds is primary information documents on other than traditional media (on CDs, video and audio cassettes, etc., as well as in the long-term memory of a PC); in the reference and search apparatus, along with traditional card catalogs and paper indexes, electronic search systems (catalogues, file cabinets, indexes, etc.) play an important role, which, as predicted, will eventually completely replace traditional search tools.

In addition, modern search systems, in particular, tools that are presented in the global computer network Internet, allow students in the library to search for sources outside of "their" library fund, that is, in the funds of the "world virtual library", and in many situations, after finding the address of the document in the virtual directory, view (or order) the document itself. Strictly speaking, we are dealing with a so-called "hybrid library", in which elements of a traditional electronic library are combined (integrated).

The emergence of hybrid libraries depends more on cultural shifts than on technological progress; they are a perfectly acceptable model of the evolution of a traditional library. The term "hybrid library" has entered the professional glossary of library and information workers over the past three years. It is used to indicate an intermediate link on the way to a full transition to digital libraries.

A digital library is a system of information services within which all information resources exist in an electronic form suitable for processing on a computer, and the functions of obtaining, saving, protecting, saving, accessing and viewing information are carried out through the use of digital technologies. Digital library services are not limited to providing information in text format; say, audio and video resources can also be provided digitally. Digital library resources are divided into originally created in digital format, for example, electronic journals and data sets, and non-digital resources, for example, manuscripts and printed publications, translated into digital format [47, p. 23].

A digital library can distribute information within a network, and in the same way users can select it. Among the advantages of a digital library, it is worth mentioning a reduction in the amount of information stored, a lower level of wear and tear of materials, the ability to provide the same information to several students at the same time, the possibility of accessing materials from home, office or other places outside the library, finally, the presence of a real potential for increasing economic efficiency [34, p. 19].

A hybrid library can be given a simple definition: a means of integrating a traditional library with a digital one. The concept of "hybridity" is often used in descriptions of activities or services that combine two basic components [125].

Today's modern user is forced to work in a hybrid environment, addressing materials that exist simultaneously in electronic and paper form.

In the information society, all members, regardless of social status, use information and knowledge in their activities, solving the tasks that arise before them. At the same time, the reserves of knowledge, experience, and the entire intellectual potential of society, which is concentrated in books, magazines, reports, and ideas, are constantly increasing. At the modern technical level, the majority of society members take part in everyday industrial, scientific, educational, and other activities.

Summarizing the approaches to pedagogical software tools, their classification and didactic properties, the following conclusions can be drawn: optimization of the educational process during the formation of communicative knowledge, skills and lessons can be achieved through the use of multimedia technologies - electronic textbooks, dictionaries, reference books, encyclopedias, computer programs, etc. According to the form of presentation of educational information, all pedagogical software tools for learning a foreign language can be conditionally divided into several types: informative, situational, game, controlling, multi-aspect (complex), intensive, instrumental.

Electronic courses contain a significant amount of video and audio materials, which provides auditory and visual clarity, making learning a foreign language more interesting, exciting, and effective.

At the current stage of society's development, information is becoming the most important global resource of humanity, the basis of modern high technologies, the basis of a new information civilization; the process of society's transition to a qualitatively new era - the informatization of society - is being observed.

These fundamental transformations lead to the creation of a new information civilization - an information society, which also determines the socio-cultural life of a person, forms and develops the information culture of an individual.

The active implementation of society's informatization technologies could not fail to affect the education system as well.

The basis of the modern stage of education modernization is the wide use of information and communication technologies and methods of preparation, transfer and presentation of information to students, using the computer as a new means of supporting the educational process, which radically changes the dynamically developing system of forms and methods of education. Multimedia and hypermedia technologies are widely implemented in the educational process .

Multimedia technologies are related to the process of creating multimedia pedagogical software, i.e. e-books, "live" and voiced pages of which are displayed on the display screen, multimedia encyclopedias, computer movies, databases, etc. A characteristic feature of multimedia pedagogical software is the combination of text, graphics, audio and video information, and animations. In contrast to ordinary pedagogical software tools, in multimedia pedagogical software tools the information itself comes to the fore.

Hypermedia technologies are the development of hypertext technologies, which represent enormous opportunities for working with texts and organizing cross-references between them. Virtually all modern information and reference systems are implemented in hypertext technology. Global network technologies are a significant direction of informatization of rapidly developing society, in general and education in particular.

The largest global network, which unites thousands of regional and corporate networks of the world into a single entity, is the Internet - a collection of various components: e-mail, electronic textbooks (manuals), encyclopedias, dictionaries, teleconferences, and even chats.

Multimedia and hypermedia technologies make it possible to increase the effectiveness of education due to the stimulation of the greatest number of sensations in the student. Educational multimedia and hypermedia systems allow users to manipulate information, deform it from various parameters, choose the necessary trajectory of actions, analyze user actions.

A computer-oriented educational environment includes many information objects and connections between them, means and technologies for collecting, accumulating, transmitting, processing, producing and distributing information [120, p. 86].

The study of domestic and foreign experience in the use of information and communication technologies, with the aim of training future specialists, as well as theoretical research in the field of informatization of education allows a computer-oriented educational environment to show that the inclusion of a computer in the educational process has a certain influence on the role of educational tools , which are used in the process of teaching this or that subject (discipline), namely the use of information and communication technologies reformats the traditionally formed structure of the educational process.

Chapter 4. Using the MATHCAD application in computational mathematics

4.1. Introduction to Mathcad. The simplest calculations, construction of graphs of functions

The "MathCAD" program package makes it possible to calculate numerical expressions and function values, which include addition, subtraction, multiplication, division, exponentiation, making logarithms, differentiation, integration, finding solutions of algebraic and differential equations and their systems in analytical or numerical in the form Problems of this type arise during mathematical modeling of any processes, including agricultural ones.

"MathCAD" is based on the traditional sequence of writing and performing calculations using numerical expressions or formulas.

The MathCAD environment has a number of features that must be taken into account when performing calculations:

- the working document is read from top to bottom, from left to right.
- symbols used in calculations, except for text zones, must be written with an English keyboard layout.
- decimal values of numbers are separated by a dot.
- strict sequence of placement of symbols and operations on the working field:
  - symbols and their corresponding numerical values included in the expression;
  - area or specific values of variables;
  - expression in general form;
  - calculation result;
  - graphical dependency based on the written expression.

If the specified order of data placement or operations is violated, those symbols in the expressions whose value is not defined are highlighted in red and an error message is displayed in the place where it was made.

<u>User interface</u>

- Menu bar - menu bar;
- Toolbars - toolbars: Standard, Formatting, Math, Resources, Controls;
- Working area – worksheet;
- Status line – status line or status bar;
- Pop-up menus or context menus;
- Dialog windows - dialogs;
- Status bar – Status bar;

<u>Menu items</u>

- File;
- Edit;
- View – managing the appearance of the document, setting toolbars;
- Insert;
- Format;

- Tools – commands for managing the computing process and additional capabilities;
- Symbolic – commands for symbolic calculations;
- Windows;
- Help;

The Math panel includes palettes

- Inserting mathematical operations - Calculator;
- Graph insertion - Graph;
- MatFigs and matrix operators - Matrix
- Calculation management operators - Evaluation;
- Operators of integration, differentiation, summation - Calculus;
- Logical operators - Boolean;
- Programming - Programming;
- Greek symbols - Greek;
- Symbolic operators – Symbolic;

Cursor view (crosshair)

- The mouse pointer is an arrow;
- The input cursor is a red cross + ;
- Input lines (editing lines) - right angle of different orientation (right, left)┘ , ∟, │ ;
- Placeholders - □, ■;

Moving input lines

- Click the mouse in the desired city;
- From the keyboard;
- arrows - →↑←↓;
- the Space key (highlighting different parts of the formula);
- key - Ins (transfers the vertical input line from one end of the horizontal input line to the opposite);

Moving formulas

- Edit menu;
- From the keyboard;
- Context menu;
- The symbol **Hand** (**Palm**), which appears after selecting the object when the cursor is placed on the border of the formula.

Entering signs, symbols, operators, functions

From the keyboard - numbers, Latin letters;
Greek letters from the palette;
Arithmetic operation signs, operators - from the keyboard or palettes;
Names of functions - from the keyboard, using the Insert→Function command, the symbol on the ***f(x) panel*** ;

Starting the MathCAD program

- download the **Windows operating system** ;
- click on the " **Start" button;**

- in the " **Programs" menu item** , select the " **MathSoft Apps" sub-item** , go to the cascade submenu and select the " **Mathcad Professional** " item;
- **MathCAD** splash screen will appear on the screen , then the **MathCAD window .**

Before starting any calculations, it is necessary to set up the **"Mathematics" panel in the working window** , which gives the opportunity to display the signs of mathematical operations, symbols, operators, graph templates, etc. on the working field. The order of coding of basic mathematical operations using the keyboard is shown in Table 1.

Table 1.18

Operator	**Keyboard shortcuts**	**Description**
+	<+>	Addition
-	<->	Subtraction
x	<*>	Multiplication
/	< / >	Division
÷	<Ctrl>+< / >	Division into one line
$\blacksquare^{\blacksquare}$	<Shift> + < 6>	Exponentiation
$\sqrt{\ }$	<\>	Square root
$\sqrt[n]{\ }$	<Ctrl>+<\>	The root of the *nth* power
□■□	<Shift> + < \>	Module
x_i	x <[> i	The variable x with a subscript and
(x)	<Shift> + < 9> x <Shift> + < 0>	The value of x is in parentheses
:=	<Shift> + <F>	Appropriation
■ .. ■	<F>	Range of values
$y_i := \begin{pmatrix} a \\ b \\ c \end{pmatrix}$	y <[> I <Shift +Ж> a <,> b <,> c	Give the variable **y** $_i$ a series of values **a,b,c**
$\frac{d}{dx}y(x)$	<Shift> + < /> in <x>	The differential of the function **f(x)** with respect to **x**
$\sum_i x_i$	<Shift> + < 4> x	The sum of the variables x amount and
$\int_a^b f(x)dx$	<Shift> + < 7>	The definite integral

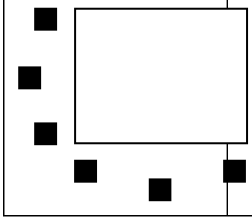
	<Ctrl>+ <M>	Matrix
	<Shift> + < 2 >	Display the graph template

Table 1.19

Coding menu and toolbar commands using the keyboard

Menu	Team	Translation	Keyboard shortcuts	Description
File (File)	**New**	Create	<Ctrl>+<N>	Create a new document
	Open	Open	<Ctrl>+<O>	Open an existing document
	Close	close	<Ctrl>+<W>	Close the active document
	Save	save	<Ctrl>+<S>	Save the active document
	Print	Print	<Ctrl>+<P>	Print the active document
Edit	**Undo**	Cancel	<Ctrl>+<Z>	Undo the last action
	Redo	Repeat	<Ctrl>+Y>	Redo the last canceled action
	Cut	Cut out	<Ctrl>+<X>	Cut the selected fragment
	Copy	Copy	<Ctrl>+<C>	Copy the selected fragment
	Paste	Insert	<Ctrl>+<V>	Insert an expression from the buffer
	Delete	Remove	<Ctrl>+<D>	Delete the selected fragment
	Select All	To single out	<Ctrl>+<A>	Select the entire worksheet
	Find	Find	<Ctrl>+<F>	Text search
	Replace	Replace	<Ctrl>+<H>	Replacing some text with another
View	**Refresh**	Renew	<Ctrl>+<R>	Update the document
Insert	**Matrix**	Matrix	<Ctrl>+<M>	Insert matrix or vector
	Function	Function	<Ctrl>+<E>	Insert built-in function
	Unit	Units	<Ctrl>+<U>	Insert the units of measurement of the value of some dimension
	Picture	Picture	<Ctrl>+<T>	Create a picture to display the matrix
	Hyperlin k	Hyperlink	<Ctrl>+<K>	Insert hyperlink

Customize the Math panel

- in the **"View" menu item** , select the **"Toolbars" sub-item** ;
- go to the cascade submenu and check the **"Mathematics" item** ;
- open the necessary palettes of the **"Mathematics" panel** by pressing the left mouse button once on the button of the corresponding palette.

The MathCAD mathematical environment is used for complex mathematical calculations, but also as a simple calculator, when calculating numerical expressions.

Calculation of an expression in numerical form

- set the cursor anywhere in the working document;
- output from the keyboard or palette: the number on which the mathematical operation will be performed, the sign of the operation, the number, the sign of the operation, etc.;
- to get the result, display the equals sign.

Example:

$$\frac{648+(24{,}6\cdot 2{,}73)-\left(\frac{245}{69}\right)\cdot\sqrt{367}}{|174-440|}=2{,}4333$$

As a rule, in this mathematical environment, calculations are carried out using the recording of mathematical operations not in numerical, but in analytical expressions, which significantly expands the possibilities of calculations and reduces the time when calculating the values of functions for given values of the argument. To calculate in this form, the following sequence must be followed.

<u>EXAMPLE No. 1</u>

it is necessary to obtain the values of the linear (y=a+b x) and quadratic (z=a+b x +c x^2) functions for the values <u>of the variable x from 1 to 5</u> , and plot the graphs of these functions in one coordinate system.

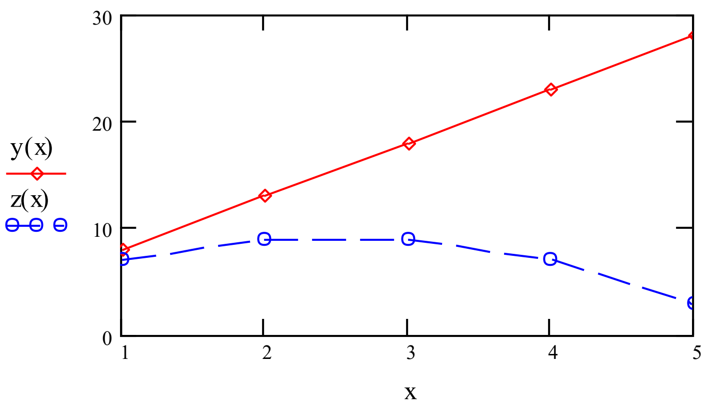
In this case, functions are denoted by different symbols. The recording of data and the procedure for performing such construction in MCAD will look like this:

$x := 1..5 \quad a := 3 \quad b := 5 \quad c := -1$

$y(x) := a + b\cdot x$

$z(x) := a + b\cdot x + c\cdot x^2$

y(x) =	z(x) =
8	7
13	9
18	9
23	7
28	3



Writing symbols and numerical values

- from the keyboard or palette, output the symbol that is part of the expression and has a numerical value;
- use the key combination " **Shift + :** " or from the **Arithmetic palette** to display the "give value" symbol, which has the form (**:=**);
- type the corresponding numerical value from the keyboard.

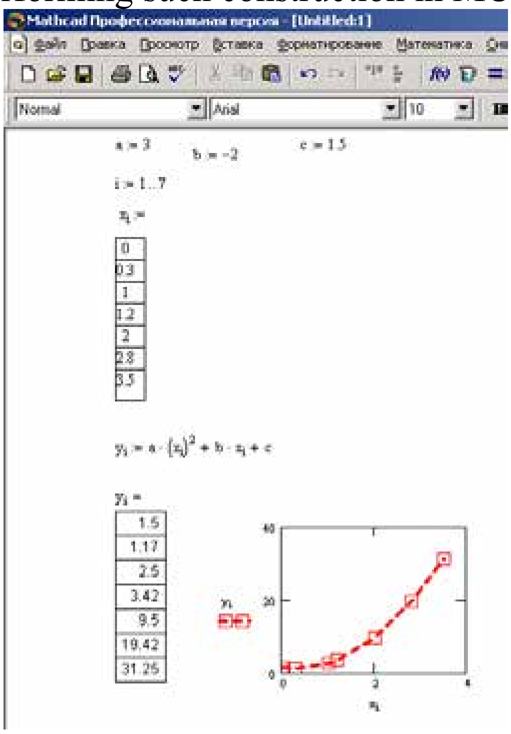
A variable value that is included in a formula can take on values in a specified range with a specified step, or these values can be a set of specific numbers.

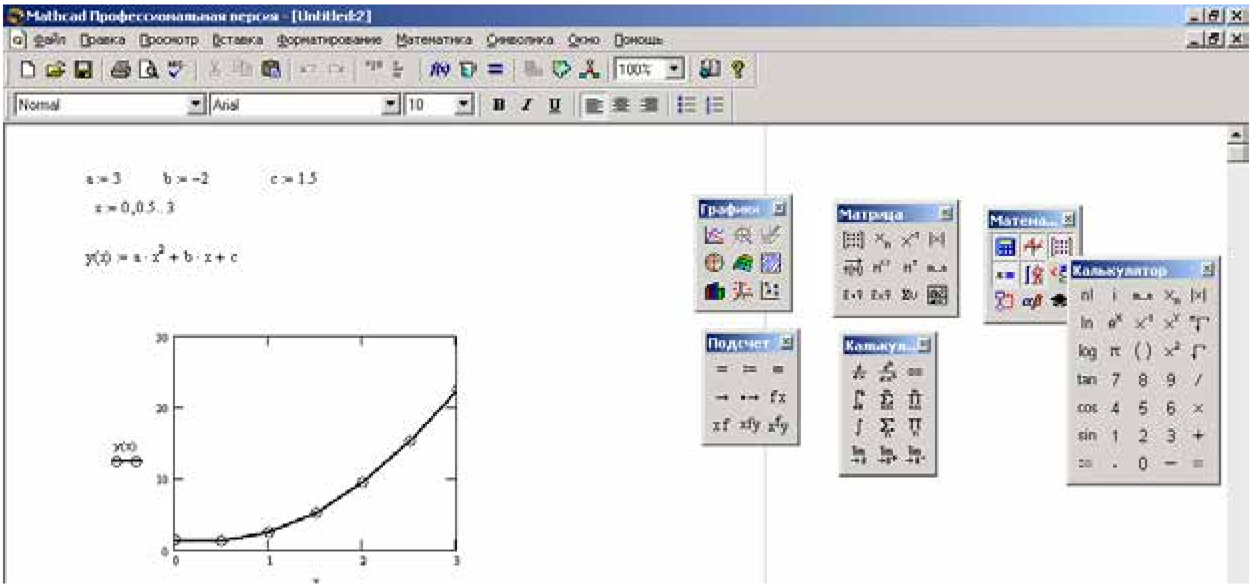
Setting the scope of variables

- output the variable symbol from the keyboard or palette;
- output the **"given value" symbol** (**:=**);
- use the " **:** " key or from the **Arithmetic palette** to display the template " **discrete value range** " **(m ..n)** and write the initial and final value of the interval in the free zones;
- to specify a step of a variable other than one, write the next value of the variable after the initial value of the interval with a comma (for example, x := 0, 0.5 ..5). In this case, the step of the variable will be 0.5.

EXAMPLE No. 2

Calculate the functional dependence y= *a* x *2* + *b* x + *c and plot the graph* of the function when the constants take the values a=3, b= -2 , c=1.5. The *x* variable takes values from 0 to 3 in steps of 0.5. The recording of data and the procedure for performing such construction in MCAD will look like this:

- 



Specifying specific variable values

In the case when the value of the variable cannot be presented in the form of a range (1...8), and it is necessary to specify their specific values, the form of their recording takes on a different form. For this you need:

- from the keyboard or from the palette, output the letter " **and** ", output the symbol **"give a value"** , output the template " **discrete value range** " **(m ..n)** ;
- write instead of the initial value of the interval 1, instead of the final value - a number that corresponds to the number of variables;
- write down the symbol of the variable, use the “[” key or from **the Arithmetic palette** to create a lower index next to the variable, write the letter “ **and** ” in the free space of the index;
- output the symbol “ **give a value** ” (:=);
- from the keyboard through which to enter specific numeric values of the variable (they will be formatted as a table).

Writing the expression in its general form

- write the function symbol from the keyboard;
- write the symbol of the variable in parentheses next to the function symbol, if it is specified through a range of values;
- next to the function symbol, display the subscript icon and write the letter " **and** " in the index, if the variable is specified with specific values;
- display the "give value" symbol;
- write the expression with the symbols of constants and variables in the form in which they were written before, and set the signs of the corresponding mathematical operations between them **.**

Obtaining the result of calculations

- write down the symbol of the function as it was given;
- output the sign (=) from the keyboard or from the palette;
- the calculation result will be presented as a table.

Construction of graphs of two-dimensional dependencies

- **"Shift + 2"** key combination or the mouse from the " **Graphics" palette** to display the template of the two-dimensional coordinate system;
- write the symbol of the argument in the free zone under the abscissa axis;
- write the symbol of the function in the free space to the left of the ordinate axis;
- to construct graphs of two or more functions in one coordinate system, it is necessary to write down the symbols of all functions through a comma along the ordinate axis;
- to build a graph, press the **"Enter" key** or click the mouse on a free space outside the graph field.

Formatting graphs of two-dimensional dependencies

- double-click the mouse in the graph field;
- in the dialog box that appears, in the **XY Axes (X–Y Axes) tab** , specify the type of coordinate axes, the presence and density of the coordinate grid, etc.;
- in the **Traces tab** , the drawing type, color, thickness of any of the function graph lines is specified using the system lists.

Copying objects (formulas, graphs)

To reduce the time of writing a calculation block that contains the same formulas, graphics or texts, it is advisable to copy them with subsequent minor formatting.

- place the cursor next to the object to be copied;
- select an object by dragging the cursor along its diagonal while holding down the left mouse button. The selected object is framed by a dashed line;
- copy the selected object to the clipboard by clicking the **"Copy" button** on the toolbar ();
- move the cursor to the place of copying the object;
- insert an object from the clipboard by clicking the **"Insert" button** on the toolbar ().

Moving objects

Sometimes, to ensure a defined sequence of placing operations and symbols on the workspace, or to organize the structure of records, it is necessary to move an already created object. For this:

- select an object by clicking on it. It will be framed in a black frame;
- set the cursor on the frame line so that it takes on the appearance of a hand;
- with the left mouse button pressed, move the object to the desired place.

Save the file

- in **the "File" menu item (File)** select the **"Save as" sub-item (Save as)** - when initially saving the document or **"Save" (Save)** - when re-saving;
- in the dialog box that appears, in the **"Save in" ribbon** , specify the name of the folder or disk where the file will be saved, in the **"File name" ribbon** , write down the name of the file.

Loading a saved file

- in **the "File" menu item (File)** select the **"Open" sub-item (Open)** ;
- in the dialog box that appears, find and open the desired folder and select the desired file;

- click the **"Open" button** within the dialog box.

Finishing work with "MathCAD"

- close **"MathCAD"** by clicking on the corresponding button in the right corner of the menu bar  ;

Practical work #1

<u>Execution program</u>

1. Download the mathematical application Mathcad .
2. Complete the following tasks.
3. Save the created document in your own folder.
4. Finish work in Mathcad .

<u>Tasks for practical work</u>

I. Calculate the value of the expression. Expression numbers are determined by the last digit of one's own option. For example, if the last number of your option is 15, then you choose task #5 and the next one with an odd number, namely #7. If your number is 8, then you choose the next one with an even number - #8 and #0, etc.

<u>Remember!</u>

A. When performing calculations in the MATHCAD environment with mixed fractions (fractions that have a whole and a fractional part), it is necessary to convert the mixed fraction into an improper fraction.

For this you need:

1) multiply the denominator of a mixed fraction by its whole part and add to the numerator;
2) write the obtained result in the numerator of an improper fraction;
3) leave the denominator unchanged.

For example, a fraction $2\frac{1}{6}=\frac{2\cdot 6+1}{6}=\frac{13}{6}$.

B. The action of division (:) is entered in the form of (÷) using the < Ctrl > + < / > key combination, which means division into one line.

1. $$\frac{\left(\left(3\frac{7}{12}-2\frac{11}{18}+2\frac{1}{24}\right)\cdot 1\frac{5}{31}-\frac{3}{52}\left(3\frac{1}{2}+\frac{5}{6}\right)\right)\cdot 1\frac{7}{13}}{\frac{19}{84}:\left(5\frac{13}{42}-2\frac{13}{28}+\frac{5}{24}\right)+1\frac{2}{27}-\frac{1}{3}\cdot\frac{4}{9}}.$$

2. $$\frac{2\frac{3}{4}:1{,}1+3\frac{1}{3}}{2{,}5-0{,}4\cdot 3\frac{1}{3}}:\frac{5}{7}-\frac{\left(2\frac{1}{6}+4{,}5\right)\cdot 0{,}375}{2{,}75-1\frac{1}{2}}.$$

3. $$\frac{0{,}4+8\left(5-0{,}8\cdot\frac{5}{8}\right)-5:2\frac{1}{2}}{\left(1\frac{7}{8}\cdot 8-\left(8{,}9-2{,}6:\frac{2}{3}\right)\right)\cdot 34\frac{2}{5}}\cdot 90.$$

4. $$\frac{\left(5\frac{4}{45}-4\frac{1}{6}\right):5\frac{8}{15}}{\left(4\frac{2}{3}+0{,}75\right)\cdot 3\frac{9}{13}}\cdot 34\frac{2}{7}+\frac{0{,}3:0{,}01}{70}+\frac{2}{7}.$$

5. $$\frac{\left(1{,}88+2\frac{3}{25}\right)\cdot\frac{3}{16}}{0{,}625-\frac{13}{18}:\frac{26}{9}}+\frac{\left(\frac{0{,}216}{0{,}15}+0{,}56\right):0{,}5}{\left(7{,}7:24\frac{3}{4}+\frac{2}{15}\right)\cdot 4{,}5}.$$

6. $$\left(2:3\frac{1}{5}+\left(3\frac{1}{4}:13\right):\frac{2}{3}+\left(2\frac{5}{18}-\frac{17}{36}\right)\cdot\frac{18}{65}\right)\cdot\frac{1}{3}.$$

7. $$\frac{0{,}5+\frac{1}{4}+\frac{1}{6}+0{,}125}{\frac{1}{3}+0{,}4+\frac{14}{15}}+\frac{(3{,}75-0{,}625)\cdot\frac{48}{125}}{12{,}8\cdot 0{,}25}.$$

8. $$\frac{0{,}725+0{,}6+\frac{7}{40}+\frac{11}{20}}{0{,}128\cdot 6\frac{1}{4}-0{,}0345:\frac{3}{25}}\cdot 0{,}25.$$

9. $$\frac{\frac{5}{6}-\frac{21}{45}}{1\frac{5}{6}}\cdot\frac{1{,}125+1\frac{3}{4}-\frac{5}{12}}{0{,}59}.$$

10. $$\frac{\left(\frac{5}{8}+2\frac{17}{24}\right):2{,}5}{\left(1{,}3+\frac{23}{30}+\frac{4}{11}\right)\cdot\frac{110}{401}}\cdot 0{,}5.$$

II. Plot graphs of linear $y=ax+b$, quadratic $y=ax^2+bx+c$, and hyperbolic functions $y=\frac{a+x}{b+x}$:

1) for odd numbers of options in the interval [-1;1] with a step of 0.1;
2) for even numbers - on the interval [-2;2] with a step of 0.2.

Coefficients a, b, c can be obtained from the following table:

Table 1.20

	Odd options	Pair options

a	Option number	The opposite number of the option number
b	The opposite number of the option number	A number that is the inverse of the option number
c	A number that is the inverse of the option number	Option number

Format the obtained graphs according to the following requirements.

For linear dependence:

- The symbol is a rhombus;
- The line is dotted;
- Color – blue;
- Type - line:
- Size - 2. (see Fig. 1 at the end of the task)

For quadratic dependence:

- The symbol is circles;
- The line is dashed;
- Color – green;
- Type – line;
- Size - 3. (see Fig. 2 at the end of the task)

For a hyperbolic dependence:

- The symbol is squares;
- The line is dash-dotted;
- Color – brown;
- Type – trunk;
- Size - 4.

Drawings should have the form shown in fig. 1, 2 at the end of the document.

III. Plot the graph of the function $y = a\cos bx + c$ for given variable values see table 1.21

Table 1.21

H	-1	-0.7	-0.6	-0.2	0	2,3	3,4	4.8	5

Format the graph according to the following requirements:

- Symbol - pluses;
- The line is dotted;
- Color – black;
- Type - drawing
- Size - 3.

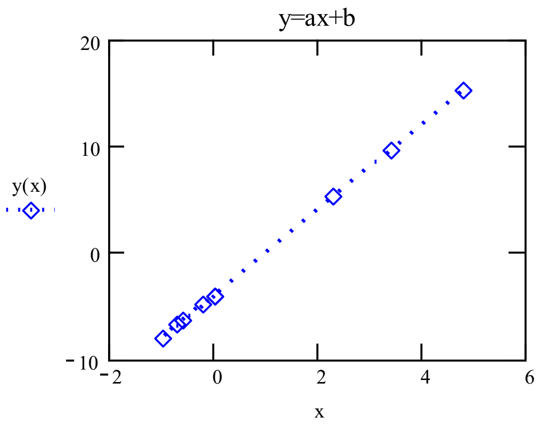


Figure 1.

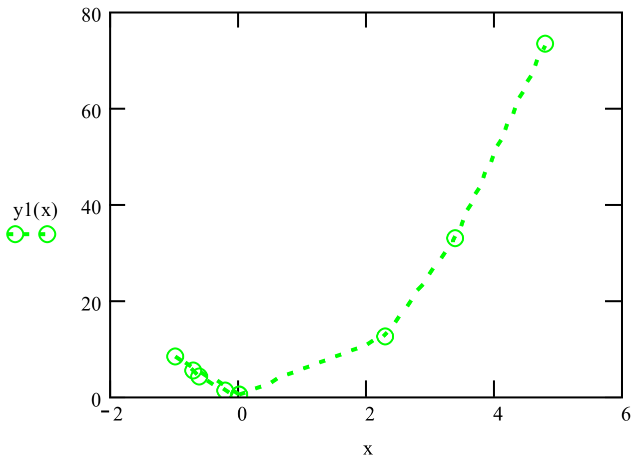


Figure 2.

4.2. Solving systems of linear algebraic equations in Mathcad

Record of determinants

When developing mathematical models, there is often a need to find solutions to a system of equations with several unknowns, for example, two x and y:

$$a_1 \cdot x + b_1 \cdot y = c_1$$

$$a_2 \cdot x + b_2 \cdot y = c_2$$

The solution of the system can be found by Kramer's method through the determinants:

$$x = \frac{|\Delta x|}{|\Delta|}, \quad y = \frac{|\Delta y|}{|\Delta|},$$

where:

$$\Delta := \begin{pmatrix} a_1 & b_1 \\ a_2 & b_2 \end{pmatrix} \qquad \Delta x := \begin{pmatrix} c_1 & b_1 \\ c_2 & b_2 \end{pmatrix} \qquad \Delta y := \begin{pmatrix} a_1 & c_1 \\ a_2 & c_2 \end{pmatrix}$$

To record matFigs in Mathcad, you need:

- write down the symbol that will denote the matrix;

- output the "give value" sign or assign, which has the form (:=);
- in the **"Matrix" palette** , click on the corresponding icon ;
- or press <Ctrl> + <M> **to** call up the matrix template;
- in the dialog box that appears, specify the number of rows and columns of the matrix;
- fill the resulting matrix template with the appropriate symbols or values.
- to find the inverse matrix in Mathcad, there is an **Inversion** operation , indicated on **the Matrix panel** by the symbol $\mathbf{X}^{-1}$.

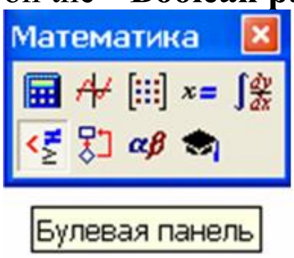
Calculation of determinants

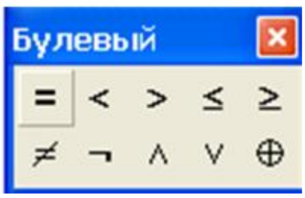
- from the **"Matrix" palette** , display the determinant symbol by clicking on the icon ($|\blacksquare|$);
- write in the free zone of the determinant the symbol that denotes its matrix;
- output the equals sign (=). For example:

$$M := \begin{pmatrix} 7 & 8 \\ 3 & 5 \end{pmatrix} \qquad |M| = 11$$

Solution of the system of equations

The solution of the system of equations with the corresponding number of unknowns can be carried out using the **Given/Find computing unit** according to the following algorithm:

- record the data that are known and included in the expressions forming the system of equations;
- unknown variables are given (:=) an arbitrary value, usually 0 or 1;
- write down the keyword of the beginning of the computing block **Given** (Given);
- write down the system of equations, but without the curly bracket sign;
- instead of the equal sign (=), use the " **Boolean equality** " sign, which is located on the " **Boolean panel** " in the " **Mathematics** " palette;
- 



- output the matrix template in n rows and one column, where n is the number of unknowns;
- fill the matrix with symbols of unknowns;
- give the matrix a value in the form of the word **Find** (Find) and in parentheses after the word list, separated by a comma, unknown;
- to find the values of unknowns, write down their symbols and write the equals sign (=).

Example: find solutions of the system of equations with respect to unknowns x , y , z :

$$\begin{cases} 2x + 2y + z = 4, \\ 3x - 5y + 3z = 1, \\ 2x + 7y - z = 8. \end{cases}$$

In **MathCAD,** the solution record will look like this:

$x := 1 \qquad y := 1 \qquad z := 1$

Given

$2x + 2y + z = 4$

$3x - 5y + 3z = 1$

$2x + 7y - z = 8$

$$\begin{pmatrix} x \\ y \\ z \end{pmatrix} := \mathrm{Find}(x, y, z)$$

$x = 1.941$

$y = 0.471$

$z = -0.824$

We will find the solutions of this system by the method of determinants.

We add the determinants:

Δ is the main determinant consisting of coefficients near the unknown system of equations;

Δx is the determinant obtained from the main determinant Δ by replacing the 1st column with a column of free members;

Δy - the determinant obtained from the main determinant Δ by replacing the II column with a column of free members;

Δz is the determinant obtained from the main determinant Δ by replacing the third column with a column of free terms.

$$\Delta := \begin{pmatrix} 2 & 2 & 1 \\ 3 & -5 & 3 \\ 2 & 7 & -1 \end{pmatrix} \qquad \Delta x := \begin{pmatrix} 4 & 2 & 1 \\ 1 & -5 & 3 \\ 8 & 7 & -1 \end{pmatrix} \qquad \Delta y := \begin{pmatrix} 2 & 4 & 1 \\ 3 & 1 & 3 \\ 2 & 8 & -1 \end{pmatrix} \qquad \Delta z := \begin{pmatrix} 2 & 2 & 4 \\ 3 & -5 & 1 \\ 2 & 7 & 8 \end{pmatrix}$$

$$x := \frac{|\Delta x|}{|\Delta|} \qquad y := \frac{|\Delta y|}{|\Delta|} \qquad z := \frac{|\Delta z|}{|\Delta|}$$

$x = 1.941$

$y = 0.471$

$z = -0.824$

Solving the system of equations by the matrix method

$$A := \begin{pmatrix} 2 & 2 & 1 \\ 3 & -5 & 3 \\ 2 & 7 & -1 \end{pmatrix} \qquad B := \begin{pmatrix} 4 \\ 1 \\ 8 \end{pmatrix}$$

$$X := A^{-1} \cdot B$$

$$X = \begin{pmatrix} 1.941 \\ 0.471 \\ -0.824 \end{pmatrix}$$

In Mathcad **the lsolve (A , B)** function can be used to solve SLAR **.** It returns a vector of unknowns X.

Solving a system of equations using **the lsolve (A , B) function**

$$A := \begin{pmatrix} 2 & 2 & 1 \\ 3 & -5 & 3 \\ 2 & 7 & -1 \end{pmatrix} \qquad B := \begin{pmatrix} 4 \\ 1 \\ 8 \end{pmatrix}$$

$$X1 := \text{lsolve}(A,B)$$

$$X1 = \begin{pmatrix} 1.941 \\ 0.471 \\ -0.824 \end{pmatrix}$$

Practical work #2

Execution program

1. Download the **MathCAD mathematical application** .
2. Solve SLAR by the proposed methods. Compare the obtained results.
3. Save the created document in your own folder.
4. Finish work in **Mathcad** .

Tasks for practical work

Solve one system of linear algebraic equations in two ways: by the determinant method, using the Given / Find computing block , by the matrix method, using the lsolve (A , B) function. The task number is determined by the last digit of the student in the group list.

1. $$\begin{cases} 2x-3y+z=7, \\ x+4y-2z=-5, \\ 3x-y+3z=2. \end{cases}$$

2. $$\begin{cases} x+2y+z=4, \\ 3x-5y+3z=1, \\ 2x+7y-z=8. \end{cases}$$

3. $$\begin{cases} 2x+y=5, \\ x+3z=16, \\ 5y-z=10. \end{cases}$$

4. $$\begin{cases} 7x+2y+3z=15, \\ 5x-3y+2z=15, \\ 10x-11y+5z=36. \end{cases}$$

5. $$\begin{cases} 3x-3y+2z=-2, \\ 4x-5y+2z=-3, \\ 5x-6y+4z=-1. \end{cases}$$

6. $$\begin{cases} 3x+2y-z=8, \\ x+y+2z=4, \\ 2x+2y+5z=9. \end{cases}$$

7. $$\begin{cases} 2x+y+z=-1, \\ x+2z=3, \\ 3x+y+2z=-1. \end{cases}$$

8. $$\begin{cases} x+2y+2z=3, \\ 2x+y-2z=-6, \\ 2x-2y+z=9. \end{cases}$$

9. $$\begin{cases} x+2y-3z=-7, \\ y+2z=1, \\ x+4z=13. \end{cases}$$

10. $$\begin{cases} 2x+y+z=7, \\ 2y+z=-2, \\ 3x+y+2z=14. \end{cases}$$

Self-test questions

1. What are the ways to solve SLAR in Mathcad ?
2. What dimension should the coefficient matrix of the left part of the system have?
3. What dimension should the column vector of free members have?
4. What dimension should the vector of unknowns have?

5. What are the arguments of the function lsolve(A,B)?
6. In what form is the result of calculations displayed using the function lsolve(A,B)?
7. What is the procedure for solving systems by the matrix method?
8. What is called matrix inversion?
9. How to inverse in Mathcad ?

4. 3. Finding roots of polynomials in Mathcad

To find all the roots of a polynomial, the built-in function **polyroots (v) is used** , where **v** is a vector consisting of the coefficients of the polynomial. Since the polynomial N - ro power has N roots, then the vector **v** must contain N +1 elements. The result of the action of the function p on roots is a vector consisting of N roots of the polynomial

For example, for a blank look:

$f(x) = x^4 - 6x^3 + 12x^2 - 10x + 3$

Vector **v** will look like:

v :=(3   -1012-61) ^{T}

The first term in the vector **v** must be the free term of the polynomial, the second - the coefficient at x^1, the third - the coefficient at x^2, etc.

The result of root calculations:

$$v := \begin{pmatrix} 3 & -10 & 12 & -6 & 1 \end{pmatrix}^T$$

$$\text{polyroots}(v) = \begin{pmatrix} 0.992 \\ 1.004 + 7.177i \times 10^{-3} \\ 1.004 - 7.177i \times 10^{-3} \\ 3 \end{pmatrix}$$

For the function ***polyroots*** one of two numerical methods can be specified: the Lagger polynomial method (which is set by default) and the pair matrix method.

To choose a numerical method, perform the following actions:

- click the right mouse button on the word ***polyroots ;***
- in the context menu choose: **LaGuerre** or **Companion Matrix** (**Pair matrix**);
- click with the mouse outside the scope of the function ***polyroots*** ;
- provided that the automatic calculation mode is enabled, the polynomial roots will be recalculated automatically in accordance with the selected method;
- when setting the **AutoSelect flag** (**Автоматический выбор**) MathCAD

will choose the calculation method independently.

Practical work No. 3

Execution program

1. Download MathCAD mathematical processor .
2. Find the roots of the polynomials given in the task.
3. Save the created document in a personal folder.
4. Exit MathCAD.

Tasks for practical work

$f(x) = 25x^4 - 14x^3 + 7x^2 + 32x - 87$;

$f(x) = 16x^3 - 11x^2 + 7x - 8$;

$$f(x) = \frac{1}{7}x^3 - 12x + 45;$$

$$f(x) = 16x^2 - \frac{7}{8}x + 19;$$

$$f(x) = 2x^4 + 3x^3 - 16x^2 + 3x + 2;$$

$$g(x) = x^4 + 5x^3 - 12x^2 + 5x + 1;$$

$$h(x) = x^4 - 4x^3 - 13x^2 + 28x + 12;$$

$$k(x) = 6x^4 - 7x^2 - 26x + 12;$$

$$z(x) = 12x^3 - 47x^2 + 4;$$

$$q(x) = \frac{3}{8}x^4 + \frac{12}{19}x^3 - 9x + \frac{234}{459}.$$

Self-test questions

1. MathCAD's built-in feature used to find the roots of a polynomial?
2. What elements does the vector v consist of?
3. How to set the type of numerical method by which the **polyroots function will operate** ?
4. What method is used to calculate roots by default?
5. How to set the mode of automatic selection of the calculation method?
6. What calculation method does MathCAD use? in auto select mode?

4.4. Solving systems of nonlinear equations

For solving systems of nonlinear equations in MathCAD, there is a special calculation block, which consists of three parts, which are used sequentially one after the other:

- **Given** - keyword;
- a system of equations written using logical operators;
- **Find** (x_1,... x_M) - a built-in function for solving a system of equations with respect to variables x_1,...x_M;

Boolean toolbar to insert logical operators (Boolean operators). The logical equals sign can also be displayed using the < Ctrl > and <=> key combination. Block **Given** / **Find** uses iterative methods to find a solution, so in this case, as for the function **root** , it is required to set initial approximations for all roots x_1,... x_M Even before using the **Given** keyword . The value of the **Find** function is a vector consisting of solutions for each variable. The number of vector elements is equal to the number of arguments of the **Find function** .

вибираються функції для представлення рівнянь системи

задаються початкові наближення змінним

вводиться ключове слово обчислювального блоку

вводяться рівності з використанням логічного знаку рівності

використовується вбудована функцій **Find** для розв'язування системи рівнянь

виводиться вектор шуканих значень

обчислюються значення функцій із шуканими значеннями змінних перевірка правильності розрахунків

Practical work no 4

The goal of the work: to master the tools of MathCAD for solving systems of nonlinear equations

Execution program

1. Download MathCAD mathematical processor .
2. Solve the systems of equations given in the task.
3. Check the correctness of the found variable values.
4. Save the created document to a personal folder.

Tasks for practical work

3. Solve systems of nonlinear equations:

1) $\begin{cases} 2x^2 + 5y^2 = 3 \\ 5x + 9y = 3 \end{cases}$,   2) $\begin{cases} 7x^2 + 6y^2 = 3 \\ 5x + 3y = 2 \end{cases}$,

3) $\begin{cases} 5x^2 + 6y^2 = 3 \\ 7x + 3y = 1 \end{cases}$,   4) $\begin{cases} 3x^2 + 2y^2 = 2 \\ 2x + 7y = 2 \end{cases}$,

5) $\begin{cases} 5x^2 + y^2 = 3 \\ 3x + 5y = 3 \end{cases}$.

Self-test questions

1. What MathCAD tool is used to solve systems of nonlinear equations?
2. What is the sequence of writing a computing unit?
3. What equals sign is used when introducing the system of nannies ?
4. What numerical method is used to solve the system of equations?

4.5 . Solving problems of linear programming in the environment MathCAD

In order to carry out effective research and production operations, it is necessary to be able to determine the optimal ratio between the costs of resources and the obtained economic effect. Linear programming is effectively used for this purpose. The main goal of linear programming is to determine the optimal allocation of resources from the position of the selected criterion under the given restrictions. Typical examples of the use of this method in agriculture are: allocating land for crops, making decisions about the types and rates of applying mineral fertilizers, planning labor costs and equipment needs, etc. Using the MathCAD package allows you to efficiently carry out similar calculations.

The process of mathematical formulation of the problem and its solution is illustrated by the following example.

Example. The farmer needs to determine the amount of manure and complex mineral fertilizers to feed a pasture of 20 hectares so that the total cost of applied fertilizers is minimal. But at the same time, 75 kg/ha of nitrogen, 25 kg/ha of phosphorus and 35 kg/ha of potassium should be applied. Productivity of labor when applying manure can be 8 t/hour, and complex fertilizer - 0.4 t/hour with time resources for performing this work 25 hours.

The cost and chemical composition of fertilizers are given in the table.

Fertilizers	PFig UAH/t	Chemical composition, kg/t		
		nitrogen	phosphorus	potassium
Manure	25	6	1.5	4
Complicated fertilizers	1300	250	100	100

To form a problem according to the scheme of linear modeling, it is necessary to define three main elements of the model, namely: unknown variables, objective function and restrictions on the values of unknown variables.

1. Unknown variables

The task of the farmer is to determine the amount of manure and complex fertilizer. Therefore, we denote by:

X_1 - amount of manure,

X_2 - the amount of complex fertilizers.

2. Objective function

The goal of the farmer is to minimize the total cost of applied fertilizers. Manure costs him 25 hryvnias. per ton, and complex fertilizers - UAH 1,300 each. per ton The full cost can be given as:

$$25 \cdot X_1 + 1300 \cdot X_2$$

If we denote the full cost by Z, then the objective function that must be minimized can be written in the form:

$$Z = 25 \cdot X_1 + 1300 \cdot X_2$$

3. Calculation

Limitations on the values of variables are determined, firstly: by agrotechnical requirements regarding the minimum doses of fertilizers and by the farmer's decision on nitrogen (75 kg/ha), phosphorus (25 kg/ha) and potassium (35 kg/ha) standards and, secondly : time resource (25 hours).

Let's first consider the restrictions on nitrogen application rates. 1 ton of manure contains 6 kg, and 1 ton of combined fertilizers contains 250 kg of nitrogen, that is, manure contains $6 \cdot X_1$ kg in total, and combined fertilizers contain $250 \cdot X_2$ kg of nitrogen.

Thus, the total amount of nitrogen that is applied per pasture is $6 \cdot X_1 + 250 \cdot X_2$ and this total amount should not be less than 1500 kg, since the minimum application rate is 75 kg/ha, and the land area is 20 ha. Taking into account the above, nitrogen restrictions are recorded as:

$$6 \cdot X_1 + 250 \cdot X_2 \geq 1500$$

Phosphorus restrictions are recorded similarly:

$$5 \cdot X_1 + 100 \cdot X_2 \geq 500$$

and potassium restrictions:

$$4 \cdot X_1 + 100 \cdot X_2 \geq 700$$

Time limits will be written in the form:

$$1/8 \cdot X_1 + 1/0.4 \cdot X_2 \leq 25$$

or

$$X_1 + 20 \cdot X_2 \leq 200$$

Special requirements

The objective function and constraints that are defined for this example are given by linear equations, that is, they do not contain variables to a power higher than 1, or a product of variables. They are deterministic, since the coefficients for variables and constraints are constant values. The unknown variables X_1 and X_2 cannot acquire negative values, since the introduction of a negative amount of fertilizers does not make physical sense. This means that the non-contradiction condition is removed, i.e

$$X_1 \geq 0, X_2 \geq 0$$

In addition, X_1 and X_2 under the specified restrictions can take on any values, which means that the continuity condition is fulfilled.

Solving linear programming problems

- write down the approximate values of the unknowns (as a rule, the symbol of the unknown quantity is given the value 1);
- record the objective function;
- write down the keyword of the beginning of the computing block **Given** (Given);
- write equations (inequalities) of restrictions, on the values of variables, using signs (≥, ≤) instead of the equal sign (=);
- display the matrix template in one column and *n* rows, where *n* is the number of unknowns;
- fill the matrix with symbols of unknowns;
- give the matrix a value in the form of a word: **Minimize** - to find the unknowns that would minimize the function, or **Maximize** - to find the values of the unknowns that would maximize the function;
- in parentheses after the word enter the symbol of functions and unknowns through a comma;
- to find the values of unknowns, write down their symbols and output the equals sign (=).

An example of solving the given problem in MathCAD will look like:

$x1 := 1 \qquad x2 := 1$

$$f(x1, x2) := 25 \cdot x1 + 1300 \cdot x2$$

Given

$x1 \geq 0 \qquad x2 \geq 0$

$6 \cdot x1 + 250 \cdot x2 \geq 1500$

$4 \cdot x1 + 100 \cdot x2 \geq 700$

$1.5x1 + 100 \cdot x2 \geq 500$

$x1 + 20 \cdot x2 \leq 200$

$$\begin{pmatrix} x1 \\ x2 \end{pmatrix} := \text{Minimize}(f, x1, x2)$$

$f(x1, x2) = 7.111 \times 10^3$

$x1 = 111.111$

$x2 = 3.333$

The result of the calculation shows that in order to minimize the costs of feeding the lye, it is necessary to apply 111.1 tons of manure and 3.3 tons of combined fertilizers, spending 7111 hryvnias.

Practical work No. 5

The goal of the work: to learn how to find solutions to linear programming problems in order to determine optimal solutions

Execution program

1. Download MathCAD mathematical environment .
2. Build a mathematical model based on the problem given in the task: write down the objective function and the system of unknown constraints.
3. Find unknowns using minimize or maximize functions .
4. Solve linear programming problems by choosing the option by number in the group list.
5. Save the created document in your own folder.
6. Finish work with MathCAD .

Task to practical work

Determine the optimal areas for sowing winter wheat and barley to ensure the maximum gross collection of grain in the farm. 630 hectares of arable land are allocated to crops, and no more than 400 hectares to barley. It is planned to spend no more than 6,700 man-days on carrying out all agrotechnical measures for growing crops. Labor costs and average yield of crops are shown in the table.

	Cultures	
	Winter wheat	Barley
Labor costs, (person-days)/ha	15	7
Average yield, tons/ha	35	23

1 .

$\max(-x_1 - x_2 + 3x_3);$

$$\begin{cases} -x_1 + x_2 - 2x_3 \ge -2, \\ 2x_1 + x_2 + 3x_3 \le 8, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

2.

$\min(x_1 - 3x_2 + x_3);$

$$\begin{cases} x_1 - 3x_2 + x_3 \le -2, \\ 2x_1 + 4x_3 \le 7, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

3.

$\max(x_1 + 3x_2 + 9x_3);$

$$\begin{cases} x_1 + x_2 + x_3 \le 10, \\ x_1 - x_2 - 2x_3 \ge -2, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

4.

$\min(x_1 + 3x_2 - 3x_3);$

$$\begin{cases} 2x_1 + x_2 - 5x_3 \ge 2, \\ -x_1 - 2x_3 \ge -6, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

5.

$\min(3x_1 - 2x_2 - x_3);$

$$\begin{cases} -x_1 - 3x_2 + 3x_3 \ge -6, \\ -2x_1 + x_2 + x_3 \ge 4, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

6.

$\max(x_1 - 5x_2 - x_3);$

$$\begin{cases} x_1 + 3x_2 + x_3 \ge 3, \\ 2x_1 + x_3 \le 4, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

7.

$\min(5x_1 + 4x_2 + 2x_3);$

$$\begin{cases} x_1 + 2x_2 + x_3 \le 5, \\ 2x_1 + 3x_2 + x_3 \ge 8, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

8.

$\max(3x_1 + 2x_2 + 3x_3);$

$$\begin{cases} 3x_1 + 4x_2 + 2x_3 \ge 2, \\ 2x_1 + x_2 + x_3 \le 8, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

9.

$\min(2x_1 + 3x_2 - 5x_3);$

10.

$\max(2x_1 + 4x_2 + 4x_3 - 3x_4);$

$$\begin{cases} x_1 + x_2 + x_3 \le 7, \\ 2x_1 - 5x_2 + x_3 \ge 10, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

$$\begin{cases} x_1 + x_2 + x_3 \ge 4, \\ x_1 + 4x_2 - x_3 + x_4 \le 8, \end{cases}$$

$x_j \ge 0, j = \overline{1,4}.$

11.

$\min(3x_1 + 2x_2 + 3x_3);$

$$\begin{cases} x_1 + 4x_2 + x_3 \ge 8, \\ 2x_1 + x_2 + x_3 \le 10, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

12.

$\max(x_1 + 5x_2 + 3x_3);$

$$\begin{cases} 2x_1 + x_2 \le 4, \\ x_1 + 2x_2 + x_3 \le 3, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

13.

$\min(x_1 + x_2 + x_3 + x_4);$

$$\begin{cases} 2x_1 + 2x_2 + x_3 \ge 7, \\ 4x_1 + 2x_2 - x_3 + x_4 \le 8, \end{cases}$$

$x_j \ge 0, j = \overline{1,4}.$

14.

$\max(x_1 + x_2);$

$$\begin{cases} 2x_1 + 3x_2 \ge 5, \\ 3x_1 + 2x_2 \le 6, \end{cases}$$

$x_j \ge 0, j = \overline{1,2}.$

15.

$\min(-3x_1 + 2x_2 + 5x_3);$

$$\begin{cases} x_1 - x_2 + 3x_3 \le 10, \\ x_1 + 3x_2 + 2x_3 \le 8, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

16.

$\max(2x_1 - 4x_2 + 5x_3);$

$$\begin{cases} x_1 + 4x_2 - 2x_3 \ge 2, \\ -x_1 + 2x_2 + 3x_3 \le 1, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

17.

$\min(2x_1 + 5x_2 - 6x_3);$

$$\begin{cases} x_1 - 2x_2 + 2x_3 \ge 4, \\ -x_1 + 3x_2 + 2x_3 \le 8, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

18.

$\max(2x_1 + 3x_2 + 5x_3);$

$$\begin{cases} x_1 - x_2 - x_3 \ge -5, \\ -x_1 + x_2 - x_3 \le 4, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

19.

$\min(3x_1 + 3x_2 + x_3);$

$$\begin{cases} x_1 + 2x_2 + 3x_3 \le 12, \\ 4x_1 + 8x_2 + 3x_3 \ge 24, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

20.

$\max(5x_1 + x_2 + x_3);$

$$\begin{cases} x_1 + x_2 + x_3 \le 5, \\ -x_1 + 3x_2 - x_3 \ge -3, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

21.

$\min(5x_1 - 2x_2 - 3x_3);$

$$\begin{cases} -2x_1 - 3x_2 + 3x_3 \ge -6, \\ -4x_1 + x_2 + x_3 \ge 4, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

22.

$\max(2x_1 - 10x_2 - 2x_3);$

$$\begin{cases} 2x_1 + 6x_2 + 2x_3 \ge 6, \\ 4x_1 + 2x_3 \le 8, \end{cases}$$

$x_j \ge 0, j = \overline{1,3}.$

23.

24.

$$\min(4x_1 - 5x_2 - x_3);$$
$$\begin{cases} -3x_1 - 9x_2 + 9x_3 \ge -18, \\ -4x_1 + 2x_2 + 2x_3 \ge 8, \end{cases}$$
$$x_j \ge 0, j = \overline{1,3}.$$

$$\max(7x_1 - 2x_2 - 3x_3);$$
$$\begin{cases} 2x_1 + 3x_2 + 2x_3 \ge 8, \\ 3x_1 + x_3 \le 7, \end{cases}$$
$$x_j \ge 0, j = \overline{1,3}.$$

Self-test questions

1. What is the order of problem formation according to the linear programming scheme?
2. What is the order of recording the computing block for solving linear programming problems in MathCAD ?
3. What keywords are used when solving the objective function?
4. In what cases are the names of the **Minimize functions written down** and **Maximize** ?

4.6. Finding the extremum of a function of one variable

The tasks of finding the extremum of a function include the search for its maximum (largest) or minimum (smallest) values in some area of the definition of arguments. The values of the arguments can be limited by some interval, which is described in the form of a system of inequalities and equations. In this case, they search for an extremum in the area of limiting arguments and call its *conditions the extremum* . In addition, the problems of finding *the local* and *global* extrema are also distinguished. There can be several local extrema, global - there can be one. To find the global extremum, you must first find all the local ones, and then choose the largest (smallest) value from them.

The point x_0 is called *the point of the local maximum* (or minimum) of the function ***f (x)*** if there exists such a neighborhood $0<|x - x_0|< \delta$ points x_0**,** which belongs to the domain of the function, and for all x from this area, the inequality $f(x)<f(x_0)$, or $f(x)>f(x_0)$. Points of local minimum or local maximum are called points ***of local extremum,*** and the value of the function at these points is called ***local minimum,*** or ***local maximum,*** or ***local extremum, respectively.***

The concept of an extremum is local in the sense that the inequality $f(x)<f(x0)$ or $f(x)>f(x_0)$ may not be fulfilled for all values *of* x from the domain of the function, but it must be fulfilled only in some neighborhood of the point x_0**.** The local maximum should not be confused with the largest value of the function that it can acquire in the domain of definition (it is also called ***the absolute maximum).*** There can be several local maxima, the absolute maximum can be only one. This applies to local and absolute minima.

Finding a local extremum

To solve problems of finding local minimum and maximum in ***MathCAD*** uses built-in functions ***Minimize*** and ***Maximize*****,** which can be used both within the computing unit and autonomously:

Minimize $(f, x_1,...,x_m)$ is a vector of values of the arguments for which the function f reaches a minimum;

Maximize $(f, x_1,...,x_M)$ - a vector of values of the arguments for which the function f reaches its maximum;

(f, x 1 ,,...,x m) - function;

$x_1,...,x_m$ - arguments by which the function is minimized/maximized.

To all function arguments f pre-assigned some values.

Consider examples of finding the extremum of a function on the interval from $-\infty$ to $+\infty$, since no additional restrictions on the value of the arguments are introduced.

Example 1

$f(x) := x^4 + 6 \cdot x^3 - 4 \cdot x$	задається функція
$x := -1$	задається початкове наближення аргументу
	знаходиться мінімум функції
$\text{Minimize}(f, x) = -4.449$	задається інше початкове наближення аргументу
$x := 1$	знаходиться мінімум функції для нового значення аргументу
$\text{Minimize}(f, x) = 0.449$	

A function is defined.
An initial approximation of the argument is given.
The minimum of the function is found.
A different initial approximation of the argument is given.
The minimum of the function is found for the new value of the argument.

Example 2

Задається функція
Задається початкове наближення аргументу
Знаходиться максимум функції
Задається інше початкове наближення аргументу

$f(x) := x^4 + 6 \cdot x^3 - 4 \cdot x$

$x := 1$

$\mathrm{Maximize}(f, x) = -0.5$

$x := -10$

$\mathrm{Maximize}(f, x) = \blacksquare$

1. A function is defined.
2. An initial approximation of the argument is given.
3. The maximum of the function is found.
4. A different initial approximation of the argument is given.
5. The maximum of the function for the new value of the argument is not found because the initial approximation went beyond the boundaries of the local extremum.

Finding the conditional extremum

In conditional extremum problems, the minimization and maximization functions must be included in the computational block, that is, they must be preceded by a keyword **Given** . Logical expressions (inequalities, equations) are written after the keyword with the help of Boolean operators, which set limits on the values of the function's arguments.

Example 3

$f(x) := x^4 + 5 \cdot x^3 - 10 \cdot x$

$x := 1$

Given

$-5 < x < -2$

$\text{Minimize}(f, x) = -3.552$

Example 4

$x := 1$

Given

$x > 0$

$\text{Minimize}(f, x) = 0.746$

Example 5

$x := -10$

Given

$-3 < x < 0$

$\text{Maximize}(f, x) = -0.944$

Practical work no 6

The goal of the work: to master MathCAD tools for finding the extremum of a function of one variable

<u>Execution program</u>

1. Download MathCAD mathematical processor .
2. Find the extrema of the functions given in the task.
3. Save the created document in a personal folder.
4. Exit MathCAD.

<u>Tasks for practical work</u>

1. Find the local extrema of the functions:

$f(x) = 7x^4 + 11x^3 - 3x,$ якщо $x = 1$

$f(x) = 6x^4 + 10x^3 - 3x^2 + 1,$ якщо $x = -1$

$f(x) = x^5 + 4x^4 - 3x^2 + 2,$ якщо $x = -1$

4. Find the conditional minimum of the function

$f(x) = 2x^5 + 4x^4 - 3x^2 + 2,\ 0 < x < 10$

5. Find the conditional maximum of the function

$f(x) = 2x^5 + 4x^4 - 3x^2 + 2,\ -3 < x < 0$

Self-test questions

1. What is the conditional extremum of a function?
2. What are the local and global extrema of a function?
3. What tools MathCAD are used to find the local extremum of a function?
4. What is the sequence of actions when using functions ***Minimize*** and ***Maximize*** to find the local extremum of a function?
5. What tools are used to find the conditional extremum of a function?
6. What is the difference between finding a local extremum and finding a conditional extremum of a function?

4.7. Finding the extremum of a function of several variables

Many phenomena and processes of nature, science, technology and production can be described by functions that depend on several independent variables.

A function of several (for example, two) independent variables is the unique correspondence of each pair of real numbers (x_1, x_2) from the set X_{12} to a single real number y from the set Y. Analytically, this correspondence is written as follows: $y = f(x_1, x_2)$

or $z = f(x, y)$.

The set X_{12} is called the domain of the function, and the set Y is called the domain of the function. The domain of the function is a part of the plane that is bounded by a closed curve (the curve itself may or may not belong to the domain).

For example, the domain of the function $y = \sqrt{a^2 - x_1^2 - x_2^2}$ is determined from the condition $a^2 - x_1^2 - x_2^2 \geq 0$ або $x_1^2 + x_2^2 \leq a^2$. So, the domain of the function is a circle of radius *and*

The graph of the function $z = f(x, y)$ of two variables is constructed in a three-dimensional Cartesian coordinate system with the ordinate z and the abscissa x, y. The graph of the function $z = f(x, y)$ has the appearance of some surface. The level line of the function $z = f(x, y)$ is called the line $f(x, y) = c = const$ on *the X0Y plane,* at the points of which the function z assumes a constant value c. For example, the lines of the level of the function $\boldsymbol{z = x^2 + y^2}$ are concentric circles $x^2 + y^2 = c$ ($c > 0$).

Functions from three $u = f(x, y,)$ and more $y = f(x_1, x_{2,\dots,} x_n)$ it is impossible to represent variables graphically, since it is impossible to imagine a material space with a dimension of more than three. But for a function of three variables
$u = f(x, y, z)$ you can introduce the concept of a level surface. The surface of the level of the function
$u = f(x, y, z)$ is called the surface $f(x, y, z) = c$, at the points of which the function assumes a constant value $u = c$. For example, the surfaces of the function level $u = x^2 + y^2 + z^2$ there is a family of spheres $x^2 + y^2 + z^2 = c$.

At the point (x_0, y_0) the function $z = f(x, y)$ has an extremum (maximum, minimum) if its value at this point $z = f(x_0, y_0)$ and any other point (x, y) satisfy the conditions

$f(x_0, y_0) > f(x, y)$ in case of maximum,

$f(x_0, y_0) < f(x, y)$ in the case of a minimum.

At the point of extremum (x_0, y_0) partial derivatives are equal to zero:

$$\frac{\partial f(x_0, y_0)}{\partial x} = 0, \quad \frac{\partial f(x_0, y_0)}{\partial y} = 0.$$

These equalities are a necessary condition for an extremum, and the points at which the partial derivatives are equal to zero are called stationary.

If the discriminator

$$\Delta = AC - B^2 = f_x''(x_0, y_0) f_y''(x_0, y_0) - [f_{xy}''(x_0, y_0)]^2 > 0,$$

then the function at the point (x_0, y_0) has a maximum at A > 0 or C < 0. If the discriminant is less than zero, then there is no extremum at the point (x_0, y_0). These conditions are sufficient conditions for the existence or absence of an extremum.

In the case of functions of many independent variables, the concept of a conditional extremum is introduced. For a function of two independent variables $z = f(x, y)$ the conditional extremum is the extremum of this function, which is reached under the condition that the variables *x i y* are connected by the corresponding equation $\varphi(x, y) = 0$ (connection equation).

Finding the conditional extremum is reduced to the study of the usual extremum of the Lagrange function

$Z = f(x, y) + \lambda\varphi(x, y)$,

where λ is an undefined constant factor. Then the necessary condition for the extremum will be reduced to a system of three equations:

$$\begin{cases} \dfrac{\partial Z}{\partial x} = \dfrac{\partial f}{\partial x} + \lambda \dfrac{\partial \varphi}{\partial x} = 0, \\ \dfrac{\partial Z}{\partial y} = \dfrac{\partial f}{\partial y} + \lambda \dfrac{\partial \varphi}{\partial y} = 0, \\ \varphi(x, y) = 0. \end{cases}$$

To find the extreme values of a function in a closed region, it is necessary to calculate the stationary points located in this region and the values of the function at these points; find the extreme values of the function on the boundary line of the region; choose the largest and smallest of all found values.

Finding the extremum of a function of several variables in Mathcad

The rules for finding the extremum of a function of several variables in Mathcad are fundamentally no different from finding the extremum of a function of one variable.

Example 1.

$f(x,y) := 3(x - 4.07)^2 + (y - 8.03)^2 - 0.4 \cdot (x - 6.07)^3$

$x := 3 \qquad y := 3$

Given

$0 < x < 15$

$0 < y < 20$

$\text{Minimize}(f, x, y) = \begin{pmatrix} 4.539 \\ 8.03 \end{pmatrix}$

Example 2.

$$f(x,y) := 3x^2 + 5y^2$$

$$x := 1 \qquad y := 1$$

$$\text{Minimize}(f,x,y) = \begin{pmatrix} -8.267\times10^{-11} \\ -1.102\times10^{-9} \end{pmatrix}$$

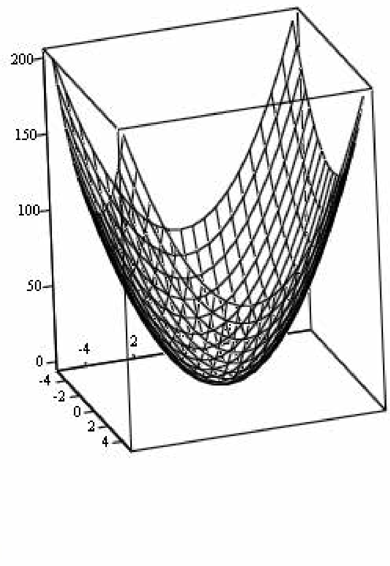
Graphic representation of example 2.

$x := -10, -9 .. 10$

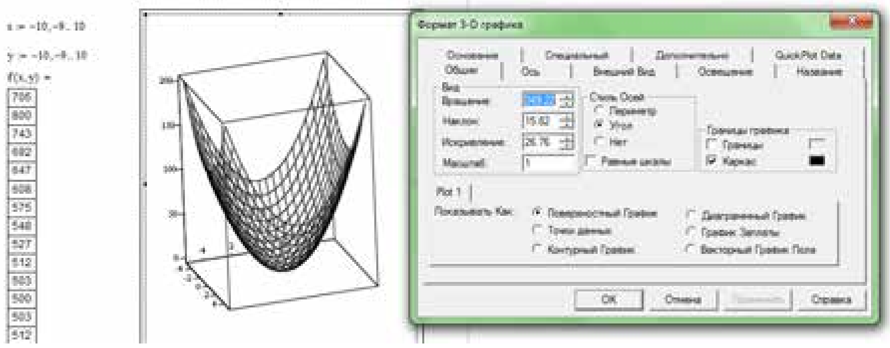
$y := -10, -9 .. 10$

$f(x,y) =$

705
800
743
692
647
608
575
548
527
512
503
500
503
512
527
548



For graphic interpretation (example 2), perform tabulation of functions and construction of graphics. For this, the limits of changing the arguments are set and a table of function values is obtained. Since the function is from two arguments, a surface template is chosen for construction. To give the graph this look, call the context menu of the surface (double-click at any point of the graph) and adjust the corresponding parameters.



Practical work no 7

The goal of the work: to master MathCAD tools for finding the extremum of a function of several variables

Execution program

1. Download MathCAD mathematical processor.
2. Find the extrema of the functions given in the task.
3. Save the document in a personal folder.
4. Complete work with MathCAD.

Tasks for practical work

1. Find the largest and smallest value of a function $z = x^2 - y^2$ in a circle $x^2 + y^2 \le 4$.

2. Find the largest *M* and the smallest *t* value of the function $z = xy$ in the circle $x^2 + y^2 \le 1$.

3. Find the largest *M* and the smallest *t* value of the function $z = x^2 + y^2 - xy - 4x$ in a closed region bounded by straight lines $x = 0$, $y = 0$, $2x + 3y - 12 = 0$.

4. Find the largest *M* and the smallest *t* value of the function $z = x + y + xy$ in the square bounded by straight lines $x = 1$, $x = 2$ $y = 2$, $y = 3$.

5. Find the largest *M* and the smallest *t* value of the function $z = \sin x + \sin y + \sin(x + y)$ in the rectangle $0 \le x \le \frac{\pi}{2}$, $0 \le y \le \frac{\pi}{2}$.

Self-test questions

1. What is the mechanism for finding the extremum of a function of two variables in **MathCAD** ?
2. In what cases is the built-in **Given function used** ?
3. How to set the interval for finding the extremum?
4. Do I need to specify an initial approximation?
5. What can be the reason for not finding the extremum of the function in the given interval?

4. 8 . Finding limits of sequences, functions in Mathcad

Definition The number *a* is called **the limit** of the ordered variable x *if* for any sufficiently small number ε> 0 there exists a value *x such that* $_\varepsilon$the condition is fulfilled for all subsequent values *of x*

$|x-a|<\varepsilon$. (1)

It is denoted as follows:

$\lim x = a$, or $x \to a$

(read: "the limit of the value of x is equal to a ", or " x goes to a ").

The symbol "lim" is an abbreviation of the Latin word "limes" - "border". The very term "boundary" was introduced by I. Newton.

The geometric content of the concept of borders. WITH inequality (1), we get :

$|x-a|<\varepsilon \Leftrightarrow -\varepsilon< x-a<\varepsilon \Rightarrow a-\varepsilon< x< a+\varepsilon$.

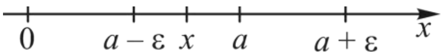


Рис.

Therefore, if $\lim x = a$, then no matter how small the number $\varepsilon> 0$, there will be such a value of x_{ε}, starting from which all subsequent values of the quantity x fall into εthe vicinity of the point a (fig.).

Definition A variable αis called **infinitely small** if its limit is zero

$\lim \alpha= 0$.

If αis an infinitesimally small value, then according to the definition of the limit, for arbitrary $\varepsilon> 0$ there exists such a value α_{ε}starting from which αthe condition $|\alpha| < \varepsilon$, or $-\varepsilon< \alpha< \varepsilon$, that is, all values of the variable, starting with α_{ε}, fall into εthe neighborhood of point O (Fig. 4).

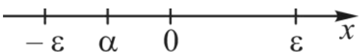


Рис 4

Definition A variable x is called **infinitely large if** , for any sufficiently large number $M > 0$, there exists such a value x M , starting from which the inequality holds for all subsequent values

$|x| > M$.

It is denoted as follows:

$\lim x = \infty$ or $x \to \infty$

(read: "the limit of x is equal to infinity", or " x goes to infinity").

Geometrically, the fact that x is an infinitely large value means that starting from x_M for all subsequent values of the variable one of the inequalities will hold

$x > M$ or $x < -M$,

that is, all values of variable x , starting with x_M, will be outside the interval $]-M, M[$ of the numerical axis.

Among infinitely large values, **positive** and **negative** infinitely large values are distinguished.

If, starting from a certain value, all subsequent values of an infinitely large quantity x are positive (negative), then the quantity x is called a **positive** (**negative**) infinitely large quantity and it is defined as follows:

$$\lim x = +\infty \quad (\lim x = -\infty),$$

or

$$x \to +\infty \quad (x \to -\infty).$$

Definition A number a is called the limit of a numerical sequence $\{x_n\}$ if for any number $\varepsilon> 0$ there exists a number N *such* εthat for all numbers $n > N$ εthe inequality holds

$$|x_n - a| < \varepsilon.$$

It is denoted as follows: $\lim\limits_{n\to\infty} x_n = a$.

If the sequence $\{ x_n \}$ has a limit a , then it is called convergent. Such a sequence is said to converge to a .

A sequence that has no limit is called divergent.

The geometric meaning of the fact that the number a is the limit of the sequence $\{ x_n \}$ is as follows: εno matter how small the neighborhood of the point a is taken, all values *of* x_n , starting from some number n ($n > N\,\varepsilon$), fall into this neighborhood (only a finite number of members of the numerical sequence can remain outside this circle).

Finding limits in the Mathcad mathematical application

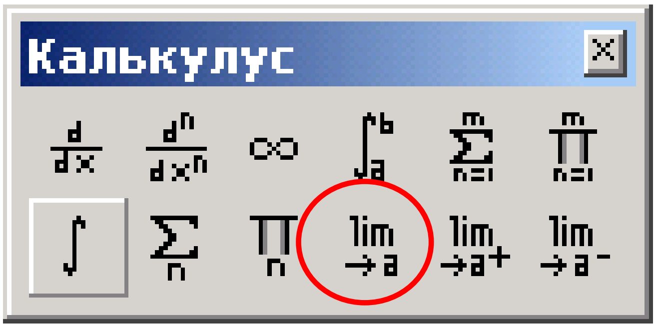
To find boundaries in the " Mathcad " application, you need to perform the following actions:

1) select the border template on **the Calculus (Calculations) panel** (see fig.);

2) enter the expression for finding the limit, the variable and the number to which it is directed in the free spaces;

3) on **the Symbols panel** , press the corresponding symbol $\longrightarrow$ **;**

4) press the Enter key and get the result;



Remember! Trigonometric functions in **MathCAD** have the following form:

- acos(z) — arccosine;
- acot(z) — cotangent;
- acsc(z) is the arc cosecant;
- angle(x,y) — the angle between the point (x,y) and the OX axis;
- asec(z) — arcsecant;
- asin(z) is arcsine;
- atan (z) — arctangent;
- atan2(x,y) is the angle counted from the OX axis to the point (x,y);
- cos(z) — cosine;
- cot(z) is the cotangent;
- csc(z) is the cosecant;

- sec(z) — sequence;
- sin(z) — sine;
  - tan(z) is the tangent;
- z is a function argument (it **MUST** be written in parentheses).

Practical work No. 8

The goal of the work: to master the **MathCAD** tools for finding the limits of a function

Execution program

1. Download the **MathCAD mathematical application** .
2. Complete the given task.
3. Save the created document in your own folder.
4. Finish work in **Mathcad** .

Tasks for practical work

Calculate the limits of functions by the option number in the group list using **Mathcad** .

1. a) $\lim\limits_{x\to\infty}\dfrac{2x^2-3x+4}{3x^2+x-2}$, b) $\lim\limits_{x\to 2}\dfrac{x^2+x-6}{3x^2-2x-8}$,

c) $\lim\limits_{x\to 0}\dfrac{\sqrt{x+1}-1}{x}$, d) $\lim\limits_{x\to 0}\dfrac{\sin 9x}{\cos 2x\,\mathrm{tg}\,5x}$

2. a) $\lim\limits_{x\to\infty}\dfrac{x^2-3x+1}{2x^3+x^2-2}$, b) $\lim\limits_{x\to -3}\dfrac{2x^2+4x-6}{3x^2+10x+3}$,

c) $\lim\limits_{x\to 1}\dfrac{\sqrt{x+3}-2}{x-1}$, d) $\lim\limits_{x\to 0}\dfrac{1-\cos 6x}{2x\sin 7x}$

3. a) $\lim\limits_{x\to\infty}\dfrac{x^3-2x^2+3}{5x^2-x+4}$, b) $\lim\limits_{x\to 1}\dfrac{3x^2+x-4}{5-3x-2x^2}$,

c) $\lim\limits_{x\to 0}\dfrac{\sqrt{9-x^2}-3}{\sqrt{x^2+25}-5}$, d) $\lim\limits_{x\to 0}\sin 5x\ \mathrm{ctg}\,7x$

4. a) $\lim\limits_{x\to\infty}\dfrac{3-4x-2x^2}{x^2+x+1}$, b) $\lim\limits_{x\to -2}\dfrac{2x^2+3x-2}{x^2-x-6}$,

c) $\lim\limits_{x\to+\infty}(\sqrt{x^2+5x+4}-x)$, d) $\lim\limits_{x\to 0}\dfrac{3x\cos 8x}{\arcsin 4x}$.

5. a) $\lim\limits_{x\to\infty}\dfrac{4x^2-3x+1}{2x^2+x+7}$, b) $\lim\limits_{x\to 3}\dfrac{3x^2-8x-3}{x^2-4x+3}$,

c) $\lim\limits_{x\to+\infty}(x-\sqrt{x^2+2})$, d) $\lim\limits_{x\to 0}\dfrac{7\sin^2 4x}{\cos x\,\mathrm{tg}^2\,3x}$

6. a) $\lim\limits_{x\to\infty}\dfrac{2x^2-x+5}{x^3+2x+1}$, b) $\lim\limits_{x\to -3}\dfrac{x^2-9}{2x^2+9x+9}$,

c) $\lim\limits_{x\to 7}\dfrac{\sqrt{x-3}-2}{x-7}$, d) $\lim\limits_{x\to 0}\dfrac{\arcsin 9x}{7\,\mathrm{arctg}\,2x}$

7. a) $\lim\limits_{x\to\infty}\dfrac{3x^2-4x+1}{1-2x-2x^2}$, b) $\lim\limits_{x\to2}\dfrac{4-x^2}{3x^2-10x+8}$,

c) $\lim\limits_{x\to11}\dfrac{x-11}{\sqrt{x-2}-3}$, d $\lim\limits_{x\to0}\dfrac{1-\cos 4x}{2\arcsin^2 2x}$.

8. a) $\lim\limits_{x\to\infty}\dfrac{2x^3-5x+3}{5x^3+x^2-8}$, b) $\lim\limits_{x\to5}\dfrac{2x^2-5x-25}{x^2-25}$,

c) $\lim\limits_{x\to7}\dfrac{\sqrt{11-x}-2}{x^2-49}$, d) $\lim\limits_{x\to0} 2\,\mathrm{ctg}\,8x\ \mathrm{tg}\,3x$.

9. a) $\lim\limits_{x\to\infty}\dfrac{x^3-3x+1}{7x^2-x+5}$, b) $\lim\limits_{x\to-4}\dfrac{2x^2+15x+28}{x^2+7x+12}$,

c) $\lim\limits_{x\to4}\dfrac{x^2-16}{\sqrt{8-x}-2}$, d) $\lim\limits_{x\to0}\mathrm{ctg}\,9x\arcsin 3x$.

10. a) $\lim\limits_{x\to\infty}\dfrac{6x^2-5x+7}{3x^2+4x-2}$, b) $\lim\limits_{x\to3}\dfrac{5x^2-16x+3}{x^2-4x+3}$,

c) $\lim\limits_{x\to11}\dfrac{\sqrt{x-2}-3}{\sqrt{36-x}-5}$, d) $\lim\limits_{x\to0}\dfrac{\mathrm{tg}\,x-\sin x}{x^3}$.

11. a) $\lim\limits_{x\to\infty}\dfrac{x^7-2}{x^6+3x^2+7x}$, b) $\lim\limits_{x\to1}\dfrac{x^3-3x+2}{x^3-1}$,

c) $\lim\limits_{x\to9}\dfrac{\sqrt{x-5}-2}{\sqrt{25-x}-4}$, d) $\lim\limits_{x\to0}\dfrac{\cos x-\cos 3x}{x\,\mathrm{tg}\,7x}$.

12. a) $\lim\limits_{x\to\infty}\dfrac{x^3+2x^2-3}{x^4-4x+5x}$, b) $\lim\limits_{x\to2}\dfrac{x^2-4}{3x^2-7x+2}$,

c) $\lim\limits_{x\to1}\dfrac{\sqrt{26-x}-5}{x^2-1}$, d) $\lim\limits_{x\to0}\dfrac{x\,\mathrm{tg}\,9x}{\cos 2x-\cos 5x}$.

13. a) $\lim\limits_{x\to+\infty} \dfrac{2x^5 - 3x^2 + 1}{3x^5 + 5x + 2}$, b) $\lim\limits_{x\to1} \dfrac{5x^2 - 4x - 1}{x^3 - 1}$,

c) $\lim\limits_{x\to7} \dfrac{x - 7}{\sqrt{x-3} - 2}$, d) $\lim\limits_{x\to0} \dfrac{x \arcsin 2x}{\cos 2x - \cos 5x}$.

14. a) $\lim\limits_{x\to+\infty} \dfrac{2x^9 - 3}{x^5 + 5x^4 + 2x}$, b) $\lim\limits_{x\to2} \dfrac{x^3 - 8}{4x^2 - 6x - 4}$,

c) $\lim\limits_{x\to12} \dfrac{\sqrt{x-3} - 3}{x - 12}$, d) $\lim\limits_{x\to0} \operatorname{ctg} 3x \operatorname{arctg} 2x$.

15. a) $\lim\limits_{x\to+\infty} \dfrac{2x^3 + 4x}{3x^7 - 5}$, b) $\lim\limits_{x\to1} \dfrac{3x^2 - 2x - 1}{x^2 - 1}$,

c) $\lim\limits_{x\to2} \dfrac{x^2 - 4}{\sqrt{6-x} - 2}$, d) $\lim\limits_{x\to0} \dfrac{\sin x - \sin 3x}{\operatorname{arctg} 2x}$.

16. a) $\lim\limits_{x\to+\infty} \dfrac{2x^5 - 3x^2}{7x^5 + 8}$, b) $\lim\limits_{x\to1} \dfrac{x^3 - x^2 - x + 1}{x^2 - 4x + 3}$,

c) $\lim\limits_{x\to2} \dfrac{\sqrt{x-1} - 1}{\sqrt{6-x} - 2}$, d) $\lim\limits_{x\to0} \dfrac{x \arcsin 7x}{1 - \cos 6x}$.

17. a) $\lim\limits_{x\to+\infty} \dfrac{2x^3 - 7}{3x^2 + 8x}$, b) $\lim\limits_{x\to2} \dfrac{5x^2 - 11x + 2}{x - 2}$,

c) $\lim\limits_{x\to1} \dfrac{\sqrt{10-x} - 3}{x^2 - 1}$, d) $\lim\limits_{x\to0} \dfrac{1 - \cos 9x}{x \operatorname{tg} 2x}$.

18. a) $\lim\limits_{x\to\infty} \dfrac{4x^4 - 7}{3x^6 + 8x}$, b) $\lim\limits_{x\to 1} \dfrac{4x^2 - 3x - 1}{x^2 - 3x + 2}$,

c) $\lim\limits_{x\to 4} \dfrac{\sqrt{13 - x} - 3}{x - 4}$, d) $\lim\limits_{x\to 0} \operatorname{ctg} 4x \sin 9x$.

19. a) $\lim\limits_{x\to\infty} \dfrac{5x^3 - 2x^2 + 1}{2x^2 - 8x - 7}$, b) $\lim\limits_{x\to 2} \dfrac{3x^2 - 5x - 2}{x^2 - 4x + 4}$,

c) $\lim\limits_{x\to -2} \dfrac{x + 2}{\sqrt{1 - 4x} - 3}$, d) $\lim\limits_{x\to 0} \dfrac{\operatorname{tg}^2 3x}{5x^2 \cos 8x}$.

20. a) $\lim\limits_{x\to\infty} \dfrac{3x^3 - 4x^2 + 9}{2x^3 - 7x}$, b) $\lim\limits_{x\to 1} \dfrac{x^2 - 8x + 7}{5x^2 - 4x - 1}$,

c) $\lim\limits_{x\to 3} \dfrac{\sqrt{2x + 3} - 3}{x - 3}$, d) $\lim\limits_{x\to 0} \dfrac{\operatorname{arctg} 5x}{6x \cdot \cos 3x}$.

21. a) $\lim\limits_{x\to\infty} \dfrac{7x^6 - 2x^3}{4x^4 + 9x - 1}$, b) $\lim\limits_{x\to 3} \dfrac{2x^2 - 7x + 3}{x^2 - 9}$,

c) $\lim\limits_{x\to 4} \dfrac{\sqrt{x} - 2}{x^2 - 5x + 4}$, d) $\lim\limits_{x\to 0} \dfrac{x \cdot \operatorname{tg} 8x}{1 - \cos 4x}$.

22. a) $\lim\limits_{x\to\infty} \dfrac{2x^2 - 3}{3x^3 + 4x + 8}$, b) $\lim\limits_{x\to 3} \dfrac{x^2 - 4x + 3}{2x^2 - 5x - 3}$,

c) $\lim\limits_{x\to -1} \dfrac{x + 1}{\sqrt{3x + 7} - 2}$, d) $\lim\limits_{x\to 0} \dfrac{4x \cdot \cos 7x}{\operatorname{arctg} 2x}$.

23. a) $\lim\limits_{x\to\infty} \dfrac{2x^6 - 1}{3x^6 + 5x^2 + 8}$, b) $\lim\limits_{x\to 2} \dfrac{2x^2 - 3x - 2}{x^2 - x - 2}$,

c) $\lim\limits_{x\to 1} \dfrac{\sqrt{x + 3} - 2}{\sqrt{x} - 1}$, d) $\lim\limits_{x\to 0} \dfrac{\sin^2 2x}{\operatorname{tg}^2 3x}$.

4. 9 . Derivative and finding it in Mathcad

Definition of the derivative and its meaning

Let the function $y = f(x)$ is defined and continuous in some interval [a , b], and let the values x and $x + \otimes x$ belong to this interval.

Definition The derivative of the function $y = f(x)$ at the point x is called the limit of the growth ratio of the function $\Delta y = \Delta f(x)$ at this point to the growth of the argument Δx that caused this growth, if Δx goes to zero and this limit exists.

To denote the derivative function $y = f(x)$ use different symbols:

$$f'(x),\quad y'(x),\quad y',\quad f'_x,\quad y'_x,\quad \frac{dy}{dx},\quad \frac{df(x)}{dx}.$$

So, by definition

$$f'(x) = \lim_{\Delta x \to 0}\frac{\Delta y}{\Delta x} = \lim_{\Delta x \to 0}\frac{\Delta f(x)}{\Delta x} = \lim_{\Delta x \to 0}\frac{f(x+\Delta x) - f(x)}{\Delta x}. \qquad (1)$$

The physical content of the derivative.

Let $s = s(t)$ be the equation of rectilinear motion. The speed $v(t)$ of rectilinear movement at time t is the derivative of the distance traveled $s(t)$ by time t , i.e.

$$v(t) = s'(t)$$

The mechanical content of the derivative.

Let $m = m(l)$ be the mass of a material thread of variable length l . The linear density $\rho(l)$ of a material thread at a distance l from its end is a derivative of the mass of the thread $m(l)$ along the length l , i.e.

$$\rho(l) = m'(l)$$

The geometric content of the derivative.

Let $y = f(x)$ is the equation of the curve. Angular coefficient tg αthe tangent drawn to the curve at a point with the abscissa x is the derivative of the function $f(x)$ by variable x :

$$\text{tg}\,\alpha = f'(x)$$

In general, if the function $y = f(x)$ describes some process, then the average speed of this process (change in y compared to x) on the segment Δx can be considered the expression:

$$v_C = \frac{\Delta y}{\Delta x},$$

and the speed of the process at a given value of x is a derivative of the function y by x , i.e

$$v(x) = \lim_{\Delta x \to 0} v_C = \lim_{\Delta x \to 0}\frac{\Delta y}{\Delta x} = y'(x).$$

From the definition of the derivative (1) follows the rule (method) of its finding .

The rule for finding the derivative.

Let $y = f(x)$ is a continuous function on $[a, b]$ and $a < x < b$. To find the derivative y 2= f2 (x) required:

1. Find the value of the function at the point $x : f(x)$.
2. Give x an increment of Δx and find the value of the function at the point $x + \Delta x : f(x + \Delta x)$.
3. Find the increment of the function:

$$\Delta y = f(x + \Delta x) - f(x).$$

4. Find a relationship

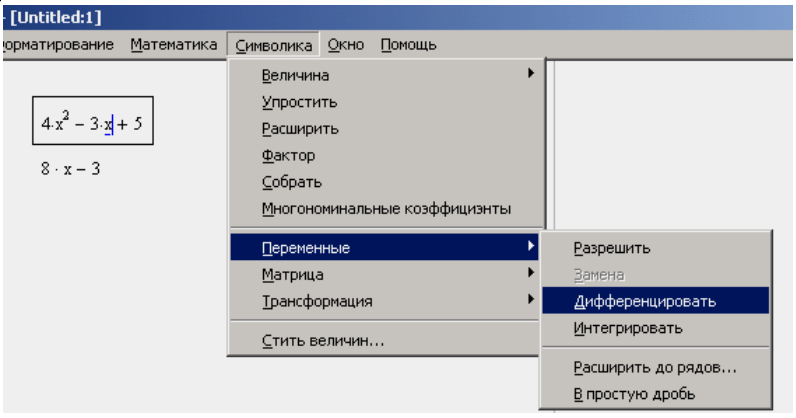
$$\frac{\Delta y}{\Delta x} = \frac{f(x+\Delta x) - f(x)}{\Delta x}.$$

5. Find the limit of this ratio at $\Delta x \to 0$ (if it exists, then it will be the sought-after derivative), i.e

$$f'(x) = y'(x) = \lim_{\Delta x \to 0} \frac{\Delta y}{\Delta x} = \lim_{\Delta x \to 0} \frac{f(x+\Delta x) - f(x)}{\Delta x}.$$

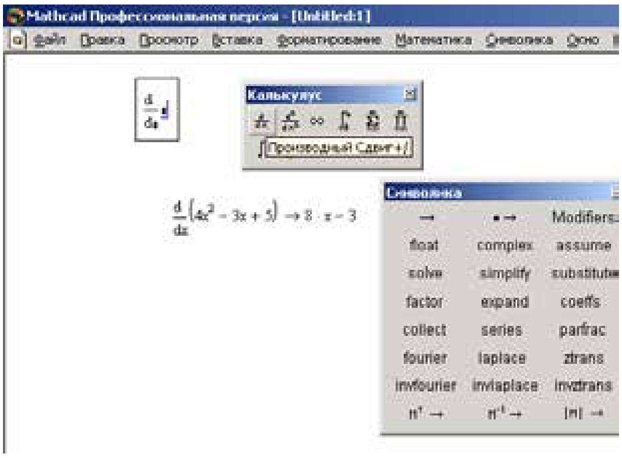
Finding derivatives in Mathcad

Using the symbol menu to find derivatives



1) Select the variable by which the integration is performed;
2) Go to the menu **Symbols** → **Variables** → **Integrate ;**
3) Below the result will appear under the expression .

Using the Calculus panel to calculate derivatives



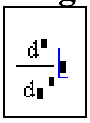
1) select the key for finding the indefinite integral on the Calculus (Calculations) panel (see figure);

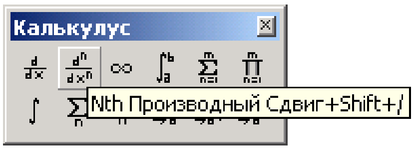
2) enter the variable on which the integration will take place and the corresponding expression in the blanks;

3) on the Symbols panel, press the corresponding symbol $\longrightarrow$;

4) press the Enter key and get the result;

Finding derivatives of higher orders and partial derivatives





1) select the differential finding key on the Calculus panel (see figure);

2) enter the variables, the order of the derivative, and the expression for differentiation in the appropriate places;

3) on the Symbols panel, select the corresponding symbol $\longrightarrow$;

4) press the Enter key and get the result

Practical work No. 9

The goal of the work: to master MathCAD tools for finding derivatives

Execution program

1. Download MathCAD mathematical processor .
2. Find the derivatives of the functions given in the task.
3. Save the created document in a personal folder.
4. Exit MathCAD.

Tasks for practical work

1. a) $y = e^{x} \cdot \arcsin \sqrt[3]{x}$; b) $y = (\sin 2x)^{\cos 5x}$; c) $x \operatorname{tg} 2y - 2^{x} = 0$.

2. a) $y = \dfrac{3^{x-1}}{\arccos^{2} 5x}$; b) $y = (\operatorname{tg} 2x)^{\sin 5x}$; c) $ye^{2x} - \sqrt{x - y} = 0$.

3. a) $y = \sqrt[3]{\ln^{3} \cos 2x - \operatorname{tg}^{3} 5x}$; b) $y = (\sin 2x)^{\sqrt{x}}$; c) $y \operatorname{ctg} x - 3^{y} = 0$.

4. a) $y = \ln^{7} \operatorname{arctg} 2^{x} - e^{8x}$; b) $y = (\cos 5x)^{\sin 2x}$; c) $x \sin y - \dfrac{1}{\cos x} = 0$.

5. a) $y = \operatorname{arctg}^{9} 3^{x} - \sqrt[3]{x - 1}$; b) $y = (\sin 9x)^{\operatorname{ctg} 2x}$; c) $y \cos x - e^{2x} = 0$.

6. a) $y = \dfrac{2^{x-7}}{\arccos^{4} 2x}$; b) $y = (\sin 4x)^{\operatorname{tg} 3x}$; c) $e^{3x} - x \arcsin y = 0$.

7. a) $y = \dfrac{e^{3x}}{\cos^{10} 5^{x}}$; b) $y = (\cos 8x)^{\arcsin x}$; c) $y \sin x - \sqrt[3]{x} = 0$.

8. a) $y = \dfrac{\arcsin^{2} 5^{x}}{e^{8x}}$; b) $y = (\cos 9x)^{\operatorname{arctg} x}$; c) $x \sin y - \ln x = 0$.

9. a) $y = \ln^{8} \arccos e^{3x}$; b) $y = (\sin 7x)^{\operatorname{ctg} 5x}$; c) $5^{x} y - \ln x = 0$.

10. a) $y = \sqrt[8]{\sin^{3} 4x - 5^{x^{2}}}$; b) $y = (\operatorname{tg} 2x)^{\cos 3x}$; c) $y \arcsin x - x^{2} = 0$.

11. a) $y = \dfrac{\sin^{5} x}{\cos^{10} 2^{x}}$; b) $y = (\sin 8x)^{\ln x}$; $xe^{2y} - \ln y = 0$.

12. a) $y = \dfrac{\sin^9 3^x}{\ln^3 5x}$; b) $y = (\sin 2x)^{\sqrt[4]{x}}$; c) $x \cos 2y - \operatorname{arctg} x = 0$

13. a) $y = \dfrac{2^{x} - 1}{\sin^4 8x}$; b) $y = (\cos 3x)^{\operatorname{tg} 2x}$; c) $e^{x+y} \sin y - x = 0$.

14. a) $y = \ln^9 \arcsin x^2$; b) $y = (\cos 5x)^{\sin 7x}$; c) $2^x + e^{3y} = 0$

15. a) $y = \sqrt[10]{\sin^3 5x - 2^{x^3-1}}$; b) $y = (\operatorname{tg} 5x)^x$; c) $x \cos 4y - e^{5x} = 0$.

16. a) $y = \dfrac{\ln 8x}{\cos^3 2^x}$; b) $y = (\cos 5x)^{\operatorname{tg} 2x}$; c) $x \arcsin y - e^{2x} = 0$.

17. a) $y = \dfrac{\arcsin 5x}{\sin^5 8x}$; b) $y = (\sin 4x)^{\sqrt[6]{x}}$; c) $e^{3y} - \operatorname{tg} 7x = 0$.

18. a) $y = \ln^{10} \arccos 5x$; b) $y = (\sin 7x)^{\operatorname{ctg} 3x}$; c) $x \cos 2y - 5^x + e^y = 0$.

19. a) $y = \sqrt[4]{\arccos^3 2^x - e^{5x}}$; b) $y = (\cos 5x)^{\operatorname{tg} 2x}$; c) $y \sin 9x - \operatorname{ctg} 3x = 0$

20. a) $y = \ln \sqrt{\dfrac{1-x}{1+x}}$; b) $y = (\operatorname{tg} 2x)^{\cos 6x}$; c) $2^{xy} + e^y = 0$.

21. a) $y = \dfrac{\ln^3 3x}{\sin^5 2x}$; b) $y = (\sin x)^{\sqrt[4]{x}}$; c) $e^y + \operatorname{tg} 2x = 0$.

<u>Self-test questions</u>

1. What methods for finding the derivative exist in Mathcad ?
2. What are the features of entering functions in Mathcad ?

4. 10. Numerical methods of differentiation

Calculation of derivatives of higher orders

The second derivative of the function $y=f\,(\,x\,)$ is called the derivative of the first derivative, which is denoted as follows:

$$y'' = (y')' = \frac{d^2 y}{dx^2} = \frac{d}{dx}\left(\frac{dy}{dx}\right).$$

Since the derivative is the rate of change of the function, the second derivative is the rate of change of the rate of change of the function or the acceleration of the function.

The third derivative is a derivative of the second derivative:

$$y''' = (y'')' = \frac{d^3 y}{dx^3} = \frac{d}{dx}\left(\frac{d^2 y}{dx^2}\right).$$

The derivative of *the nth* order of the function $y = f\,(\,x\,)$ is called the derivative of the derivative of the (*n-1*) order:

$$y^{(n)} = (y^{(n-1)})' = \frac{d^n y}{dx^n} = \frac{d}{dx}\left(\frac{d^{n-1} y}{dx^{n-1}}\right).$$

To calculate the derivative of the function $f\,(\,x\,)$ ***For the Nth order*** at the point *x,* you perform the same actions as when calculating the derivative of the first order, except that the template is selected ***The Nth*** derivative is entered from the palette or from the keyboard using the <Ctrl>+ <?> key combination . This template additionally contains a placeholder for entering a number ***N.*** Before using the differentiation operator , the function argument must be given the value for which the derivative will be calculated.

When calculating derivatives, a fairly complex and accurate algorithm is used, which allows you to perform calculations with an accuracy of 7-8 decimal places, which implements Ridder's numerical method, which does not depend on the value of the built-in constant TOL .

Derivatives of higher orders are also calculated using Ridder's method, and when the order of the derivative is increased by one order, the accuracy of calculations decreases by approximately one digit.

Calculation of partial derivatives

In contrast to the function of one variable, the concept of partial derivatives is introduced for the function of many variables.

The partial derivative of the function of many variables $y = f\,(\,x_1,\, x_{2,\ldots,}\, x_n$) with respect to the independent variable x_{and} (u= 1,2,...n) is called a finite boundary

$$\frac{\partial y}{\partial x_i} = y'_{xi} = \lim_{\Delta x_i \to 0} \frac{f(x_1,x_2,\ldots,x_i+\Delta x_i,\ldots,x_n) - f(x_1,x_2,\ldots,x_i,\ldots,x_n)}{\Delta x_i}.$$

Similarly, the partial derivative with respect to *y is found* .

Thus, the partial derivatives are the instantaneous rates of change of the function $y = f\,(\,x_1,\, x_{2,\ldots,}\, x_n\,)$ when one of the arguments x_{and} and constant values of all other n - 1 independent arguments.

Partial derivatives of higher orders (for example, the second) are determined by the formulas:

$$\frac{\partial^2 y}{\partial x_i^{\ 2}} = y''_{xi,xi} = \frac{\partial}{\partial x_i} \cdot \frac{\partial y}{\partial x_i}, i = 1,2,$$

$$\frac{\partial^2 y}{\partial x_i \partial x_k} = y''_{xi,xk} = \frac{\partial}{\partial x_i} \cdot \frac{\partial y}{\partial x_k}, i \neq k.$$

If the derivative y''_{x_i,x_k} exists in the vicinity of the point **(** x_1**,** x_2,..., x_n**)** and is continuous at this point, and the derivative y''_{x_k,x_i} exists at this point, then

$$y''_{x_i,x_k} = y''_{x_k,x_i}.$$

When calculating partial derivatives, the rules regarding the sum, product, fraction, etc. are also used.

When finding the partial derivative $z'_{x,}$ the ordinary derivative of the function of one variable *x is calculated* , considering the variable *u as* a constant. When finding the derivative z'_y variable x is considered constant .

Calculation of the derivative of the second order numerically (=) and symbolically (→).

$$x := 0.2$$

$$\frac{d^2}{dx^2}\left(\cos(x) \cdot x^2\right) = 1.762$$

$$\frac{d^2}{dx^2}\left(\cos(x) \cdot x^2\right) \rightarrow 1.96 \cdot \cos(.2) - .8 \cdot \sin(.2)$$

Examples of symbolic and numerical calculation of partial derivatives in Mathcad .

$$f(x,y) := x^{2y} + \cos(x) \cdot y$$

$$\frac{d}{dx} f(x,y) \rightarrow 2 \cdot x^{(2 \cdot y)} \cdot \frac{y}{x} - \sin(x) \cdot y$$

$$\frac{d}{dy} f(x,y) \rightarrow 2 \cdot x^{(2 \cdot y)} \cdot \ln(x) + \cos(x)$$

$x := 1 \qquad y := 0.2$

$$\frac{d}{dy} f(x,y) = 0.54$$

$$\frac{d}{dy} f(x,y) \rightarrow \cos(1)$$

$$\frac{d}{dx} f(x,y) = 0.232$$

$$\frac{d}{dx} f(x,y) \rightarrow .4 - .2 \cdot \sin(1)$$

Practical work #10

The purpose of the work: to master the numerical methods of differentiation using the tools of the MathCAD mathematical processor

Execution program

1. Download MathCAD mathematical processor .
2. Find the derivatives of the functions given in the task.
3. Save the document in a personal folder.
4. Complete work with MathCAD

Tasks for practical work

1. Find the partial derivatives of the first order for each independent variable

1. $z = x^2 - y^2 + 2xy - 4x - 8y + 1.$

2. $z = x^2 + y^2 - xy + 9x - 6y + 20.$

3. $z = 2xy - 2y^2 - 3x^2 + 10.$

4. $z = 4(x - y) - x^2 - y^2.$

5. $z = 1 - \sqrt{x^2 + y^2}.$

6. $z = x^4 + y^4 - x^2 - 2xy - y^2.$

7. $z = 2 - \sqrt[3]{x^2 + y^2}.$

8. $z = arctg \dfrac{x + y}{1 - xy}.$

9. $z = \dfrac{y^2}{x^2}.$

10. $z = x \ln \dfrac{y}{x}.$

2. Find second-order derivatives of functions

1. $z = e^{xy}.$ **2 .** $z = \ln \sqrt{x^2 + y^2}.$

3. $z = \dfrac{2x+3y}{x-y}$.

4. $z = \dfrac{xy}{\sqrt{x^2+y^2}}$.

5. $z = 2x^3 + x^2y + xy^2 + 2y^3$.

6. $z = x^4 + x^3y + x^2y^2 + xy^3 + y^4$.

7. $z = \dfrac{\cos y^2}{x}$

Self-test questions

1. What is the differentiation of a function ?
2. What means are used to find derivatives of higher orders in Mathcad ?
3. What is the difference between numerical and symbolic methods of calculating derivatives in Mathcad ?
4. How to find partial derivatives in Mathcad ?

4.11. Numerical methods of integration

Integration is the inverse operation to differentiation, when performing which a function is found based on a given derivative or differential.

Let $f(x)$ be the derivative of the function $F(x)$ ($f(x) = F'(x)$) for all values *of* x in some interval, and let $f(x)\,dx$ be its differential ($df(x) = f(x)\,dx$).

The function $F(x)$ is called the primitive function $f(x)$ or the differential $f(x)\,dx$. Finding the original function is an integration operation.

If the function $f(x)$ has a primitive $F(x)$, then all other functions of the form
$G(x) = F(x) + c$ (c is a constant value) will also be primitive, since the derivatives of the left and right sides of the equality are the same, that is, $G'(x) = F'(x)$.

The general form of the original function for the differential $f(x)\,dx$ is called the indefinite integral and is denoted as follows:

$$\int f(x)dx = F(x) + C,$$

where $f(x)\,dx$ is the integrand expression, $f(x)$ is the integrand function, x is the variable of integration.

Let the function $y = f(x)$ be continuous on the interval $[a, b]$, which we divide into n parts

the average value of the function on the intervals Δx_i by $f(x_i)$. Then the area of the curved trapezoid S is approximately equal to the sum of the areas of the rectangles

$$S = \sum_{i=1}^{n} f(x_i)\Delta x_i,$$

which when Δx_i decreases ($\Delta x_i \to 0$, $n \to \infty$) will approach the real area. This limit is called a definite integral, i.e

$$\int_a^b f(x)dx = \lim_{\Delta x_i \to 0} \sum_{i=1}^{n} f(x_i)\Delta x_i.$$

Since $f(x)\,dx = dF(x)$, then

$$\int_a^b f(x)dx = \int_a^b dF(x) = F(x) = F_0(x) + c.$$

the constant c from the condition that at $x = a$ the area $F(x) = 0$.

$0 = F_0(a) + c$,

$c = -F_0(a)$,

$F(x) = F_0(x) - F_0(a)$.

Then the area $F(b)$ is equal to

$F(b) = F_0(b) - F_0(a)$.

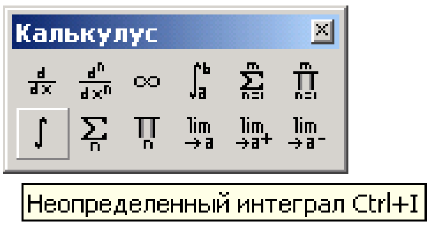
Thus, to calculate the integral

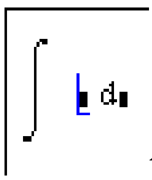
$$\int_a^b f(x)dx = F(x)\Big|_a^b = F_0(b) - F_0(a),$$

it is necessary to take the difference of the initial values in the upper and lower limits of integration. The expression is called the Newton-Leibnitz formula.

Mathcad tools for defining integrals

Calculation of integrals in Mathcad is carried out by selecting the appropriate template located in **the Calculus (Calculations) panel.**



After entering the symbol,  the integrand and the variable of integration are entered in the placeholders. To get the result, enter the equal sign (=) or symbolic equality (→) followed by pressing the Enter key . In the first case, the integration will be carried out numerically, in the second – symbolically.

Finding integrals is possible using **the Symbols menu** .

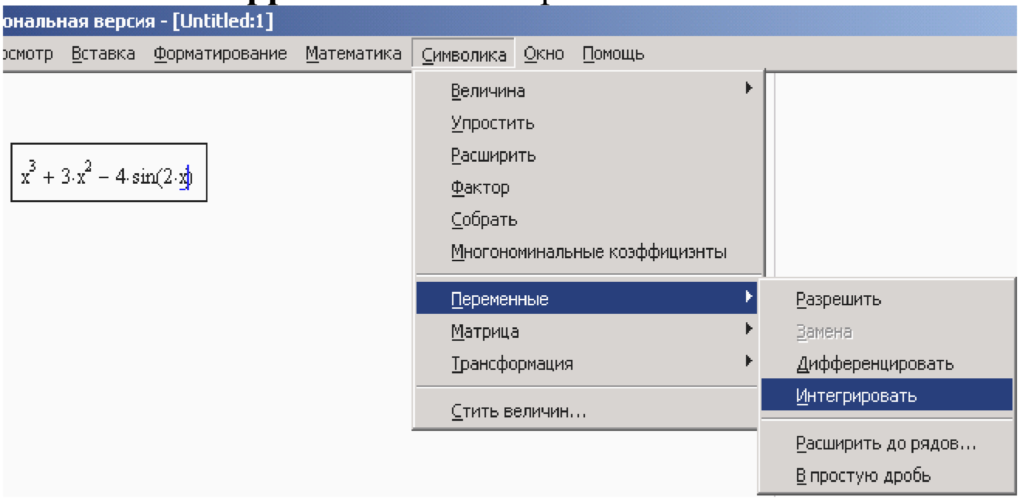
For this you need:

1) enter the integral function as an expression without using the integration sign and without dx;

2) single out the variable by which the integration is performed (most often only ***x***);

3) go to the menu **Symbols → Variables → Integrate ;**

4 **) the result will appear** below the expression.



Specifying the accuracy of calculations

The result of numerical integration is not the exact, but the approximate value of the integral, determined with an error that depends on the value of the built-in constant TOL . The smaller it is, the more accurately the integral will be calculated, but more time will be spent on calculations. By default, TOL =0.0001. In order to speed up the calculation, set a larger TOL value . By default, Mathcad independently selects the calculation algorithm, based on the analysis of the limits of integration, the type of integrand function, etc. In this case, the AutoSelect option is set (Automatic selection) . The user can choose the numerical integration algorithm independently. For this purpose, the following actions are performed:

- Call the context menu on the left side of the integral being calculated;
- In the context menu, choose one of four numerical algorithms:
  - Romberg (Romberga) – for most functions without features;
  - Adaptive (Adaptive) – for functions that quickly change on the integration interval;
  - Infinite Limit (Infinite limit) – for integrals with infinite limits;
  - Singular Endpoint - a modified Romberg algorithm for functions undefined on one or both limits of integration.

Practical work #11

<u>The goal of the work</u> is to master the numerical methods of integration using the tools of the Mathcad mathematical processor .

Execution program

1. Download the mathematical application Mathcad .
2. Calculate the integrals from the task with the calculation accuracy set by default.
3. Set the value of the system constant TOL =0.01, repeat the calculation.
4. Compare the obtained results.
5. Check which calculation algorithm is installed in the math processor by default.
6. Save the created document in your own folder.
7. Finish work in Mathcad .

Tasks for practical work

1. Calculate indefinite integrals

1. $\int \frac{x^4}{1-x}dx.$

2. $\int \frac{x^4 dx}{x^2+1}.$

3. $\int \frac{dx}{x(x-1)}.$ **4.** $\int \frac{dx}{x(x+1)}.$ **5.** $\int \frac{dx}{(2x-3)(x+1)}.$

6. $\int \frac{x^2+1}{x^2-1}dx.$ **7.** $\int \frac{dx}{x^2-7x+10}.$ **8.** $\int \frac{dx}{x^2+3x-10}.$

9. $\int \frac{dx}{4x^2-9}.$ **10.** $\int \frac{dx}{2-3x^2}.$ **11.** $\int \frac{dx}{(x-1)^2+4}.$

12. $\int \frac{dx}{x^2+2x+3}.$ **13.** $\int \frac{dx}{x-x^2-2{,}5}.$ **14.** $\int \frac{dx}{4x^2+4x+5}.$

15. $\int \frac{dx}{\sqrt{1-(2x+3)^2}}.$ **16.** $\int \frac{dx}{\sqrt{4x-3-x^2}}.$ **17.** $\int \frac{dx}{\sqrt{8+6x-9x^2}}.$

18. $\int \frac{dx}{\sqrt{2-6x-9x^2}}.$ **19.** $\int \cos^2 x dx.$ **20.** $\int \sin^2 x dx.$ **21.** $\int \frac{dx}{1-\cos x}.$ **22.** $\int \frac{dx}{1+\sin x}.$ **23.** $\int \frac{1-\cos x}{1+\cos x}dx.$ **24.** $\int \frac{1+\sin x}{1-\sin x}dx.$ **25.** $\int (tg^2 x + tg^4 x)dx.$

26 . $\int \frac{dx}{1+\sqrt{x+1}}.$ **27.** $\int \frac{4x+3}{(x-2)^2}dx.$ **28.** $\int \frac{dx}{x\sqrt{x+1}}.$

29. $\int \frac{x^3dx}{\sqrt{x-1}}.$ **30.** $\int \frac{x+1}{x\sqrt{x-2}}dx.$

3

2. Calculate definite integrals

1. $\int_0^1 x\ln x\,dx.$ **28.** $\int_0^{\sqrt{\frac{2}{\pi}}} \cos\frac{1}{x^2}\frac{dx}{x^3}.$ **3.** $\int_0^{\frac{\pi}{2}} ctgx\,dx.$

4. $\int_0^{\frac{\pi}{4}} \frac{xdx}{\sin x^2}.$ **5.** $\int_0^5 \frac{5dx}{\sqrt{25-x^2}}.$ **6.** $\int_2^4 \frac{dx}{\sqrt{6x-x^2-8}}.$

7. $\int_{\frac{1}{3}}^{\frac{2}{3}} \frac{dx}{x\sqrt{9x^2-1}}.$ **8.** $\int_0^2 \frac{x^3dx}{\sqrt{4-x^2}}.$ **9.** $\int_0^1 \frac{dx}{\sqrt{x(1-x)}}.$

10. $\int_0^1 \frac{dx}{\sqrt{x}+\sqrt[3]{x}}.$ **11.** $\int_3^5 \frac{x^2dx}{\sqrt{(x-3)(5-x)}}.$

12. $\int_{-1}^1 \frac{\ln\left(2+\sqrt[3]{x}\right)dx}{\sqrt[3]{x}}.$

Self-test questions

4.12. Programming of linear algorithms using MathCAD function programs

implement one or another calculation algorithm in MathCAD in two ways:

- using appropriate operators or functions directly in the text of the MathCAD document . This method is called *programming in the text of the document* ;
- using so-called function programs, which contain constructions similar to the constructions of the programming languages Pascal , Fortran : "assign value" operators, loop operators, conditional operators, etc. This method is called *programming in a function program* . It includes two stages:

- o description of the program-function;
- o program-function call.

Using program functions

Before using the function program, it must be specified, that is, described. The description of the program-function in the working document is placed before its call and contains: the name of the program-function, a list of formal parameters (which may not be present), and the body of the program-function.

Each function program has *an original name* by which it is called. Due to this name, the result of executing the function program is "returned" to the working document.

The name of the function program is followed by a list of formal parameters enclosed in parentheses. Through formal parameters, the data required for calculations are transferred inside the function program. Names of simple variables, arrays, and functions can be used as formal parameters. Formal parameters are separated from each other by a comma. A program-function may not have formal parameters, and then data is passed through the variable names defined above the description of the program-function.

The body of a program-function can include any number of statements, local "assign value" statements, conditional statements and loop statements, as well as other program-functions and user functions.

Sequence of program-function description

To enter a description of the function program into the working document, perform the following actions:

- ▪ enter the name of the function program and the list of formal parameters;
- ▪ enter the character ":", ":=" will be displayed on the screen.
- ▪ open the **Programming panel** and press the **Add button line** . A vertical dash and a vertical column with two input fields for entering statements that form the body of the function program will appear on the screen.
- ▪ if there are more operators, the number of input fields is added by pressing the button again **Add line**
- ▪ an additional input field is added below the currently highlighted operator;
- ▪ the entered operator or input field, if necessary, can be removed by placing it between the input cursor and pressing the Delete key .
- ▪ fill the lower input field with the expression that determines the result.

To give a value to a variable in the middle of the program, use the local operator "give value": the name of the ←value variable. Using the regular operator ":=" in the body of a function program results in a syntax error.

Reference to the function program

To execute a function program, you need to refer to its name with a list of actual parameters. The actual parameters indicate for which specific values the calculations in the body of the program are performed. Actual parameters are separated by a comma. Between the actual and formal parameters there should be a correspondence in number, sequence and type. The latter means:

- if the formal parameter is a simple variable, then the actual parameter can be a constant, a variable, an arithmetic expression;
- if the formal parameter is a vector or matrix, then the actual parameter must be a vector or matrix.
- if the formal parameter is the name of a built-in function or other program, then the actual parameter must be the same object.

The reference to the program-function must be after the description of the program-function and the actual parameters must be defined before the reference.

The names of the actual parameters when calling the function program may not coincide with the names of its formal parameters.

Programming in the function program of linear algorithms

A computing process in which the necessary operations are performed strictly sequentially is called a linear algorithm. The operators that implement this algorithm in the body of the function program are also arranged sequentially and are all executed, starting from the first and ending with the last.

$$ax^2 + bx + c = 0$$

$$x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Enter the description of the function program

$$qq1(a,b,c,sig1) := \left| \begin{array}{l} d1 \leftarrow b^2 - 4 \cdot a \cdot c \\ d2 \leftarrow 2 \cdot a \\ d3 \leftarrow -b + sig1 \cdot \sqrt{d1} \\ \dfrac{d3}{d2} \end{array} \right.$$

The program $dd1$ has four parameters. The parameter $sig1$ specifies the sign before the square root. If $sig1$=1, then we get the root x_1, if $sig1$=-1, then x_2.

The program implements a linear algorithm and all operators are always executed strictly sequentially.

Practical work #12

***<u>Purpose of work</u>*:** acquiring practical skills in programming linear algorithms

<u>Execution program</u>

1. MathCAD mathematical processor .
2. Write function programs for solving the equations given in the task.
3. Save the document and send it for review.
4. Exit MathCAD .

<u>Tasks for practical work</u>

1. Develop a function program and find the roots of the equation that describes the dependence of phosphorus concentration in the soil on the time of bioremediation .

Let the concentration of phosphorus *Y* in oil-contaminated soil depend on the time of bioremediation *X* is described by the equation: $Y = 0{,}0035X^2 - 1{,}0766X + 93{,}44$.

It is required to determine the period of time after which the concentration of phosphorus in the soil will be equal to the value that was before the ecological disaster, namely: 135 mg/kg. That is, it is required to solve the following equation:

$0{,}0035X^2 - 1{,}0766X + 93{,}44 = 135$, or $0{,}0035X^2 - 1{,}0766X + 93{,}44 - 135 = 0$: After reduction, we have: $0{,}0035X^2 - 1{,}0766X - 41{,}56 = 0$.

2. Develop function programs and find the roots of equations:

$16x^2 - \frac{7}{8}x + 19 = 0$

$x^2 + 10x - 11 = 0$

$x^2 + 5x + 6 = 0$

$2x^2 - 6x = 0$

$2\sqrt{x+5} = x + 2$

Questions for self-control

1. What are the ways to implement the calculation algorithm in MathCAD ?
2. What are the rules for using program functions?
3. What does the description of program functions consist of?
4. Is it necessary to set formal parameters?
5. What are the methods of transferring data to a function program?
6. What is the sequence of the program-function description?
7. How to add an additional field for entering an operator in the body of a function program?

4.13. Programming branched algorithms using MathCAD function programs

In branched algorithms, there are several branches of computational processes. The choice of a specific branch depends on the fulfillment or non-fulfillment of the specified conditions on the values of the algorithm variables.

if function and the conditional operator are used for programming branched algorithms . Using the specified constructions, you can change the sequence of execution of operators. New concepts can be used in these constructions.

Expressions of relations . These expressions are used to compare two arithmetic expressions with each other. Expressions of relations are written in the form:

<Expression A> <Relation sign> <Expression B>. Signs of relationships can be the following symbols: $= < > \le \ge \ne$. If the given relation is fulfilled, then the

expression of the relation takes the value 1 (true), if not, then 0 (false). Unlike programming languages, it is possible to check several conditions at once in one expression by adding relational signs and arithmetic expressions.

Logical operations . Two logical operations are defined, which are applied between expressions of relations.

Logical OR operation . It is denoted by the sign "+" and written in the form: <Log.expression1> +<Log.expression2>. The result is 0 if both Boolean expressions are 0 and is 1 for the rest of the Boolean expression values.

Logical operation I. It is denoted by the sign "*" (in the text it is a dot) and written in the form: <Log.expression1> .<Log.expression2>. The result is 1 if both logical expressions are equal to 1 and equal to 0 for the rest of the values of the logical expressions.

Logical expression . A logical expression is a construction consisting of relational expressions, signs of logical operations, and parentheses. The value of the logical expression is calculated from left to right, taking into account the well-known rule about the priority of operations. List of priorities in descending order:

- parenthesis;
- logical operation I;
- logical OR operation.

Conditional function and f . The function is written in the form:

And f (< logical expression >, < arithmetic expression1>, < arithmetic expression2>).

If the logical expression =1, then the function will accept the value of the arithmetic expression1, if the logical expression =0, then the function will accept the value of the arithmetic expression2.

An example .

For most populations, there are restraining factors, and for one reason or another, cell growth stops. In this case, until the nutrient medium is exhausted, cell growth occurs according to the exponential law, and then, for some time, it remains unchanged. In the general case, the growth model under the condition of depletion of the nutrient medium has the form:

$$x(t)=\begin{cases} x\cdot e^{r\cdot t} & \text{при } 0\le \mathrm{t}\le \mathrm{t_f} \\ x\cdot \mathrm{e}^{\mathrm{r\cdot t_f}} & \text{при } \mathrm{t}>\mathrm{t_f} \end{cases},$$

where t_f – the time of exhaustion of the nutrient medium;

x – initial number of cells;

t – observation time;

r is const .

The growth rate calculation algorithm contains two branches, the choice of which depends on the time of depletion of the nutrient medium. That is, the calculation algorithm contains *a logical condition* : if the time of observation is less than or equal to the time of depletion of the nutrient medium, then the growth rate is calculated according to the formula: $x \cdot e^{r \cdot t}$, if less, then according to the formula $x \cdot e^{r \cdot t_f}$.

$$x(t) = \begin{cases} x \cdot e^{r \cdot t} & \text{ïðè} \quad 0 \le t \le t_f \\ x \cdot e^{r \cdot t_f} & \text{ïðè} \quad t > t_f \end{cases}$$

An example of solving a problem by means of MathCAD

$x := 2$

The initial number of cells

$f := 25$

The time during which depletion of the nutrient medium occurs

$t := 0, 5 .. 50$

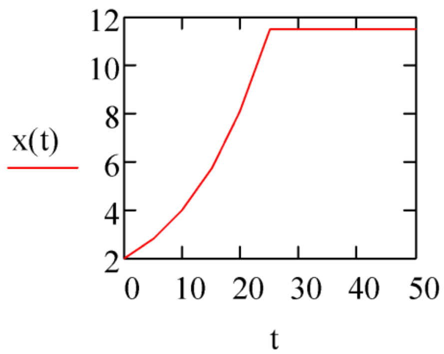
Observation time

$$x(t) := \begin{cases} x \cdot e^{r \cdot t} & \text{if } t \le f \\ x \cdot e^{r \cdot f} & \text{otherwise} \end{cases}$$

The body of the function program

$x(t) =$

2
2.838
4.028
5.715
8.11
11.509
11.509
11.509
11.509
11.509
11.509



The result of calculations by the function program

The graph of the function x(t) at f =25

Practical work #13

Purpose of work **:** acquiring practical programming skills of branched algorithms

Work execution program

1. MathCAD mathematical processor .
2. Write a function program to solve the problem given in the task.
3. Save the document and send it for review.
4. Exit MathCAD .

Task

The dependence of the rate of biochemical transformation of substances on water temperature in predictive calculations is determined by the formulas:

$$\begin{cases} k = k_{20} \cdot (1{,}12 \cdot (T+1)^{-0{,}038})^{T-20} & npu \quad 0 \le T < 5^0 C \\ k = k_{20} \cdot 1{,}047^{T-20} & npu \quad T \ge 5^0 C \end{cases}$$

,

where k_{20} - the value of the coefficient of non-conservativeness of the substance at 20 ^{0}C, 1/day; T is water temperature, $^\circ$C .

Task options:

1) k_{20}=0.07 1/d; T= 1..10 ^{about}C ;
2) k_{20}=0.0 8 1/d; T= 1..10 ^{about}C ;
3) k_{20}=0.0 9 1/d; T= 1..10 ^{about}C ;
4) k_{20}=0, 1 1/d; T= 1..10 ^{about}C ;
5) k_{20}=0.15 1 /d; T= 1..10 ^{about}C ;
6) k_{20}=0.2 1 /d; T= 1..10 ^{about}C ;
7) k_{20}=0.25 1 /d; T= 1..10 ^{about}C ;
8) k_{20}=0.3 1 /d; T= 1..10 ^{about}C ;
9) k_{20}=0.4 1 /d; T= 1..10 ^{about}C ;
10) k_{20}=0.07 1/d; T= 1..10 ^{about}C ;

Questions for self-control

8. What are the ways to implement the calculation algorithm in MathCAD ?
9. What are the rules for using program functions?
10. What does the description of program functions consist of?
11. Is it necessary to set formal parameters?
12. What are the methods of transferring data to a function program?
13. What is the sequence of the program-function description?
14. How to add an additional field for entering an operator in the body of a function program?

SECTION 5. MS DATABASE MANAGEMENT SYSTEM ACCESS

MS Access desktop databases are quite diverse. Access databases can be used to store and track any information, including inventory, contacts, or business processes. This section describes how to create Access desktop databases, add data to them, and configure and use the created databases.

5.1. The main window and menu of MS DBMS Access

Before starting work with DBMS and creating a database, consider the main elements of the MS Access window.

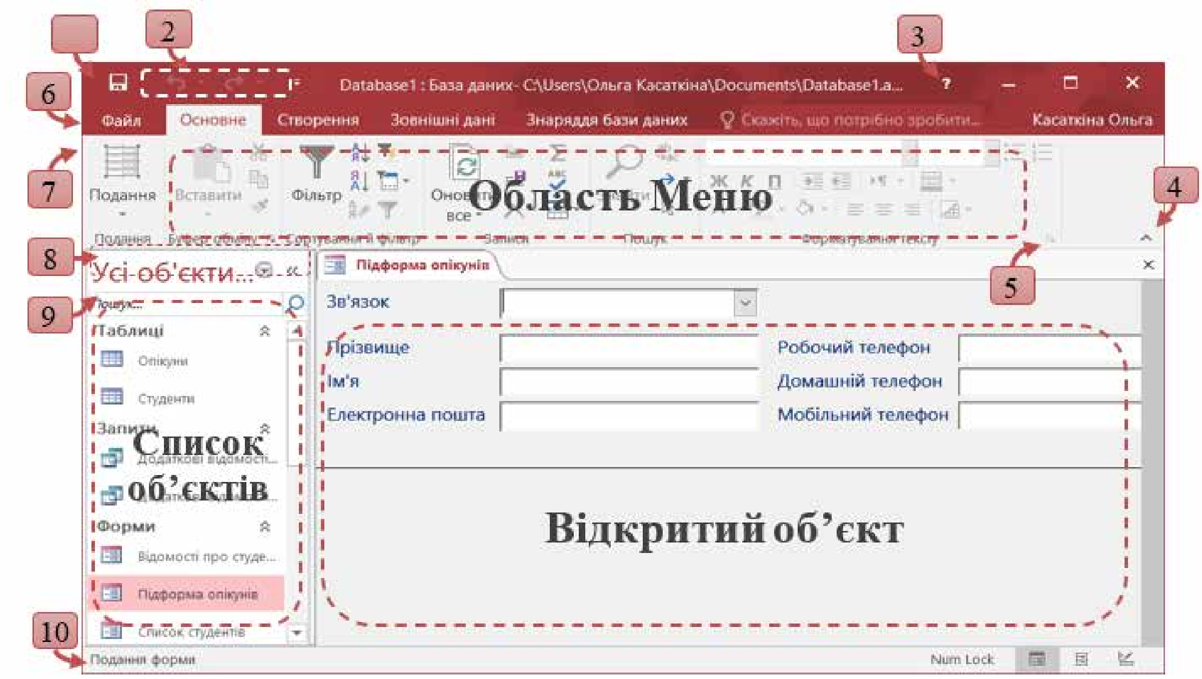


Fig. 5.1 – The main window of MS Access 2016 DBMS.

1. **Save the database.** Standard icon for all MS programs Office , which allows you to quickly save changes made to a file.
2. **Using controls from the Quick Access Toolbar.** You can quickly add controls to a form or report, or modify existing controls, by clicking the tools icon when the form or report is open in markup or design view.
3. **Obtaining a certificate** . Click on the question mark to view the help content.
4. **Hiding the menu bar** . Click the up arrow to hide the ribbon and leave only the tabs.

5. **Launching dialog windows** . If an icon is displayed next to any group of menu ribbon commands, that group contains additional hidden options. Click on the icon to access additional features available to the group.
6. **File management.** The database can be opened, closed, printed, shared, saved as previous versions or chalons, encrypted, compressed, or restored.
7. **Mode button** (View, depending on the translation of the interface). To switch from one mode (view) of the current object to another, click **the Mode button** . The down arrow under the button will reveal a list of available views for the current object.
8. **Sorting objects.** Specify sorting criterion (by object type, by connections, by creation date, by editing date) and a filter label by groups depending on the selected filtering criterion.
9. **Object filtering.** Enter a keyword in the search field to filter objects in the database.
10. **Status bar.** Displays information about the current object.

MS Access 2016 DBMS menu bar

bar is located under the title bar in which the commands are located:

FILE - MAIN - CREATE - EXTERNAL DATA - DATABASE TOOLS

FILE - create, open, save a document, finish work. You can also view the properties of the database, compress or restore it, manage users and access , set the database password.

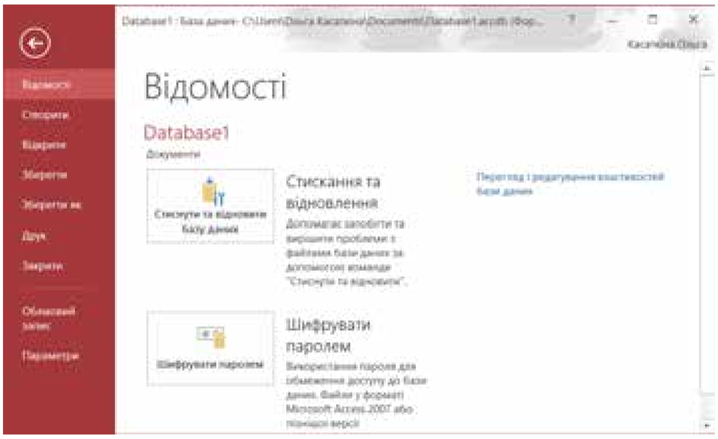


Fig. 5.2 – MS Access 2016 database properties window.

MAIN - to select the mode (view) of the current object , install a filter and sort, work with records (creation, saving, deletion), search for the required information, format text.

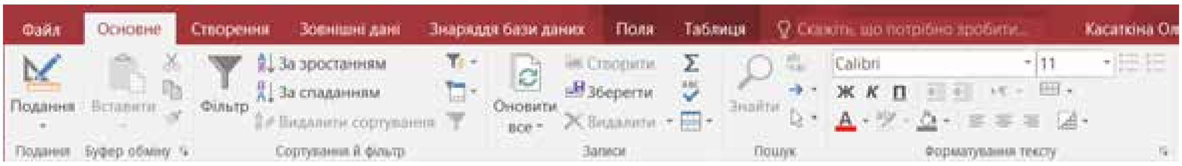


Fig. 5.3 - The "Main" menu of the MS Access 2016 DBMS.

CREATION - using the designer or wizard to create tables, queries, forms, reports and macros.

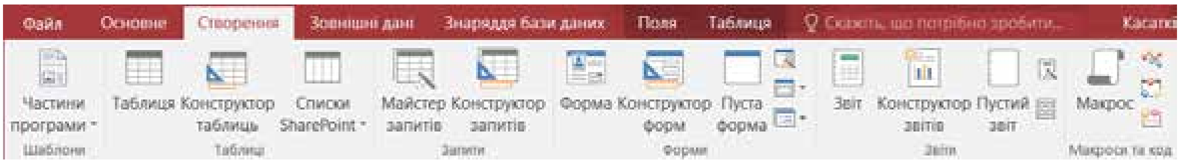


Fig. 5.4 - MS Access 2016 DBMS "Create" menu.

EXTERNAL DATA - import data from Excel , Access , ODBC database , text file, XML file, etc. Save import options . Export data in a variety of formats or send it by e-mail.

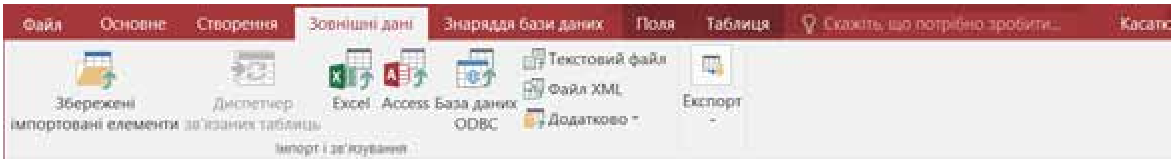


Fig. 5.5 - "External data" menu of MS Access 2016 DBMS.

DATABASE TOOLS – compress or restore a database, open the Visual editor Basic , execute a macro, create a data schema, analyze the dependence of objects and rapid actions or table structures, split the database into two files, call the manager of add-ons or button forms.

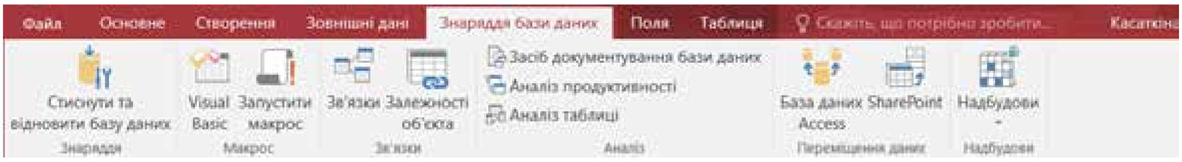


Fig. 5.6 - The "Database tools" menu of the MS Access 2016 DBMS.

5.2. Access template information

If you need to organize and manage your data in Access, but don't want to spend time building a database from scratch, you can use the classic database template.

An Access template is a file that, when opened, creates a complete database application with the built-in tables, forms, reports, queries, macros, and connections you need to get started. Because templates are designed as end-to-end database solutions, they save you time and effort and get you up and running with your database right away. Once you create a database using a template, you can customize it to suit your needs, just like a database created from scratch.

Selecting a template

Access templates include ready-to-use built-in tables, queries, forms, and reports. As soon as you start Access, a number of available templates are displayed. More patterns can be found online.

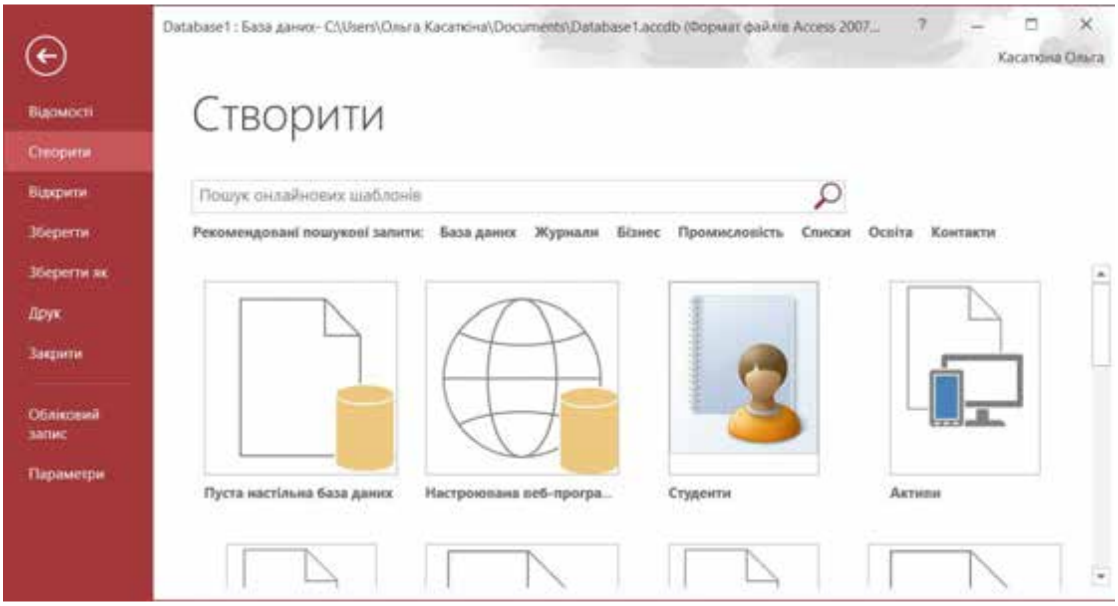


Fig. 5.7 – MS Access 2016 DBMS template selection window.

1. In Access, choose **File** > **New** .
2. Select the desktop database template and enter the name of the database in **the File name field. (If there is no suitable template, use the Find Online Templates field).**
3. To save, you can use the default location shown under the **File name field** , or click the folder icon to choose a new location.
4. Click the **Create button** .

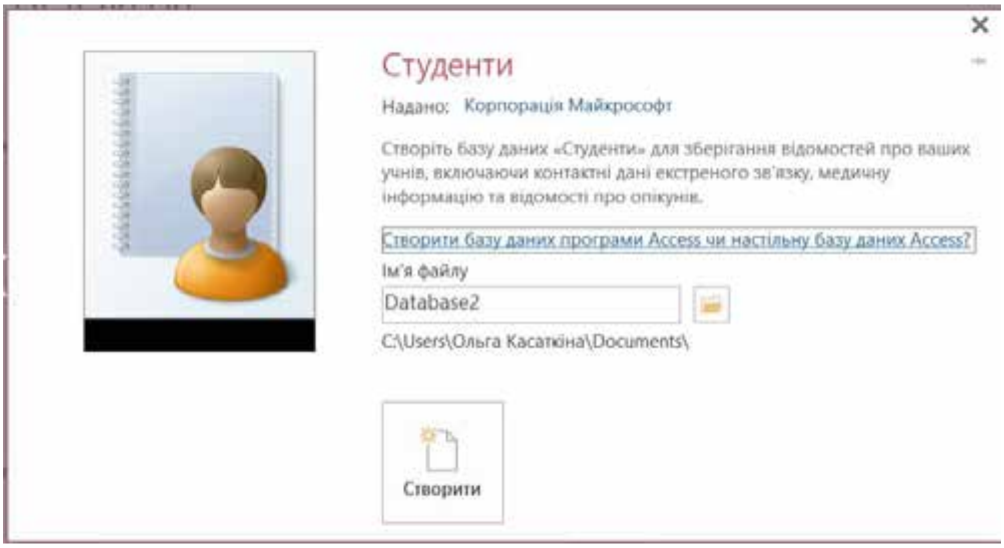


Fig. 5.8 – Creation of a new database in MS Access 2016 DBMS.

Depending on the template, you'll need to do one of the following to get started.

- If Access displays the **Sign In dialog box** with an empty list of users, do the following.
    a. Select the **New User item** .
    b. **User Information** form .
    c. Select **Save and Close** .
    d. Select the username you just entered and click the **Login button** .
- **Security Warning** message in the Access message bar and you trust the source of the template, click the **Enable Content button** . If the database requires re-login, log in again.

5.3. Creating a database from scratch .

If no template meets your needs, you can create a new desktop database.

1. In Access, choose **New** > **Empty Desktop Database** .
2. In **the File name field** , enter a name for the database.
3. To save, you can use the default location shown under the **File name field** , or click the folder icon to choose a new location.
4. Click the **Create button** .

Adding a table

In a database, information is stored in several related tables. Here's how to create a table.

1. When you first open a database, the tabular view of the data will display an empty table to which you can add data. To add another table, go to the **Create tab** and click **the Table button** . Data can be simply entered into an empty field (cell) or inserted from another source, such as an Excel workbook.
2. To rename a column (field), double-click the column header and type a new name.

   Advice. Choose meaningful names so you know what each field contains without looking at its contents.

1. On **the File tab** , select **Save** .

- To add more fields, enter data in the **Click to add column** .
- To move a column, select it by clicking the column header, then drag it to the desired location. You can also select multiple adjacent columns and drag them together to a new location.

Copy and paste data

You can copy and paste data from other programs, such as Excel or Word, into an Access table. It is most convenient to do this if the data is divided into columns. If the data is in a word processing program such as Word, use commas to separate the columns or convert the data to a table before copying.

1. If the data needs to be edited, such as separating first and last names, do so in the source program.
2. Open the data source and copy the data (Ctrl+C).
3. Open the Access table to which you want to add data in the data table window and paste the data (Ctrl+V).
4. Double-click each column header and enter meaningful names.

5. Select **File** > **Save** and give the new table a name.

Note. In Access, the data type for each field is set based on the data added to the first row of each column, so make sure that the data in subsequent rows matches the data in the first row.

Import or link to data

You can import data from other sources or link to data from Access without moving the information from where it is stored. Linking is convenient to use when multiple users update data at the same time and you need to always see the latest version, or you need to save storage space. For most formats, you can choose the way you want to add data: import or link.

The import process may vary slightly depending on the source, but the instructions below will help you get started.

1. On **the External Data tab** , select the data format to import or link. If the desired format is not displayed, click **the Advanced button.**
2. Follow the instructions in the **Get External Data dialog box** .

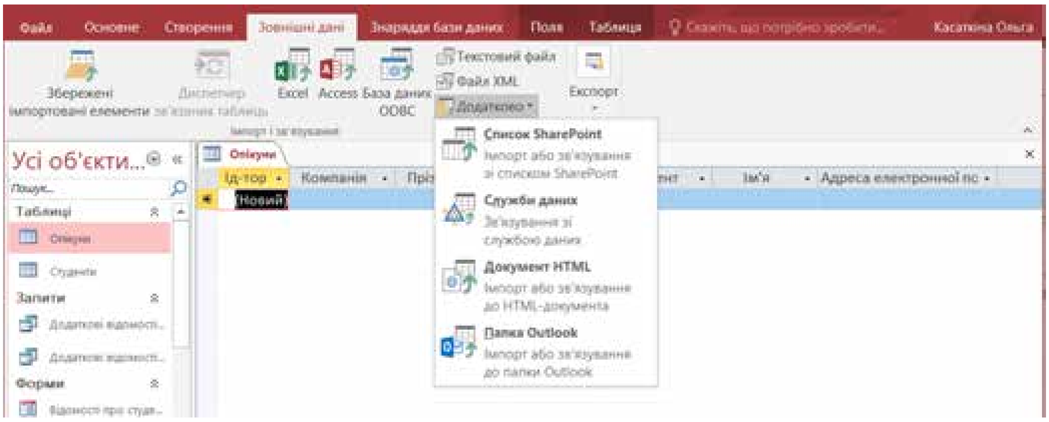


Fig. 5.9 – Importing or linking with data in the MS Access program.

Note. If the desired format is still not available, you may need to first export the data to a file format supported by Access (for example, a delimited text file).

During binding, some data formats are read-only. Below are the external sources from which data linking or importing is supported.

Table 5.1.

List of data formats of external sources for linking or importing data.

Data formats	Importation	Binding
Microsoft Excel	Yes	Yes (read only)
Microsoft Access	Yes	Yes
ODBC databases such as SQL Server	Yes	Yes

Text files or comma-separated data (CSV) files	Yes	Yes (only adding new records)
SharePoint list	Yes	Yes
XML	Yes	
Data Services		Yes (read only)
HTML document	Yes	Yes
Outlook folder	Yes	Yes

Organizing data using a table analysis tool

You can use the table analysis wizard to quickly identify redundant data. Using the wizard, you can easily organize data into separate tables. The original table is saved as a backup copy.

1. Open the Access database with the table you want to analyze.
2. On the **Database Tools tab,** click **the Analyze Table button** .

The first two pages of the wizard contain a quick guide with examples. If the Show intro pages check box is displayed, select the check box and click the Back button twice to view the intro. If you no longer want to see the introduction pages, clear the Show introduction pages check box.

Further actions

The rest of the design process depends on what you need to do. You will most likely need to create queries, forms, reports, and macros. Listed below are topics with useful information to read before creating a database:

- General information about tables
- General information about requests
- Creating an Access form
- General information about reports in Access
- Data protection through backup and recovery processes

5.4. General information about tables in MS Access .

Tables are important objects in a database because they contain all the information or data. For example, a business database might contain a Contact table that stores vendor names, email addresses, and phone numbers. This article provides an overview of tables in Access. Before creating tables, determine what tables you might need and what your requirements are.

A relational database, such as an Access database, usually has several related tables. In properly designed databases, each table stores data on a specific topic, such as employees or products. The table consists of records (rows) and fields (columns). Fields contain different types of data, such as text, numbers, dates, and hyperlinks.

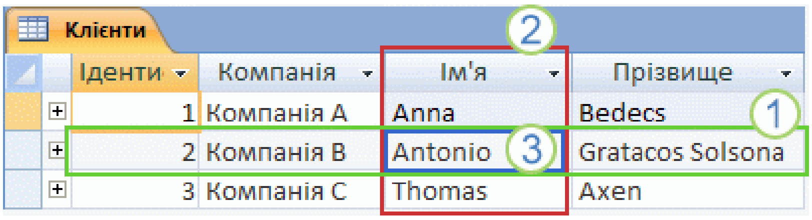


Fig. 5.10 - Table mode in MS Access.

1. Record - contains certain data, for example, information about a specific employee or product.

2. Field – contains data about one aspect of a table subject, such as a name or email address. A field is also commonly called a column or attribute.

3. Field value – each record has a field value. For example, Contoso , Ltd. or abc@example.com .

Properties of tables and fields

The characteristics and behavior of tables and fields are defined and controlled by properties. Table properties are set in the table properties window, for example, to define the way the table is displayed by default, you should set the table property **Default View** . A field property defines an aspect of the field's behavior. Field properties can also be set in design mode using the **Field Properties** area . Each field has a data type that determines the type of information stored in it. For example, data types are multiple lines of text or a currency.

Connections of tables

Although each table contains data on a separate topic, tables in a relational database such as Access store data on related topics. For example, a database may contain:

- customer table, which contains the names of the company's customers and their addresses;
- a table of the items you sell, including pFigs and images for each item;
- an order table that tracks customer orders.

To link data stored in different tables, you should create relationships. A relationship is a logical combination of two tables with common fields.

Keys

Fields used to link tables are called keys. A key usually consists of one field, but can also consist of several fields. There are two types of keys:

- Primary Key – A table can have only one primary key. The primary key consists of one or more fields - unique identifiers of each record stored in the table. Access automatically assigns a unique identification number that acts as a primary key.
- Foreign Key – A table can also have one or more foreign keys. A foreign key contains values that match the primary key values of another table. For example, suppose there is an Orders table in which each order has a customer ID corresponding to an entry in the Customers table. The Customer ID field is a foreign key to the Orders table.

Correspondence of values in the key fields forms the basis of table connections . A table relationship is used to combine data from related tables. Suppose you have two tables: "Customers" and "Orders". In the "Clients" table, each record is determined by the primary key field (identifier).

To associate each order with a customer, add a foreign key field to the Orders table that corresponds to the ID field in the Customers table, and then create a relationship between the two keys. When adding a record to the Orders table, you should use the customer ID value from the Customers table. So, if you need to look up any information about a customer, you use a relationship to determine which data from the Customers table matches the desired records in the Orders table.

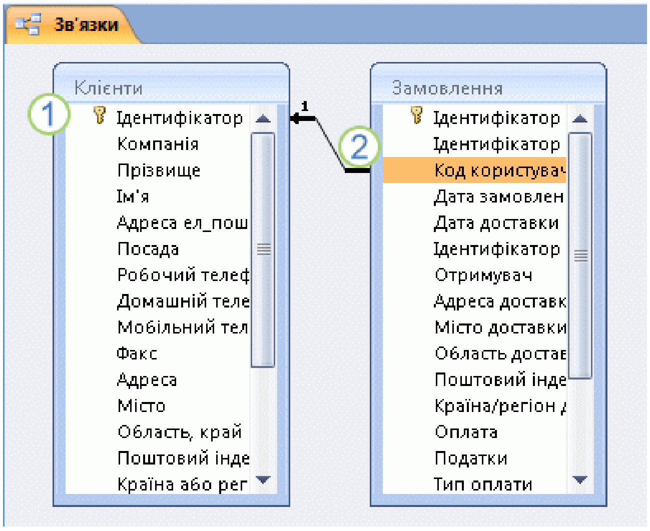


Fig. 5.11 - The relationship between the tables displayed in the Relationships window.

1. The primary key is indicated by a key icon next to the field name.
2. External key. Note: The key icon is missing.

Advantages of using connections

Storing data separately in linked tables provides the following advantages:

- **Consistency.** Because each data item is recorded only once in a single table, there is less chance of ambiguity or inconsistency. For example, a customer's name is stored only once in the customer table, and not multiple times (and possibly inconsistently) in the order table.
- **Efficiency.** Writing data to one location means that less disk space is used. In addition, it is usually faster to find data in small tables than in large ones. In the end, if you do not use separate tables for different subjects, the tables will have an excessive amount of data and Null values (absence of data). Both lead to wasted disk space and reduced performance.
- **Intelligibility.** Database layout is easier to understand if subjects are properly separated between tables.

Adding a table to a local database

You can create a table by creating a new database, inserting a table into an existing database, or importing or linking to a table from another data source, such as a Microsoft Office Excel workbook, a Microsoft Office Word document, a text file, a Web service, or another database. When a new empty database is created, a new empty table is automatically inserted into it. So you can enter data into it to start defining fields.

Creating a new table in a new local database

1. On **the File tab** , choose **New** > **Empty Desktop Database** .
2. In **the File name field** , enter the file name of the new database.
3. To save the database to a different location, click the folder icon.
4. Click the **Create button** .

A new database will open with a new table named "Table1". Rename the table according to the type of data it will store.

Creating a new table in an existing database

1. On **the File tab** , click **Open** , and then click the desired database if it appears in the **Recents list** . If it does not appear in this list, select one of the browser options to find the required database.
2. On the **Create tab,** click **the Table button** .

A new table will be added, which will open in a tabular data window.

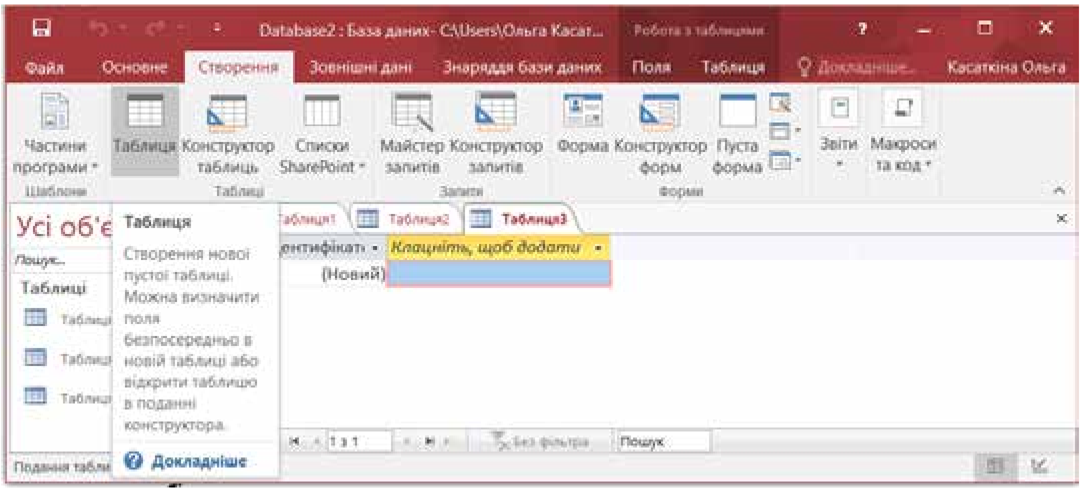


Fig. 5.12 - Creating a table using the "New" menu in MS Access.

The structure of the not yet filled table can be edited both in tabular mode (table view) and in designer mode.

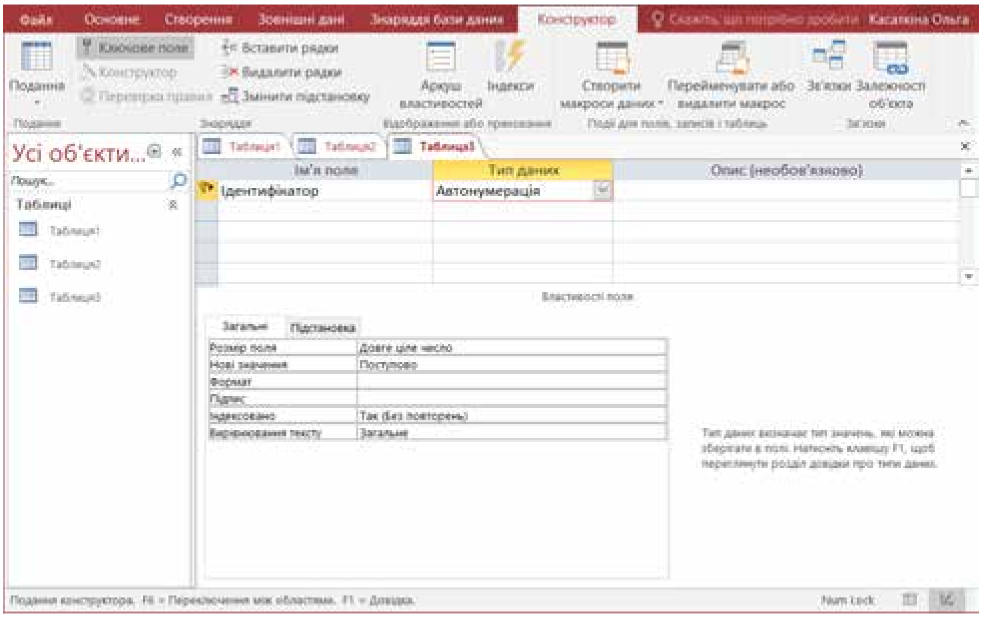


Fig. 5.13 - Table designer mode in MS Access 2016.
The picture shows a screenshot of a database design interface. A table named "Таблиця1" is selected, and its fields are visible. The fields include "Ідентифікатор" (Identifier), "Антонумерація" (Autonumber), and "Опис (необов'язково)" (Description (optional)).

External data

The database can be linked to various external data sources, such as other databases, text files, and Excel workbooks. When an external data relationship is created, Access can use it as a table. Depending on the external data source and the relationship method, you can edit the data in the linked table and create relationships that span that table. However, the external data layout cannot be changed using this connection.

Creating a table by importing and linking

A table can be created by importing or linking to data stored in another location. You can import or link to data that resides in an Excel sheet, in a Windows SharePoint Services list , in an XML file, in another Access database, in a Microsoft Office Outlook folder, and so on.

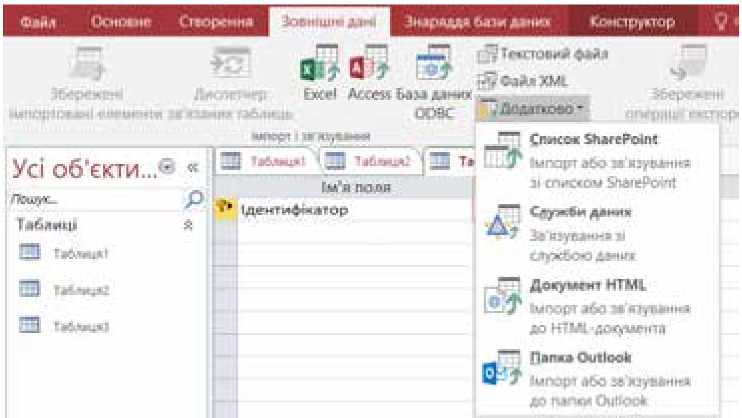


Fig. 5.14 - Data import in MS Access 2016.

Importing data creates a copy of the data in a new table in the current database. Subsequent changes to the data source do not affect the imported data, and changes to the imported data do not affect the data source. After you connect to a data source and import data from it, you can use it without connecting to the data source again. You can also change the layout of the imported table.

When a data link is established, a linked table is created in the current database that maintains a persistent link to existing data stored in another location. If you change the data in the linked table, it will also change in the source. If the data changes in the source, the changes are also reflected in the linked table. When using a linked table, you must ensure a persistent connection to the data source. You cannot change the layout of a linked table.

Note. You cannot change data on an Excel sheet using a linked table. Instead, import the data from the source into an Access database, and then connect to that database in Excel. For more information about connecting to Access in Excel, see Excel Help.

Create a new table by importing or linking to external data

1. On the **External Data tab** , in the **Import and Binding group** , select one of the available data sources.

2. Follow the instructions that appear in the dialog boxes for each step. A new table is created and displayed in the navigation area.

Creating a table using a SharePoint site

You can create a table in your database that will import data from or be linked to a SharePoint list. You can also create a new SharePoint list using the built-in template.

1. On the New tab **,** click **SharePoint Lists** , and then do one of the following:

2. Create a SharePoint list based on a template

a. Select **Contacts** , **Tasks** , **Questions** , or **Events** .

b. In the **Create New List dialog box** , enter the URL of the SharePoint site where you want to create the list.

c. Enter the name of the new list and its description in the **Enter a name for the new list** and **Description fields** .

d. To open the linked table after it is created, select the **Open list after completion check box** (set by default).

3. Create a new custom list

a. Click **Custom** . In the **Create New List dialog box** , enter the URL of the SharePoint site where you want to create the list.

b. Enter the name of the new list and its description in the **Enter a name for the new list** and **Description fields** .

c. To open the linked table after it is created, select the **Open list after completion check box** (set by default).

4. Import data from an existing list

a. Select **Existing SharePoint List** .

b. In the **Get External Data dialog box** , enter the URL of the SharePoint site that hosts the data you want.

c. Select the **Import source data into a new table in the current database radio button** and click **Next** .

d. Select the check box next to each SharePoint list you want to import.

5. Create a link to an existing list

a. Select **Existing SharePoint List** .

b. In the **Get External Data - SharePoint Site dialog box** , enter the URL of the SharePoint site that contains the list you want to connect to.

c. Select the **Connect to data source by creating a linked table radio button** and click **Next** .

d. Select the check boxes next to the SharePoint lists you want to link to.

Creating a table using a web service

You can create a table in your database that will connect to data on a website with a web service interface.

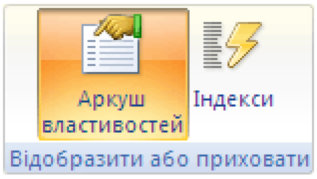
Note. Web service tables are read-only.

1. On the **External Data tab** , in the **Import and Binding group** , click **Advanced** , and then click **Data Services** .
2. If the required connection is already established, go to step 5. Otherwise, continue with the next step.
3. Click the **Set up a new connection button** .
4. Select the desired connection file and click **OK** .
5. In the **Create Web Services Data Connection dialog box** , expand the desired connection.
6. Fields will appear on the right side of the Access dialog box.
7. If necessary, enter the name of the linked table in the **Specify link name field** . Access will use this name for the linked table in the navigation pane.
8. Click the **OK button** . A linked table will be created in Access.

Assign table properties in a local database for desktop systems

You can set properties to apply to the entire table or to all records.

1. Select the table where you want to set the properties.
2. On the **Home tab,** in the **View group** , click the **View button** , and then click **Designer** .
3. On the Design tab, in the Show or Hide group, select Property Sheet.



4. In the properties window, select the **General tab** .
5. Click the box to the left of the property you want to set and enter the desired option for it. To view a list of table properties, select **Available table properties** .
6. Press Ctrl+S to save changes.

Table 5.2.

A list of table properties in MS Access and a description of their use.

Table property	**Using**
Display a view on a SharePoint site	Used to determine whether table-based views can be displayed on a SharePoint site.
data table is expanded	Used to expand all subtables after opening a table.

The height of the data subtable	Do one of the following: ● if you want the subtable window to expand to display all rows, leave this property at 0"; ● to control the height of the subtable , enter the desired height in centimeters.
Orientation	Used to set the display orientation according to the direction of reading the language: left-to-right or right-to-left.
Description	Description of the table. It will appear in the table tooltips.
Default view	Used to set **the Table View** , **PivotTable** , or **PivotChart view** as the default view when the table is opened.
Check rule	Used to enter an expression that must be true each time a record is added or modified.
Verification text	Used to enter the message that will be displayed if an entry conflicts with an expression in the **Validation Rule property field** .
Filter	Used to specify conditions to display only matching rows in the tabular data view.
Location for	Used to select one or more fields to define the default sort order for rows in a tabular data view.
The name of the data subtable	Used to specify whether the subtable should be displayed in the tabular data view window, and if so, to specify the table or query that will provide the rows for the subtable .
Link main fields	Used to list in a table or query the fields that are used for a subtable and that correspond to **the Link main fields property specified for the table** .
Link child fields	It is used to list the fields in the table that correspond to the **Link Child Fields property specified for the table** .
Filter when loading	It is used to automatically apply the filter conditions in **the Filter property** (by setting it to **Yes**) when the table is opened in the tabular data view window.
Order of location in case of download	It is used to automatically apply the sorting conditions in the **Arrange by property** (by setting it to **Yes**) when the table is opened in the tabular data view window.

Advice. Press Shift+F2 to open the help field for entering or editing the parameter value in the property field. **The Scale** window will appear .

If an expression is defined for the **Validation Rule property** and you need help creating it, click the button ... next to **the Validation Rule** property field to display the Expression Builder window .

Adding a field to a table in a local database

Each data item to be tracked is stored in a field. For example, the fields "Last name", "First name", "Phone number" and "Address" are created in the contact table. The "Product name", "Product code" and "PFig" fields are created in the product table.

Before creating fields, try to break the data into its smallest significant components. Over time, it will be much easier to combine data than to separate it. For example, instead of the field "P.I.B." It is worth creating separate fields "Surname", "First name" and "Patronymic". This will allow you to easily search or sort data by first name, last name, or both. If you plan to use the data element for reporting, sorting, searching, or calculation purposes, place it in a separate field. For more information about database construction and field creation, see link in section.

After you create a field, you can also set field properties to control its display and behavior.

In Access, you can create a new field by entering data in a new column in the data table window. When you create a field by entering data in a tabular data view, Access automatically assigns a data type to the field based on the data you entered. If other types of data cannot be entered for the value, Access sets the data type to text, but the data type can be changed.

Add a field using data entry

When you create a new table or open an existing table in the data table window, you can add a field to it by entering data in the **Click to add** table column.

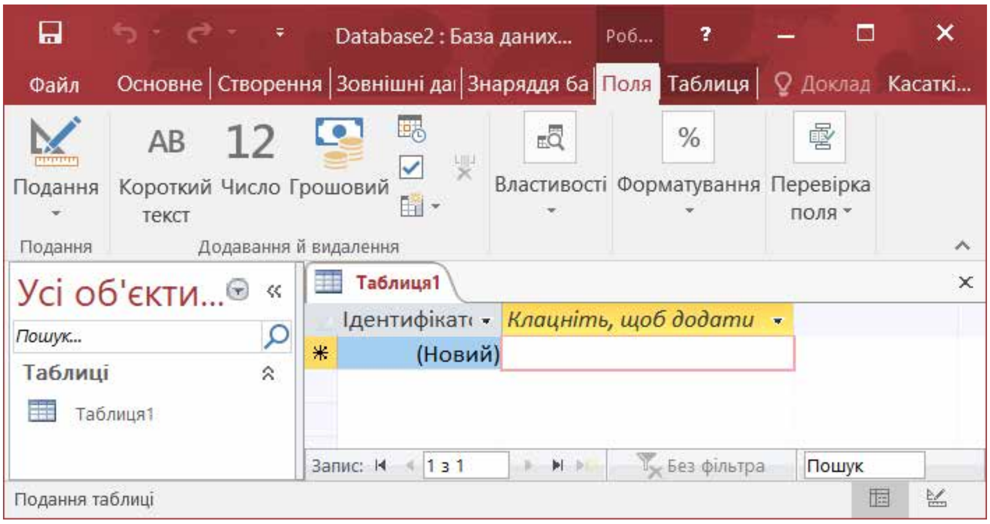


Fig. 5.15 - Entering data into a column *Click to add* .

To add a new field, do the following.

1. Create or open a table in the data tabular window.

2. In the **Click to add column,** enter the name of the field you want to create. Enter a descriptive name so the field can be easily recognized.
3. Enter the data in the new field.

Setting field properties

After creating a field, you can set its properties. This will allow you to control its display and behavior.

For example, setting field properties provides the following options:

- control the display of data in the field;
- avoid entering incorrect data in the field;
- specify the default value for the field;
- speed up the search and sorting of data in the field.

Some of the available field properties can be set while working in the data tabular window. However, to access the field's properties and define a complete list of them, you need to switch to designer mode.

Setting field properties in the data tabular window

While working in the tabular data view window, you can rename a field and change its data type, **Format property** , and some other properties.

- **Opening the table in the data tabular window** . In the navigation area, right-click the table and in the context menu, select the **Tabular data window item** .
- **To rename a field, do the following.** When you add a field by entering data in a data table window, Access automatically assigns a common name to the field. The first new field will be named "Field1", the second new field will be named "Field2", etc. By default, the field name is used as its label whenever the field is displayed, such as a table column header. To make fields easier to use when viewing or editing records, give fields more descriptive names.
- Right-click the header of the field you want to rename (for example, "Field1").
- In the context menu, select the **Rename field item** .
- Enter a new name in the field header.

Field names can be a maximum of 64 characters (letters or numbers), including spaces.

Change the data type of a field

When a field is created by entering data in a data table view, Access examines the data to determine the appropriate data type for the field. For example, if you enter **01/01/2006** , Access will interpret the data as a date and set the field to Date and Time. If Access cannot determine the data type for sure, it defaults to a text data type.

The data type of the field depends on what other field properties can be set. For example, for a field with a data type of Hyperlink or Memo, you can only set the **Append Only property** .

You may need to change the data type of the field manually in some cases. Suppose there are room numbers that resemble dates, such as "10/2001". If you enter **10/2001** in the new field in the data tabular window , the automatic data type detection function will select the data type "Date and Time" for the field. Because room numbers are signatures, not dates, they should be assigned a text data type. To change the data type of a field:

1. Go to the **Fields tab** .
2. In **the Formatting group,** in the **Data Type list** , select the desired data type.

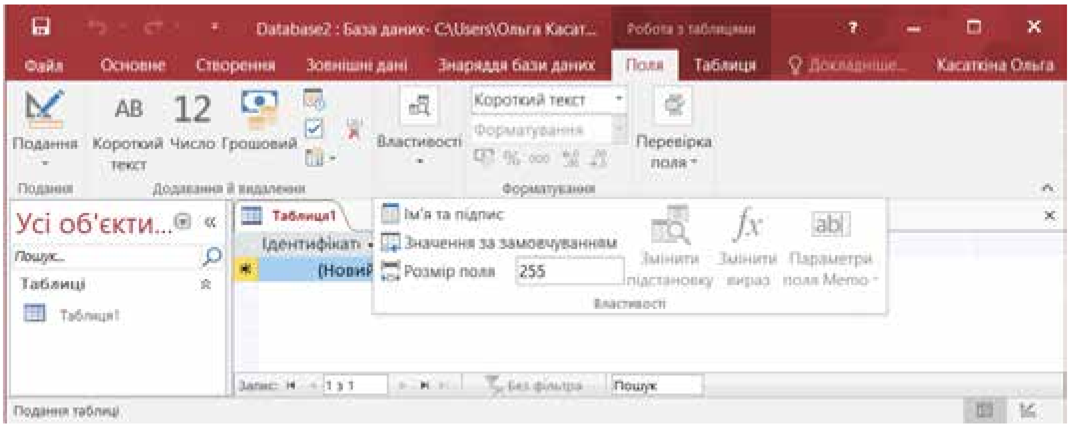


Fig. 5.16 - The Data Type and Formatting menu in MS Access 2016.

Changing the field format

In addition to determining the data type of a new field, Access can also set **the Format property of a field** based on the data you enter. For example, entering "10:50" would define the data type as "Date/Time" and set **the Format property** to "Average Time Format". To manually change **the Format** field property, follow these steps:

1. On the ribbon, click the **Field tab** .
2. In **the Formatting group,** in **the Formatting list** , select the desired format.

   Note. Depending on the data type of the field, **the Formatting list** may not be available for some fields (for example, for text).

Setting other field properties

1. In the data tabular window, select the field for which you want to set the property.

2. On the **Field tab,** in **the Formatting group** , select the desired properties.

Setting field properties

The calculated field is created in the designer mode.

- **Open the table in the designer mode in which you need to create a calculated field.** In the navigation area, right-click the table and select **Design Mode from the context menu** .
- **Change the data type of a field** Find the name of the field for which you want to set the data type, select **the Data type box** , and then select a data type from the list.
- **To set other field properties, do the following** . In the table layout grid, select the field for which you want to set properties. In **the Field Properties area,** enter the required settings for each property. Press Ctrl+S to save changes.

Note. The properties that can be set depend on the data type of the field.

Tables in Access web apps

The Access client enables developers to create and modify tables that will be stored on SQL Server. The information that Access needs to create and maintain the table and its properties, such as input masks, substitution information, and formatting, is stored in a system table (Access.ColumnProperties) in the user database.

5.5. Basic information about queries in MS Access.

A query makes it easy when you need to view, add, change, or delete data in an Access database. Here are some more reasons to use queries:

- quick data search using filtering according to certain criteria (conditions);
- calculating or summarizing data;
- automating data management tasks, such as periodically reviewing a dataset.

An on-premise Access database offers more querying options, but some of them (listed below) are also available in Access web applications (a new type of database created in Access and published online).

Note. To try using the queries in this example, you should use a local Access database.

Let's take a closer look at the following examples of creating and using queries in the Access program:

- with the help of queries it is easier to search for data and work with them ,
- creating a selective query ,
- viewing data from selected fields ,
- simultaneous viewing of data from several related tables ,
- creating a parameterized query ,
- defining the data type of the parameter ,
- creating a summary request ,
- performing calculations on the basis of data ,
- display of summary or aggregate data ,
- creating a consolidated query ,
- creating a request to create a table ,
- creating an add request ,
- creating an update request ,
- creating a deletion request .

Using queries makes it easier to find and work with data

If the database is structured correctly, the data that needs to be represented by a form or report is usually contained in several different tables. A query allows you to retrieve information from different tables and collect it for display in a form or query. A query can be a request to retrieve data results from a database, or a request to perform an action on the data, or both. With the help of a query, you can get an answer to a simple question, perform calculations, combine data from different tables, or add, change, or delete data from a database. Because of this versatility, there are many types of queries that can be created to suit the task at hand.

Creating a selective query

If you need to check data only in certain fields of a table, or view data from multiple tables at once, or simply view data based on certain conditions, you should use a select query.

View data from selected fields

For example, if you have a table in your database that contains a lot of product information and you need to view a list of products and their pFigs, you can create a select query that returns only the product names and their corresponding pFigs by following the procedure below.

1. Open the database, and on the **Create tab** , click **the Query Builder button** .

2. In the **Table Display dialog box** , on **the Tables tab,** double-click the **Products table** , and then close the dialog box.

3. Suppose that the table "Products" has the fields "Product name" and "PFig according to the pFig list". Double-click **the Product Name** and **List PFig fields** to add them to the inquiry request form .

4. On **the Design tab,** click the **Run button** . The request will start, then the list of products and pFigs will be displayed.

Simultaneous viewing of data from several related tables

Suppose, for example, there is a database for a store that sells products, and it is necessary to view the orders of customers who live in a certain city. Let's say that data about orders and customers is stored in two tables named, respectively, ``Customers" and ``Orders". Assume that each table has a customer ID field that forms the basis of a one-to-many relationship between the two tables. With the help of the following procedure, you can create a query that will return the orders of customers from a certain city, for example, Donetsk.

1. Open the database. On the **Build tab,** in the **Queries group** , click **the Query Builder button** .
2. In the **Table Display dialog box** , on **the Tables tab** , double-click **Customers** and **Orders** .
3. Close the **Table Display dialog box** . Notice the line (called a link) connecting the ID field in the Customers table to the Customer ID field in the Orders table. This line shows the relationship between the two tables.
4. In the Clients table, double-click **the Company** and **City fields** to add them to the inquiry form.
5. **City** column, clear the check box in the **Display row** .
6. In the **Criteria line of the City** column , enter **Donetsk** .
   If the **Display check box** is disabled, the city is not displayed in the query results, and the word **Donetsk** entered in **the Criteria line** indicates that only records with the value "Donetsk" in the "City" field should be displayed. In this case, the request returns only clients from Donetsk. You don't need to display a field to apply a criterion to it.
7. In the Orders table, double-click **the Order ID** and **Order Date fields** to add them to the next two columns in the query form.
8. On **the Design tab,** in the **Results group** , click **Run** . After completing the request, a list of orders for clients from Donetsk will be displayed.
9. Press CTRL+S to save the query.

Creating a parameterized query

If you need to use variants of a certain query often, it makes sense to use a parameterized query. When executing a parameterized query, you will be asked to specify field values. The values you specify will be used to create the query criteria.

Note. You cannot create a parameterized query in an Access web application .

Continuing the theme started in the previous example, which demonstrated the creation of a select query that returns orders for customers from Donetsk, the following procedure can be used to modify the select query so that it prompts for the city every time it is executed. For further consideration, you should open the database created in the previous example.

1. In the navigation area, right-click the query named **Out-of-town orders** (created in the previous section) and select the context menu item **Designer** .
2. On the request form, in **the Criteria line** in the "City" column, delete **Donetsk** and enter **[For which city?]** .

   The line **[For which city?]** is the parameter that you will be prompted to specify. The square brackets indicate that the parameter must be entered during the query, and the text (in this case: **For which city?**) is the question that will be displayed when prompted for the parameter value.

   Note. You cannot use a dot (.) or an exclamation mark (!) in the text of the hint.

1. Enable the check box in the **Display row** of the "City" column to display the city in the query results.
2. On **the Design tab,** in the **Results group** , click **Run** . A prompt will appear to enter the value of the "City" parameter.
3. Enter **Ivano-Frankivsk** and press Enter to view orders from customers in Kharkiv.

   And what if you don't know what value to enter? You can use generalization symbols as part of a hint.
4. On the **Home tab,** in the **View group** , click the **View button** , and then click **Designer** .
5. On the request form, in the **Criteria line of the City** column , enter **Like [To which city?]&"*"** .

   In this option prompt text, the keyword **Like** , the ampersand character (**&**), and the asterisk (*****) in quotes allow the user to enter a combination of characters, including wildcards, to return a string of results. For example, if the user enters * , the query will return all cities; if he enters **L** , the query will return all cities whose name begins with the letter "L"; if the user types *c* , the query will return all cities whose name contains the letter "c".

6. On **the Design tab** , in the **Results group** , click **Run** , and then in the query prompt, type **New** and press Enter .
   The request will be fulfilled, and the orders of customers from Ivano-Frankivsk will be displayed.

Defining the data type of the parameter

You can also define what data type the parameter should accept. You can set the data type for any parameter, but it is most important to set the data type for numeric and monetary data or date and time data. If the data type to be accepted by the parameter is specified, an error message will be displayed if the wrong data type is entered, for example, if a text data type is entered instead of the expected monetary one.

Note. If the parameter is set to text data, any data input is interpreted as text and no error message is displayed.

To determine the data type for a query parameter, follow the procedure below.

1. With the query open in Designer view, on the **Designer tab,** in the **Show or Hide group** , click **the Options button** .
2. In the **Query Parameters dialog box** , in the **Parameter column** , type a hint for each parameter for which you need to specify a data type. Make sure that each parameter matches the prompt used in the **Criteria line** of the request form.
3. In the **Data Type column** , select the data type for each parameter.

Create summary query

A summary row in the data in a tabular view is very useful, but for more complex questions, a summary query is used. A summary query is a selective query that allows you to group and summarize data, for example, if you want to display the total sales volume of a product. You can use the "Amount" function (aggregate function) in the summary request to display the total sales volume of goods.

Note. You cannot use aggregate functions in an Access web application.

To modify the product subtotals query created in the previous example to get product subtotals by product, follow the procedure below.

1. On the **Main tab,** click the **View button** , and then click **Designer** .
   In the designer view, a request for product summaries will open.
2. On the tab **Designer** in the group **to display or to hide** click element **Results** .
   Summary line will be displayed on the request form .
   Note. Despite their similar names, **the Summary form row** and the Data **Summary row** in a tabular view are not the same thing.

- You can group items by field values using the **Summary form line** .
- You can add a row of data to the results of a summary query in the **Summary tabular view** .
- When using the **Summary form row,** you must select an aggregate function for each field. If there is no need to perform field calculations, you can group by field.
- In the second column of the form, in the **Summary row** , select **the Sum function from the drop-down list** .
- On **the Design tab,** in the **Results group** , click **Run** . The query will run, then a list of products with subtotals will be displayed.
- Press CTRL+S to save the query. Leave the request open.

Perform calculations based on data

Typically, tables are not used to store calculated values such as subtotals, even if they are calculated based on data within the same database, because calculated values can become out of date if the values on which they are based change. For example, there is no need to store data about a person's age in tables, because this value needs to be updated every year. Instead, that person's date of birth is stored and then a query is used to calculate the person's age.

Let, for example, there is a database for some products that need to be sold. In this database, there is a table called "Order Details", which contains information about the product in fields such as the pFig of each product and requests. To calculate a subtotal, you can use a query that multiplies the quantity of each item by the unit pFig of that item, multiplies the quantity of each item by the unit pFig and discount for that item, and then subtracts the total discount from the item's total cost. If the previous example created a sample database, open it and do the following.

1. On **the Build tab,** click **the Query Builder button** .
2. In the **Table Display dialog box** , on **the Tables tab,** double-click **Order Details** .
3. Close the **Table Display dialog box** .

4. In the Order Details table, double-click the **Product ID item** to add this field to the first column of the inquiry form.
5. In the second column of the request form, right-click the **Field line and select the Scale** context menu item .
6. In the **Scale window** , type or paste the following expression:: **Summary: ([Quantity]*[Unit Cost])-([Quantity]*[Unit Cost]*[Discount])**
7. Click the **OK button** .
8. On **the Design tab,** click the **Run button** . The query will run, then a list of products and subtotals for each order will be displayed.
9. To save the query, press CTRL+S, and then name the query: **Product Summaries** .

5.6. Displaying summary or aggregate data

If tables are used to record transactions or regularly store numerical data, it is useful to be able to view such data as a whole, as sums or averages. In Access, you can add a "Summary" row to a data table. A totals row is a row at the bottom of a data table that can display a running total or other aggregate value.

1. Run a product summary query and leave the results open in the Data Table View.
2. On the **Main tab,** click the **Summary button** . A new row will appear below the data in the table view with the word **Summary** in the first column.
3. Click the cell in the last row of data in the table view labeled **Summary** .
4. Click the arrow to display the available aggregate functions. Since the column contains text data, there are only two options: **None** and **Number** .
5. Select **the Quantity item** . The content of the cell will change, and it will no longer be **the Total** , but the number of column values.
6. Click the adjacent cell (second column). A button with an arrow will appear in the cell.
7. Click on it and select the **Sum function** . The field will display the sum of the column values.
8. Leave the query open in the data tabular window.

Create a summary query

Now let's say you want to view product totals, but you also want to display month-by-month totals so that each row shows product totals and each column shows monthly totals. To display product totals and product totals for a month, use a cross query.

Note. The cross-reference query is not displayed in the Access web application.

You can change the product totals query again so that the query returns product totals rows and monthly totals columns.

1. On the **Home tab,** in the **View group** , click the **View button** , and then click **Designer** .
2. In the **Query Customization group** , click the **Show Table button** .
3. In the **Table Display dialog box** , double-click **Orders** , and then click **Close** .
4. On the tab **Designer** in the group **Request type** click element **Cross table** On the form, the line **Display** is hidden , and the line **is crossed table** is displayed .
5. In the third column of the form, double-click the **Field line with the right mouse button and select the Scale...** context menu item . **The Scale** field will open .
6. In the **Scale window** , type or paste the following expression: **Month: "Month" & DatePart ("m", [OrderDate])**
7. Click the **OK button** .
8. In **the Crosstab row** , select the following values from the drop-down list: **Row Heading** for the first column, **Value** for the second column, and **Column Heading** for the third column.
9. On **the Design tab,** in the **Results group** , click **Run** . The query will run, then the subtotals for the month will be displayed.
10. Press CTRL+S to save the query.

Creating a request to create a table

You can use the create table query to create a new table based on data stored in other tables.

Note. The table creation query is not available in Access web applications.

For example, you need to send data for Chernihiv orders to a business partner in Chernihiv who uses Access to prepare reports. Instead of sending all the order data, you need to send only the data related to the Chernihiv orders.

You can build a select query that contains the Chernihiv orders data and then use it to create a new table by following the procedure below.

1. Open the example database from the previous example.
   You may need to enable database content to execute a query to create a table.
   Note. If you see a message under the ribbon about enabling the database, select the **Enable Content option.** If the database is already in a trusted location, the message line will not be displayed.
2. On the **Build tab,** in the **Queries group** , click **the Query Builder button** .
3. In the **Table Display dialog box** , double-click **Order Details** and **Orders** , and then close the **Table Display dialog box** .
4. In the **Orders table** , double-click **the User ID** and **Shipping City fields** to add these fields to the form.
5. In the **Order Details table** , double-click **the Order ID** , **Product ID** , **Quantity** , **Unit PFig ,** and **Discount fields** to add these fields to the form.
6. In the column of **the Delivery City form** , clear the check box in the **Display line** . In **the Criteria line,** enter **'Chernihiv'** (in single quotes). Check the query results before using them to create a table.
7. On **the Design tab,** in the **Results group** , click **Run** .
8. Press Ctrl+S to save the query.
9. In the **Request name field,** enter **Request for orders from Chernihiv** and click the **OK button** .
10. On the **Home tab,** in the **View group** , click the **View button** , and then click **Designer** .
11. On the tab **Designer** in the group **Request type** click element **Creation tables** .
12. In the **Create Table dialog box, in the Table Name** field , enter **Order from Chernihiv** and click the **OK button** .
13. On **the Design tab,** in the **Results group** , click **Run** .
14. In the confirmation dialog, click **Yes** and see the new table that appears in the navigation area.
    Note. If a table with the specified name already exists, it will be deleted in Access before the query is executed.

Create an add request

You can use an append query to retrieve data from one or more tables and add it to another table.

Note. Add request is not available in Access web applications **.**

Suppose, for example, that a joint table with a business partner from Chernihiv was created, but it is known that he also works with clients from Donbas. You need to add rows to the table that contain data about Donbass before giving the partner shared access to the table. This is how you can add data about Donbas to the "Orders from Chernihiv" table.

1. In the "Designer" view, open the request with the name "Request for orders from Chernihiv".
2. On the tab **Designer** in the group **Request type** click element **Adding** . It will open dialogic window **Adding** .
3. In the **Add dialog box** , click the arrow button in **the Table Name field** and select the **Order from Chernihiv drop-down list item** , and then click **OK** .
4. On the form, in the **Criteria line** of the "Delivery city" column, delete "Chernihiv" and enter **"Donbas"** .
5. In the **Add to row,** select the appropriate field for each column.
   In this example, the value of the **Append to string** must match the value of the **Field string** , but this is not necessary for the append query to work.
6. On **the Design tab,** in the **Results group** , click **Run** .
   Note. When running a query that returns a large amount of data, you may receive an error message stating that you cannot cancel the query. To ensure that the request is fulfilled, try increasing the memory segment limit to 3 MB.

Create an update request

You can use an update request to change data in tables. You can also use this query to enter criteria to determine which rows to update. An update request provides an opportunity to view the updated data before performing the update.

WARNING! A change request cannot be canceled. You need to back up the table that will be updated using the update request.

Note. An update request is not available in Access web applications.

In the previous example, you added rows to the "Orders from Chernihiv" table. In this table, the Product ID field displays the numeric product ID. To make the data more reportable, you can replace product IDs with product names. To do this, you should do the following.

1. Open the "Orders from Chernihiv" table in the designer view.
2. In the "Product ID" line, change the data type from **Number** to **Text** .
3. Save and close the "Orders from Chernihiv" table.
4. On the **Build tab,** in the **Queries group** , click **the Query Builder button** .
5. In the **Table Display dialog box** , double-click the **Orders from Chernihiv** and **Products items** , and then close the **Table Display dialog box** .
6. On the tab **Designer** in the group **Request type** click element **Update** .
7. **The Sort** and **Display** lines will disappear on the form , and **the Update to line will appear** .
8. In the **Orders from Chernihiv table** , double-click the **Product ID item** to add it to the form.
9. On the form, in the **Update line to the Product ID** column , type or paste: **[Products].[Product Name]**

   Advice. You can use an update request to remove field values with an empty string (**""**) or a NULL value in the **Update to line** .
10. In **the Criteria line** , type or paste: **[Product ID] Like ([Products].[ID])**
11. In the data tabular window, you can see which values will be changed by the update request.
12. On **the Design tab,** click **View** > **Table View** . The query will return a list of item IDs to be updated.
13. On **the Design tab,** click the **Run button** .

    When opening the "Orders from Chernihiv" table, the numerical values in the product identifier fields will be replaced by the product names from the "Products" table.

Create a removal request

To delete data from tables, you can use a delete request. With the delete query, you can also enter criteria to determine which rows to delete. The delete request provides an opportunity to view the rows to be deleted before the deletion is performed.

Suppose, for example, that while preparing to send the "Orders from Chernihiv" table from the previous example to your business partner from Chernihiv, it turned out that some rows contain several empty fields. You chose to delete these rows before submitting the table. You can simply open the table and delete the rows manually, but if there are a lot of rows and you have clear criteria to determine which rows to delete, it may be more convenient to use a delete request.

You can use the request to delete rows from the "Orders from Chernihiv" table that are not relevant for the order ID, following the procedure below.

1. On **the Build tab,** click **the Query Builder button** .
2. In the **Table Display dialog box** , double-click the **Order from Chernihiv item** and close the **Table Display window**
3. On the tab **Designer** in the group **Request type** click element **Delete** On the form **the Sort** and **Display** rows will disappear and the **Delete** row will appear .
4. In the **Orders from Chernihiv table** , double-click **the Order ID field** to add it to the form.
5. On the form, in **the Criteria line** of the Order ID column, enter **Is Null** .
6. On **the Design tab,** in the **Results group** , click **Run** .

4.7. General information about reports in Access

With reports, you can view, format, and summarize data. For example, you can create a simple report that will show the phone numbers of all your contacts, or a summary report of sales data in different regions and for different time periods.

This section provides an overview of reports in Access. It also provides an overview of how to create a report and use options such as sorting, grouping, and summarizing data, as well as how to preview and print the report.

A report is a database object that is convenient to use to present information in a database for any of the following purposes.

- Display or distribute a summary of data.
- Archive snapshots of data.
- Providing detailed information about individual records.
- Creating signatures.

Parts of the report

Although you can create free reports that do not contain data, this article will use a report that is bound to a data source, such as a table or a query. According to its structure, the report is divided into sections that can be viewed in the designer mode. Understanding how each section works will help you create even better reports. For example, the part that houses the calculated control determines how Access calculates the results. The table below describes the types of parts and their purpose.

Table 5.3.

Description of types of report parts and their purpose.

Section	Section display when printing	The place of use of the section
Header of the report.	At the beginning of the report.	A report header is used for data that would normally appear on the title page, such as logos, names, or dates. If you place a calculated control that uses the Sum aggregate function in the report header , the sum will be calculated for the entire report. The report header is printed first, followed by the page header.
Page header.	At the top of each page.	The page header is used to repeat the report title on each page.
header .	At the beginning of each new group of records.	The group header is used to print the name of the group. For example, in a report grouped by products, the group header is used to display the product name. If you place a calculated control that uses the Sum aggregate function in the group header , the sum will be calculated for the current group. Depending on the number of grouping levels, the report may contain several parts with a group header. For more information on creating group headers and footers, see in the section on adding grouping, sorting, and summarization.
Details	Appears once for each row in the record source.	This is where the controls that make up the body of the report are placed.
Group footer.	At the end of each group of records.	The group footer is used to display summary data for the group. Depending on the number of grouping levels, the report may contain several parts with a group footer.
Page footer.	At the end of each page.	A page header is used to print page numbers or information that pertains to each page.
Report footer.	At the end of the report. **Note** In design mode, the report footer is placed below the page footer. But when printing or previewing,	The report footer is used to print summaries or other summary data for the entire report.

Section	Section display when printing	The place of use of the section
	the report footer will be placed *above the page* footer , just after the last group footer, or after the detail row on the last page.	

Creating meaningful reports is much easier when the database has a well-designed table structure and well-defined relationships.

Creating a report

Follow the steps below to generate reports for your local Access database.

Step 1. Selection of the recording source

The record source can be a table or a named or built-in query. The record source must contain all the rows and columns from which data is to be added to the report.

- If the data you want came from an existing table or query, select that table or query in the navigation pane and go to step 2 .
- If the record source has not yet been created, do one of the following:
  Go to step 2 and use **the Blank Report tool**

  Or
- Create a table(s) or query with the required data. Select a query or table in the navigation area and go to step 2 .

Step 2. Choosing a reporting tool

The tools for creating reports are located on the **Create tab** in **the Reports group** . The parameters are described in the table below.

Table 5.4.

Tools for creating reports and their parameters.

Instrument	Description
Report	Creates a simple tabular report that contains all the fields of the record source selected in the navigation pane.
Report Builder	Opens a blank report in design mode. You can add fields and controls to this report.
Blank report	Opens a blank report in layout view and opens a field list from which you can add fields to the report.
Report Wizard	Launches a step-by-step wizard where you can specify fields, grouping/sorting levels, and layout options.

Instrument	Description
Signatures	Launches a wizard where you can choose a standard or custom signature size, and specify which fields to display and how they should be sorted.

Step 3. Creating a report

1. Click the button of the desired report. If the wizard starts, follow its instructions and click **Finish on the last page** .
2. Access displays the report in the Layout view.
3. Format the report as needed.
   - o Resize fields and labels by dragging their edges.
   - o Drag the field to another location.
   - o Right-click a field and select the appropriate command from the context menu to split or merge cells, delete or select fields, or perform other formatting.

In addition, with the help of the functions described in the following sections, the report can be made even more attractive and convenient to read.

Grouping, sorting and summarizing

The fastest way to add grouping, sorting, or summarization to a local database report is to right-click the desired field and select the appropriate command from the context menu.

Grouping, sorting, and totaling can also be added using the Grouping, Sorting, and Totaling panel when the report is open in markup or design mode:

1. To open this panel, click **the Design tab** , and in **the Grouping and Summarizing group,** click **the Grouping and Sorting button** .
2. Click **the Add Group** or **Add Sort button** , and then specify the field by which you want to group or sort.
3. To specify additional parameters and add summaries, click **the Expand button in the grouping or sorting row** .

Selection of data with conditional formatting

Access includes tools for highlighting data in a report. You can add conditional formatting rules for each control or a group of such controls, and in client application reports, you can also add histograms for comparing data.

Add conditional formatting to controls

1. Right-click the report in the Navigation Pane and select **Layout View** .

2. Select the controls that you want, and then on the **Format tab** , in the **Control Formatting group** , click **the Conditional Formatting button** .

Advice. To select multiple controls, hold down the Ctrl key while selecting the controls .

3. In the **Conditional Formatting Rule Manager dialog box** , click the **Create Rule button** .

4. In the **New Formatting Rule dialog box** , in the **Choose Rule Type area** , select the value you want.

- To create a rule that will be calculated for each record individually, select **Check values in the current record or Use expressions** .
- To create a rule that compares records with each other using histograms, select the **Compare with other records value** .

1. In the **Change rule description area** , specify the rule that will determine when and what formatting should be applied, and then click **OK** .

2. To create an additional rule for the same control or set of controls, repeat this procedure starting at step 4.

Customizing color and fonts

Try using the **App Theme options** to customize the color and fonts.

1. Open the report in markup mode by right-clicking the report in the navigation pane and selecting **Markup Mode** .

2. In the **Report Layout Tools options group, on the Design** tab , click **the Themes button** . Hover over different themes in the collection to view the effects. To select a topic, click it, then save the report.

3. in the **Colors** and **Fonts collections** .

Adding a logo or background image

You can add a logo or background image to the report. When this image is updated, it will be updated in all places where it is used in the database.

Add or remove an image

1. In the Navigation Pane, right-click the report, and then click **Layout View** .

2. In the report, click the position where you want to add the image, and then on **the Design tab, in the Footer** group, click **the Logo button** .

3. Navigate to the image and click the **Open button** . Access will add the image to the report.

4. To delete an image, right-click the image and select Delete from the context menu.

Adding a background image

1. In the Navigation Pane, right-click the report, and then click **Layout View** .
2. On **the Design tab,** in the **Background group** , click **the Background Pattern button** .
3. Select an image from **the Image Collection list** , or click **Browse** , select an image, and then click **OK** .

Preview and print the report

Preview

1. Right-click the report in the navigation pane and select **Preview** . Using the commands on the **Preview tab** , you can perform the following actions:
   - print the report;
   - change page size or layout;
   - zoom in or out or view multiple pages at the same time;
   - update the data in the report;
   - export the report to a file of another format.
2. Click the **Close window button.**

Print the report

Print report without preview

1. Right-click the report in the navigation pane and select Print. The report will be sent to the default printer.

Note. If you select a report in the navigation pane and select **Print** on the **File tab** , you can set additional print options, such as the number of pages and copies, and specify the printer.

2. Click the Print button to open a dialog box where you can select a printer, specify the number of copies, and more.

5.8. Creating an Access form

The form is an analogue of a window in a store, which allows you to easily browse and choose the products you need. Because forms are objects that users can use to add, edit, or display data stored in a Microsoft Access database, the structure of the form is an important consideration. If the database is expected to be accessed by multiple users, properly designed forms are critical to efficient and accurate data entry.

There are several ways to create a local Access database form, the most common of which are described in this article.

Creating a form from an existing table or query

To create a form from a database table or query, in the Navigation Pane, click the table or query that contains the data for the form, and then on the New tab, **click** Form **.**

Access will create a form that will appear in the Layout view. If necessary, you can change the structure, for example, adjust the size of the text fields according to the amount of data.

Creating an empty form

1. To create a form with no controls or preformatted elements, on the **Design tab,** click **the Blank Form button** . Access will open a blank form in the Layout view and display the **Field List area** .
2. In **the Field List area** , click the plus sign (+) next to one or more tables that contain fields that you want to appear on the form.
3. To add a field to a form, double-click it or drag it onto the form. To add multiple fields at once, hold down the Ctrl key , click multiple fields, and then drag them all together onto the form.

Note. The order of the tables in the **Field List area** can change depending on which part of the form is currently selected. If you can't add a field to a form, try selecting another part of the form and then add the field again.

1. Use the tools in the **Controls group** on the **Form Layout Tools tab** to add a logo, title, page count, or date and time to your form.
2. If you want to add a wider variety of controls to your form, select **the Design tab** and use the tools in **the Controls group** .

Creating a split form

A split form allows you to simultaneously view data in two views:

– in form submission
– in the data tabular window.

Working with split forms allows you to take advantage of two types of forms in one form. For example, you can use a table view to quickly find a record, and then a form view to view and edit that record. These two views are connected to the same data source and are constantly synchronized with each other.

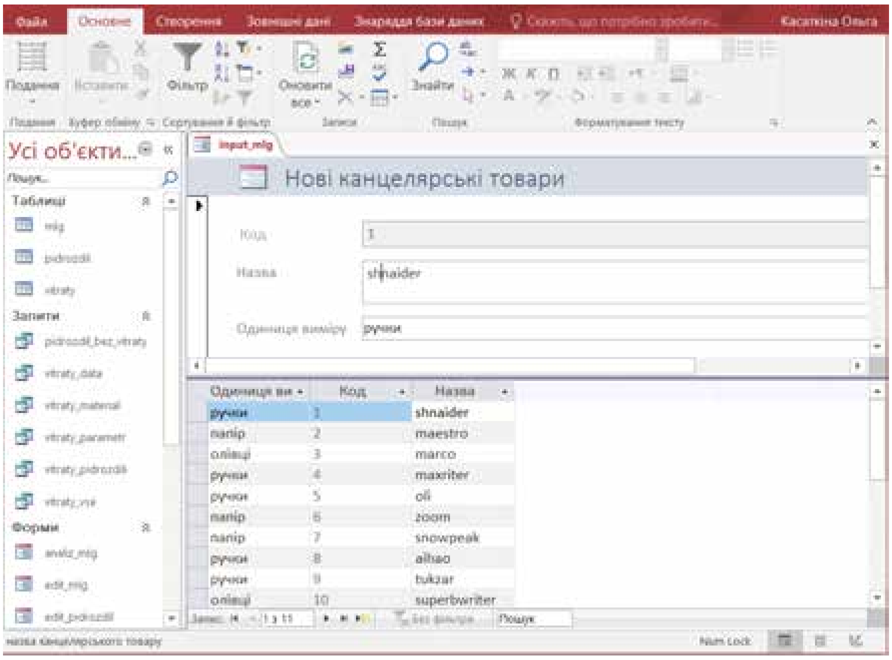


Fig. 5.17 - Working with a split form in MS Access 2016.
The picture shows a form for entering new stationery items. The form has fields for the item code, name, unit pFig, and quantity. The user can enter data into these fields and then save the information to the database.

To create a new split form using the Split Form tool, in the Navigation Pane, click the table or query that contains the data for the form, and then on the **New tab** , click **More Forms** , and then click **Split Form** .

Access creates a form whose structure you can change. For example, you can adjust the size of the text fields according to the amount of data if necessary.

Create a form that displays multiple records

A multi-item form, also known as a continuous form, is convenient to use if you need to display multiple records on the form, but have more customization options than data in a table view, you can use the Multi-item tool.

1. In the navigation pane, click the table or query that contains the data you want to display on the form.
2. On the **Create tab,** click **Advanced Forms** > **Multiple Elements** .

Access will create a form that will appear in the Layout view. In layout view, you can change the layout of the form while displaying data in it. For example, the size of text fields can be adjusted according to the amount of data.

Create a form that contains a subform

When working with related data stored in separate tables, there is often a need to view data from multiple tables or queries in a single form. For this, it is convenient to use subforms . Subforms can be added in a variety of ways, depending on your needs.

Creating a navigation form

A navigation form is a regular form that contains a navigation control. Navigation forms are a great addition to any database, but if your database is going to be published online, creating a navigation form is especially important because the Access navigation area is not visible in the browser.

1. Open the database to which you want to add the navigation form.
2. On the **New tab,** in **the Forms group** , click **the Transitions button** , and then select the desired navigation form style.

Access will create the form, add a navigation control to it, and display the form in the Layout view.

String functions and their use

You can use string functions to create expressions for a variety of text operations. For example, you may want to display only part of the serial number on a form, or combine multiple lines such as last name and first name.

Table 5.5.

A list of the most commonly used string operations and the functions used to perform them.

Action	Function	Example	The results
Returns characters from the beginning of a string	Left function	= Left ([Serial_Number],2)	If [Serial_Number] is "CD234", the result is "CD".
Returns characters from the end of a string	Right function	= Right ([Serial_Number],3)	If [Serial_Number] is "CD234", the result is "234".

Action	Function	Example	The results
Determining the position of a character in a line	InStr function	= InStr (1,[Name],"about")	If [Name] is "Mykola", the result is 4.
Returns characters from the middle of a string	Mid function	= Mid ([Serial_Number],2,2)	If [Serial_Number] is "CD234", the result is "D2".
Remove spaces at the beginning and end of a line	Functions LTrim , RTrim and Trim	= Trim ([Name])	If [Name] is "Mykola", the result is "Mykola".
Joining two lines	The plus sign operator (+)*	=[First Name] + [Last Name]	If [First Name] is "Mykola" and [Last Name] is Voloshyn, the result is " Mykola Voloshyn "
Joining two lines with a space between them	The plus sign operator (+)*	=[First name] + " " + [Last name]	If [First Name] is "Mykola" and [Last Name] is Voloshyn, the result is "Mykola Voloshyn"
Change the string case to lower or upper case	UCase function or LCase function	= UCase ([Name])	If [Name] is "Mykola", the result is "MYKOLA".
Determination of string length	Len function	= Len ([Name])	If [Name] is "Mykola", the result is 6.

* This is not actually a function, but an operator. However, this is the fastest way to concatenate strings. In a desktop database, you can also use the ampersand (&) operator to join. You must use the plus sign (+) in the Access web application.

Access has many other text-related features. To learn more about them, open the expression builder and view the list of functions. The Expression Builder is available almost every time you need to build a function. Most of the time, you'll see a small **Build** button that looks like this: .

To explore the Expression Builder , open it from the **Source property of a control** on a form or view. Use one of the methods below, depending on whether you are using a desktop database or an application.

Displaying the expression builder in a desktop database

1. Open the desktop database (ACCDB).
2. Press F11 to open the navigation pane if it is not already open.
3. If the form is already available, right-click it in the Navigation Pane and select **Markup Mode** . If there is no ready-made form, on the **Create tab** , click **the Form button** .
4. Right-click the text box on the form and select **Properties** .
5. In the property sheet, select **All** > **Control Source** and click **Build** on the right side of the **Control Source property field** .

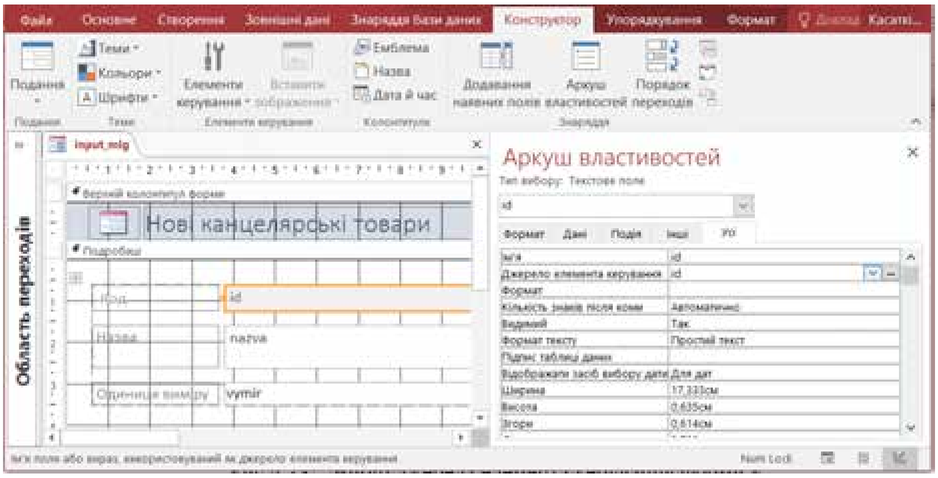


Fig. 5.18 - Selection of the source of the control element of the form.

6. Under **Expression Elements,** expand the **Functions node** , and then click **Built-in Functions** .
7. In **the Expression Categories section** , select **Text** .
8. In the **Expression Values section** , choose different functions and read the brief description at the bottom of the expression builder .

   Note. Different functions are available for different situations. Access automatically filters the list based on which functions will work in a particular situation.

Display the Expression Builder in an Access web application

1. Open the web app in Access. If you're viewing it in a browser, choose Options > Preferences **in Access** .
2. Click a table in the left column, and then click the view name to the right of the list of tables.

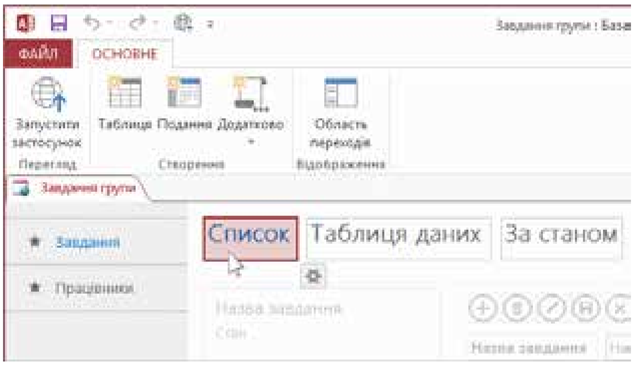
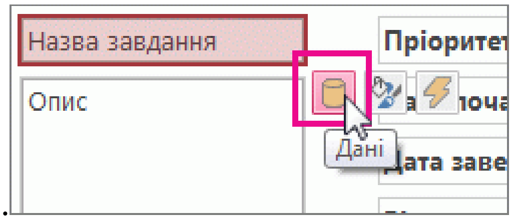


Fig. 5.19 - Selecting a view in the list of MS Access tables.

3. Select **Edit** , click the text box, and click the **Data button** that appears next to the text box



4. Click **the Build button** to the right of **the Control Source drop-down list** .
5. Under **Expression Elements,** expand the **Functions node** , and then click **Built-in Functions** .
6. In **the Expression Categories section** , select **Text** .
7. In the **Expression Values section** , choose different functions and read the brief description at the bottom of the expression builder .

Practical work no 13. Creation of databases. Work with tables .

The purpose of the work : to master the practical skills of creating databases, working with tables.

Work execution program

1. Download Access .
2. Consider the project of the database "Students" from the assignment for practical work. Explain the expediency of creating the specified tables.
3. Create a "Students" database.
4. Create using the database table constructor according to the task for practical work.
5. Enter data in the table in editing mode.
6. View entered table data.
7. Save the database.

Tasks for practical work

Create a database for processing information on university students. When filling out the database tables, take arbitrary data. The number of objects in the main database table must be at least 10, and in the additional ones - at least 5. The structure of the "Students" database tables:

- **Students** (Last name , First name, Patronymic name, Year of birth, Faculty code, Specialty code, Group, Course, Year of enrollment, Region code, Address, Place of residence) - main table;
- **List of faculties** (Faculty code, Faculty name);
- **List of specialties** (Specialty code, Specialty name);
- **Composition of faculties** (Faculty Code, Specialty Code);
- **List of groups** (Group code, Faculty code, Group name,);
- **List of regions** (Region Code, Name).

Theoretical information

A database (DB) is a systematized repository of information. A telephone directory is an excellent example of a database. Databases are created in cases where it is necessary to track, analyze and store information over a period of time.

A database management system (DBMS) is a program whose main functions are the creation of a database structure, recording, searching, sorting, processing (analysis) and printing of information stored in the database.

In a computer database, information is presented in the form of a table, very similar to a spreadsheet. The names of the columns are *the names of the fields* , and the columns themselves are *the fields* . Rows of data are called *records* .

Microsoft Access is one of the simpler relational database management systems that is part of Microsoft Office . Working with Access , you can solve the following tasks:

- break the data into logically connected parts;
- enter, edit and find the necessary data;
- find a lot of data according to the given conditions;
- create forms and reports;
- automate the performance of standard tasks;
- graphically establish a relationship between data;
- insert pictures into forms and reports;
- create your own programs with menus, dialog boxes and command buttons that are ready to work with the database.

Database design

Before starting to create tables, forms and reports, it is necessary to spend some time designing the database. Focus your attention on data, performers and tasks. Some tips to follow when designing a database:

- Start by analyzing an existing database (manually or computer generated). Review the forms and reports used. Determine the source of the data (if it is a computer, consider the possibility of importing data). Talk to people who use information from the database, discuss the problems and wishes that arise in connection with this. Review the problems that are solved with the help of the database and think about the ones that need to be solved in the future.
- Identified the data and tasks that need to be solved, divided them into groups. These groups will later become tables.
- Determine the types of data that will be stored in each table. These groups of table data are called *fields* .
- View common elements of the tables (for example, the name of the customer can be a common element of the customer table and the invoice table). These common elements are called *key fields.*
- Consider designing forms and reports.
- Define selection criteria for queries.

- Consider how to automate standard database tasks such as running queries and printing reports.
- Consider data security issues such as backup strategy, data sharing, and access restrictions when working on a network.
- in this subject area

Thus, the result of the database design process is the distribution of data by tables, the structure of tables, establishing the connection of tables (definition of fields for connection).

Getting started with Access

To download Access , you need to execute the command: " **Start"** **" Programs "** **" Microsoft Access "** . In the window that appears, you can create a new database and open a previously created database.

Creating a new database

After selecting the " **New desktop database" item** , you must specify the name of the database and its location (disk, folder). After clicking the " Create" button, a file with the extension . acc db . A database window with a list of database objects (tables, queries, forms, reports, pages, macros, modules) will appear on the screen.

The database window has roots for each type of database object. If we select an object type, for example, a table, a list of database table names appears on the screen. To open the required object, double-click on its name or select the name and select the "Open" command from the context menu.

To create new database objects or modify existing database objects, use the "Create" menu.

Database objects

Tables are a place to store data. The table consists of rows and columns. Each column has its own format. Tables can be created and edited.

Queries are used to filter and select data. During their operation, you can link tables, which allows you to create complex tables from a series of small ones or from large tables to make small ones. Thus, an analogue of additional (virtual) tables is created, which are only in the computer's memory.

Forms allow you to create an interface that allows users to work with tables in a more convenient way. The form is created based on tables and queries.

Reports are a tool for displaying data on the screen or for printing in a convenient form. Reports are created based on queries and tables.

Macros are an automation tool that allows you to use ready-made commands to create a sequence of execution.

Modules are software procedures for organizing more functional process management than macros. They are created using the VBA language.

Tables

You can perform operations on database tables: creation, editing, deletion.

After designing and creating a database, the next step is to create tables to store data. To do this, select the "Create" menu and select one of the table creation methods in the "Tables" group:

- empty table (by entering data);
- in designing mode;
- letters SharePoint .

One of the main characteristics that must be specified when creating tables is the type of data.

<u>*Data type definition*</u>

The data type defines the type of information that is stored in the field. When you specify a field's data type, Access knows not only what data can be stored in that field, but also how much space to reserve for it.

Access provides the following basic data types:

- **Numerical** . Any type of numbers. They are used in calculations.
- **Text** . Text or numbers that do not require calculations (maximum number of characters 255).
- **MEMO field.** Long text or a combination of text and numbers (up to 65535 characters/64 Kbytes).
- **Date/Time** Date and time relative to years from 100 to 9999 inclusive (8 bytes).
- **Pecuniary.** Monetary values and numerical data used in mathematical calculations with an accuracy of up to 15 whole digits and up to 4 digits after the decimal point.
- **Counter.** Unique sequentially increasing by 1 or random numbers that are automatically entered Access when adding each new record to the table. The value of counter type fields cannot be updated.
- **Logical.** The fields contain one of two logical values in 1 bit (True / False , Yes / No).

- **An OLE object field.** An object (for example, a Microsoft Excel table, a Microsoft Word document, a picture or other data in binary format) is linked or " embedded " in a Microsoft Access table (up to 1 GB).
- **Master of substitutions.** A field is created that offers a selection of values from a list, or from a field with a list that stores a set of constants or values from another table.
- **Hyperlink.** A string of letters and numbers, which is the address of the hyperlink.

When you create a field, Access will automatically prompt you to make it text. But you can change the field type using a list.

Setting a field property

Fields are characterized by properties that determine the way data is stored and displayed. Field properties are automatically transferred to other database objects that use this table - forms, reports, queries. In the " Field Properties " tab of the " Table " window, the following properties are indicated:

- **"Field size"** . Specifies the size of text fields by a specified number of characters; limits numeric fields to a specified range of values.
- **"Field format"** . Specifies the specified format for displaying dates and numbers.
- **"Number of decimal places"** . Sets the number of decimal places in type fields *Numerical* and *Monetary* .
- **"Input mask"** . Sets (only for Text and Memo fields) formatting characters , such as "-" in phone number fields, to be filled in automatically during data entry.
- **"Field signature"** . The label used in forms and reports instead of the field name.
- **"Default value"** . Sets the initial value that is automatically entered in the new record.
- **"Condition for value"** . Limits data entry to values that meet previously specified conditions.
- **"Required field"** . It is set for data that must be entered.
- **"Empty lines"** . Allows fields of type " *Text* " and " *Memo* " to have a term of zero length (""). By default, Access does not store these dates.
- **" Indexed field"** . Sets an additional index that is based on the specified field. Indexes help Access find the values it needs. An index for primary key

fields is automatically created and maintained. If you need to frequently search or sort on some fields, you can significantly increase the search speed thanks to this property of the field. Indexes can be set to fields of all types, except for attached and “ embedded ” OLE , Memo and logical type objects. The list of all field indexing possibilities is in the line of this property.

Control questions

1. What is the purpose of the database design stage?
2. Define characteristics of data types?
3. What is the purpose of table fields and their characteristics?
4. Describe database objects?
5. Determine the possibilities of working with database tables?

Practical work No. 14 . Using forms in databases .

The purpose of the work : to master the skills of building forms and their use in database management.

Work execution program

1. Download Access .
2. Create forms for filling in the tables of the "Students" database using the wizard.
3. Edit forms in Designer mode:
   - insert the name of the form;
   - replace the name of the fields with the Ukrainian language;
   - for some fields, set precision and additional parameters for input;
   - set a formula for calculation fields.
4. Enter the data in the table according to the form.
5. Save the work results.
6. Search for students according to the conditions of data matching of some fields, for example, faculty, date of birth - year, region).

Theoretical information

Forms are used for the convenience of the user when working with the database (viewing, entering, managing and printing data). More often, they are created to simplify entering and viewing data in database tables.

Form creation

Select the "Create" menu and use the Form Wizard in the "Forms" group. First, we select the table for which we are creating a form, and then in the window that appears, using the arrow buttons, we transfer the fields necessary for the form to the " Selected fields" object.

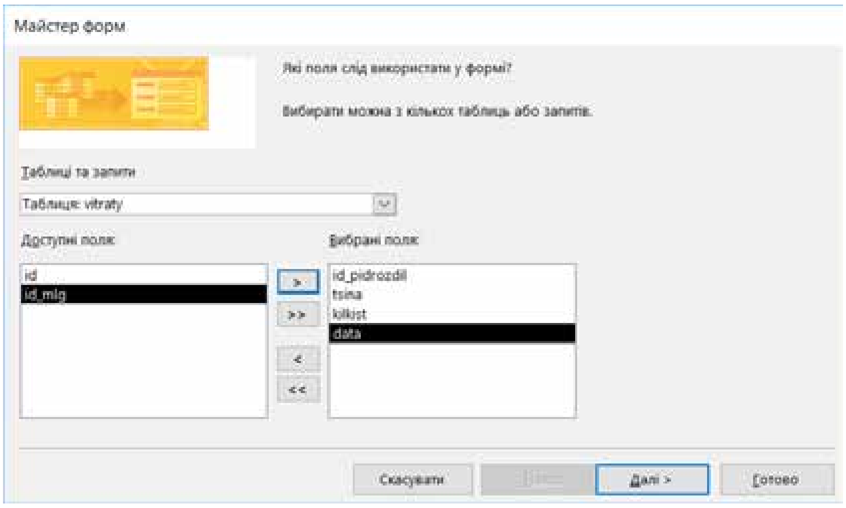


Fig. 5.20 - Selection of fields when creating a form in MS Access .

For example, the form (table type or ribbon type) for working with the **Subdivision table** looks like this:

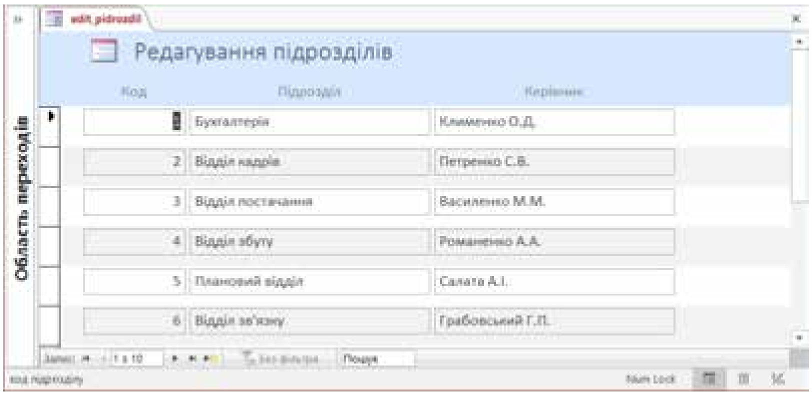


Fig. 5.21 - View of the created form in MS Access .

Editing the form

To make changes to a previously created form, select a specific form and click the "Designer" button. On the screen we will see the layout of the form, which can be changed to a more user-friendly one.

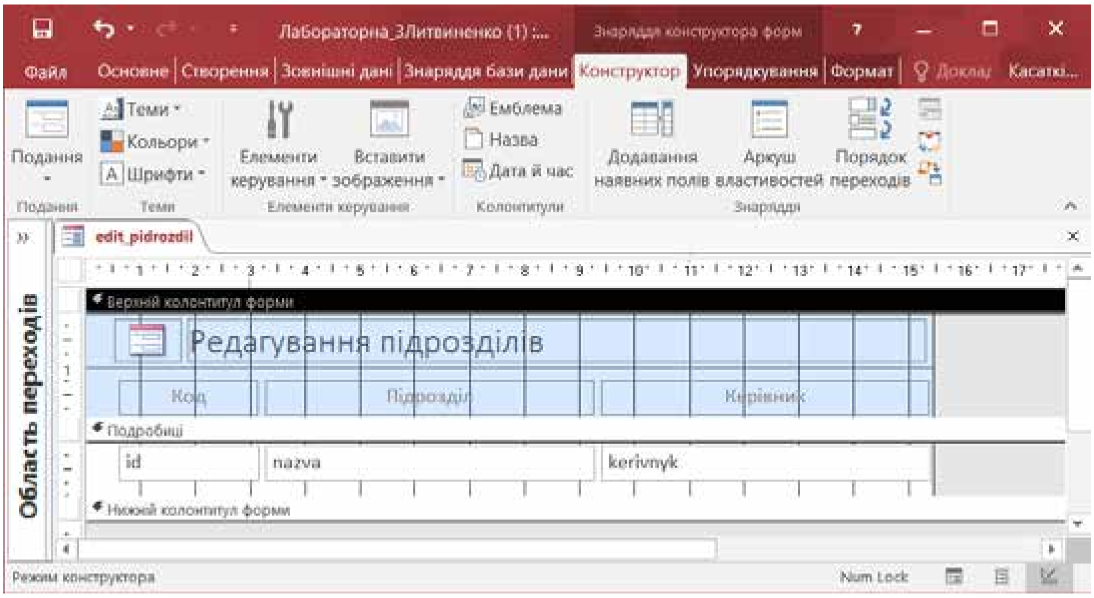


Fig. 4.22 - Form designer mode in MS Access .

The operation of changes to the layout of the form is associated with a certain sequence of changes in the sections "Header (Form Header)", "Page Header", "Details (Data Area)", "Form Footer", "Form Note". To change the size of the section, it is enough to bring the mouse pointer to the lower edge of the section and, holding down the left mouse button, resize the section.

To reformat the names in the "Form Header" section, click on the name of the element. The form layout element is highlighted with size markers that allow you to change its size. In the highlighted element, you can enter information about its name, for example, we want to change the name of the element. The rules for entering text are similar to the rules of Word . To move an element, you need to move the mouse pointer with the left mouse button, move the element to the edge of its rectangle (the pointer will take the form of a hand) and, without releasing the left mouse button, move it to the desired place.

When editing the layout of the form, the "Control elements" panel, which is located in the additional "Designer" menu, is often used. The "Select" key is active by default.

Table 5.6.

Assignment of the main keys of the panel of elements

Button	Name	Button	Name
	"Choice"		"Switch"
ab|	" Inscription "		"List"

	"Field"		"Rectangle"
	"Button"		"Flag"
	"Tab"		" Free object frame "
	"Hyperlink"		"Attachment"
	"Parameter group"		"Switch"
	"Page break"		" Subform /report"
	"List box"		" Attached object frame "
	"Chart"		"Image"
	"Line"		

If one of the fields of the database has a calculation value, then the data is entered into it from the form where the calculation formula is located. For example, product data (pFig, quantity) is entered into the table, and the cost is calculated. Then, when working with the form of this table in the designer mode, you need to select the "Field" element for the cost, which is in the data area, call up the context menu on it (right mouse button) and select the "Properties" item in it. In the properties window of the selected form element, in the "Data" tab, in the "Control element source" line, click the "Expression builder " button (...). In the " Expression Builder " window, open the required table (Costs), select the necessary fields and mathematical symbols for calculating the cost, and press the " OK " button at the end of the expression.

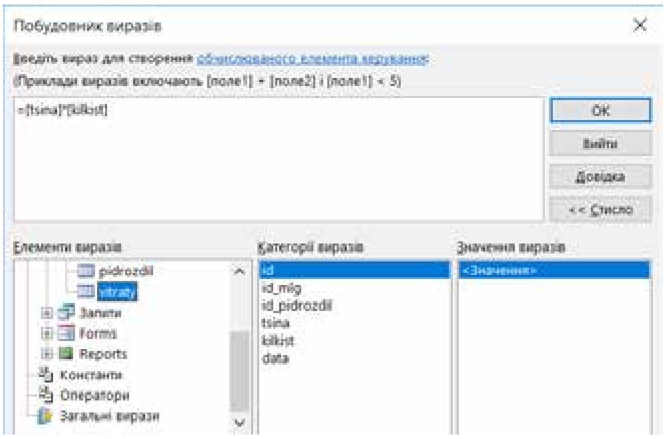


Fig. 5.23 - " Expression Builder " window in MS Access .

In the properties window of the selected form element, in the "Format" tab, you can set the number of decimal places in the number, etc. (see Fig. 5.24).

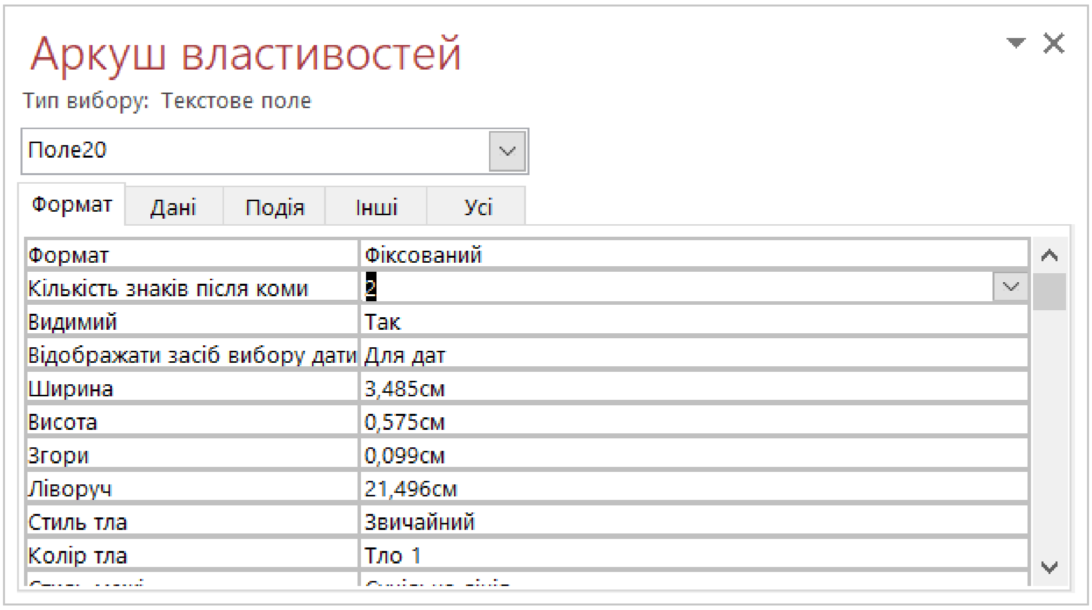


Fig. 5.24 - Properties window of the "Area" field.

View table data

The form is used for entering and editing data. Changing the current record is done using the scroll buttons (,) or the command "Go" in the main menu, which allows you to view all records. To enter a new record, you need to go to the last empty line.

You can use filters to view the data in the form. Thanks to filters, you can display in the form only those of the table records that meet the specified criteria.

Filters are saved automatically when you save the form. That way, when you apply the form again, you can reuse the saved filter. If it is not necessary, then it is necessary to remove the filter using the main menu command "Filter" or "Clear all filters".

Control questions

1. What is the purpose of forms?
2. Describe the main points of creating forms?
3. What is the purpose of filters in the form?

Practical work no 15 . Creation of queries in MS Access .

The purpose of the work: to master the practical skills of creating and using queries in MS Access.

The order of work

1. Download Access , the "Students" database.
2. Create sample requests:
    - c students with a year of birth more than 1994;
    - c students born from 1990 to 2002;
    - c students from the region (determine the region independently), year of admission – 2016;
    - list of students of the faculty (indicate the specific faculty);
    - c students of the 3rd year of all specialty groups (indicate a specific specialty).
3. Based on the requests from point 2, create parametric requests.
4. Create cross queries:
    - the number of students in all regions by year of admission from 2015-2017;
    - the number of students in each specialty in different courses.
5. Save the database.

Theoretical information

Queries allow you to link tables, which allows you to create complex tables from a series of small ones or from large tables to small ones. Thus, an analogue of additional (virtual) tables is created, which are only in the computer's memory and do not take up space on the disk. The methods of working with queries are the same as with tables.

Queries are used to view, change and analyze data by various means. Queries can also be used as a source for forms, reports, and data access pages.

Request types:

- sample requests ;
- requests with parameters ;
- cross-examination ;
- change requests (deletion, update or addition of entries in the table);
- SQL queries (unification requests, management requests, subordinate requests, requests to the server) .

The most common request is a sample request. It selects data from one or more tables and then displays them in the required order.

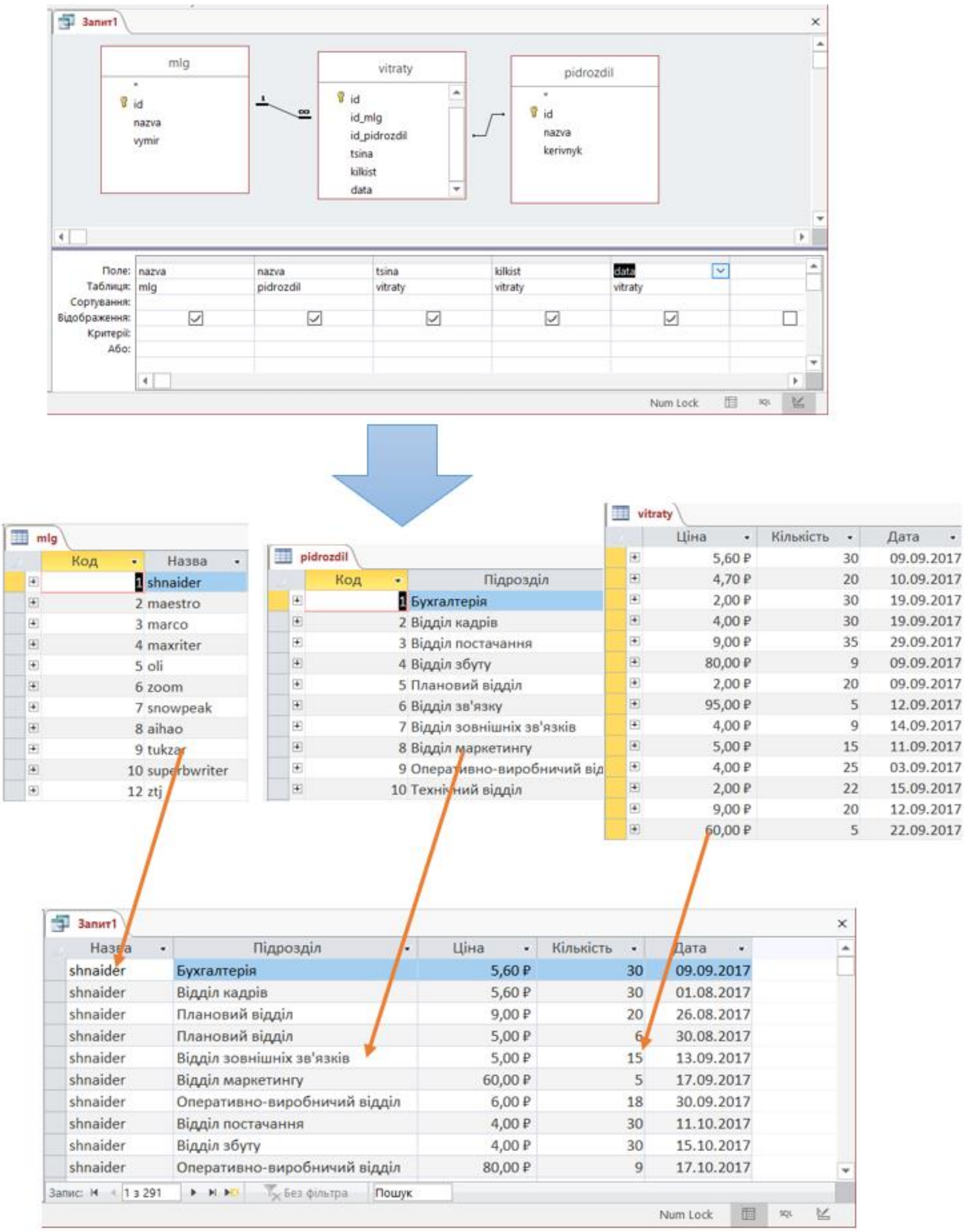


Fig. 5.25 – An example of using a request for sampling from several tables.

A parameter query is a more flexible query that, when used, displays prompts for input in its dialog box, such as conditions for two dates. Therefore, these queries are often used to create forms and reports.

Cross-reference queries display the results of statistical calculations (totals, number of records, and average values) performed on data from one table field. These results are grouped into two sets of data, one in the left column of the table and the other in the top row.

Creating requests in the designer mode (QBE form)

Creation of queries is carried out in relation to the conditions of selection of records, which can be quite different.

Table 5.7.

Types of requests relative to different selection conditions

Selection condition	Example
Exact match	$1000
Search using pattern characters	IN*; 1# A
Search for mismatches (the " NOT " operator is used)	NOT " In *"
Search by date	04.04.04; Date ()
Search for empty fields (using the operator " NULL " or " NOT NULL ")	NULL
The comparison operator	04.04.05 ; < Date ()
Value Yes/No	No/True/0/1 specify one of the options
Complex selection condition (logical operations " AND ", " OR ", " NOT " are used)	1000 OR 3000

Table 5.8.

Use of symbols in selection conditions

Symbol	***Explanation***
*	Any number of any characters
?	One any symbol
#	Used instead of any number
[]	It is used to represent one of the symbols indicated in square brackets (U[IA])
!	It is used to represent characters missing in square brackets (U[!IA])
-	Used to represent a single character that is in a range, for example Y[Y-A])

LIKE	Used to represent symbols similar to a condition . For example, LIKE “[А-Д]*”
Between	Used when the value must be within a given range
In	used when the values must be in the field itself.

To create requests, you must perform the following actions:

- go to the "Create" menu;
- select designer mode;
- select the tables needed for the query (after each table, press the "Add" button). Press the "Close" button;
- if the necessary tables were not selected in time, this action can be performed using the context menu, which is called to the upper part of the designer, where the selected tables are placed;
- if it is necessary to create a connection between the fields of different tables, we do it with the mouse (we move the field from one table to the field from the second table). The result should be a line that shows the connection;
- specify the fields of the tables that are needed to form the request ("Field" line);
- check the presence of the "Display" flag for each field that we want to display in the result table after the query is executed;
- if it is necessary to sort the query result by any field, then in the "Sorting" line, specify the sorting order;
- conditions for requests are specified in the "Criteria" line;
- switch to table view mode.

In the Criteria line, you can use square brackets with the text of the question or the sign “ **?** ” (empty question), if it is necessary to ask a question about this field during the request (parametric request).

Control questions

1. What is the purpose of parametric queries?
2. What types of requests are there?
3. How can I create a request?

Practical work No. 16. Reports in Microsoft Access .

The purpose of the work : to master the practical skills of creating reports and working with them.

Work execution program

1. Download Access .
2. Open the Students database
3. Create the following reports, where the field names are written in Ukrainian:
   – the report is generated by the "Report Master" based on the list of all faculties of the university (the name of the report **is Faculties**);
   – a report on students of a separate faculty with the calculation field *Age* (select the faculty yourself, the name of the report **is Students_faculty**);
   – a report on students from a separate region (define the region yourself, the name of the report **is Students_region**).
4. Save the database.

Theoretical information

Creating reports

When working with databases, it is often necessary to process and display information on a monitor or printer. This can be done using reports. In the report, the user can select data from one or more tables or database queries, make the necessary calculations and prepare it in the most convenient form. In Access, you can use samples of standard report structures (mostly simpler forms), or build your report of any complexity. If the user does not yet have the skills to build reports, it is better to use the Access software tools for building reports, which is called the "Report Wizard **"** .

To build a report, you need:

- open the database file window, select the "Create" menu;
- in the "Reports" group, select the option to build a report:
  - *" Autoreport "* - the selected or calculation fields are issued automatically in the report;
  - *"Constructor"* - construction of a report by the user;
  - *"Report Wizard" - building a report using* Access software ;
  - " *Empty report* " – a completely empty report without data is created;

- " *Labels* " are used to prepare address labels and stick them on postal envelopes for mailing.

- for example, we choose the report creation option "Report Wizard";
- select the table or query and the fields from which we will use information to build the report;
- click on the " *Next" button* ;
- windows for creating reports open, where we select the grouping levels (if necessary), the sorting order (if necessary), the type and style of the report layout , the name of the report.

The "View report" option indicates that the result of the report created using the "Report Wizard" will be displayed on the screen (active by default).

Option "Changing the structure of the report" - a version of the constructed report appears on the screen for making changes to it by the user. We leave it unchanged and click on the Finish button, a report execution results window appears on the screen

Editing the report

To make changes in the report, you must perform the following actions:

1. to choose necessary report ;
2. click the " **Designer" button** .

A report will appear on the screen, which has sections:

- *" Report Title / Report Header "* - in this section maybe find the title of the report , information about the date and time. Covers once at the start report .
- *" Upper footer "* - is used mainly for the formation of caps (permanent information) weekend reports . Repeated from above each page .
- *" Details / Data area "* is the main area, where they take out data database fields , calculated indicators and other data It is repeated for each record .
- *" Page footer "* - used for placement rooms pages and auxiliary data . It is repeated at the bottom of each page .
- *Notes of the report / Footer of the report "* - you can place final results , auxiliary data Outputs once at the end everything report .

Resize sections in a report

The height of each report section can be changed, and all report sections have the same width. Changing the width of one area automatically changes the width of the entire report.

To change the width or height of the report, you need to place the mouse cursor on the bottom or right edge of the section being changed, respectively. At the same time, the mouse cursor should take the form of a vertical or horizontal bidirectional arrow. By moving it in the desired direction, the size of the partition also changes. In order to change the height and width of the section at the same time, you need to set the mouse cursor in the lower right corner of the section and repeat the operations described above.

Resizing, moving, and editing report elements

Each section of the report consists of separate rectangles filled with data. This rectangle is called a report element. To change the size of the report element, you must: select it by clicking the left mouse button, bring the cursor to the corner or edge of the rectangle so that the mouse cursor takes the form of a bidirectional arrow. By moving the cursor in the desired direction, without releasing the left mouse button, we change the size of the report element.

To move a report element, you must: select it by clicking on it with the left mouse button. After that, move the cursor along the rectangle until it takes the shape of a palm. This is an indication that the report item can be moved. By moving the cursor in the desired direction, without releasing the left mouse button, we also move the report element.

Control questions

1. What is the purpose of reports?
2. What are the sections in the report?
3. How to save the report in a separate file?
4. Explain the method of editing reports.

CHAPTER 6. DESIGNING PRESENTATIONS IN THE POWERPOINT PROCESSOR

Microsoft PowerPoint 2016 has a new look. It looks cleaner and is perfect for tablets and phones, allowing you to present with touch and swipe. Presenter mode automatically adapts to the presentation settings. It can even be used on one monitor. Themes are now offered in several variants, making it easier to give your presentation the look you want. Also, when working with other users, you can add notes to ask questions or get feedback.

6.1. Getting started with PowerPoint

Instead of opening a blank presentation, PowerPoint 2016 offers several ways to create your next presentation based on a template, theme, recent presentation, older presentation, or blank presentation.

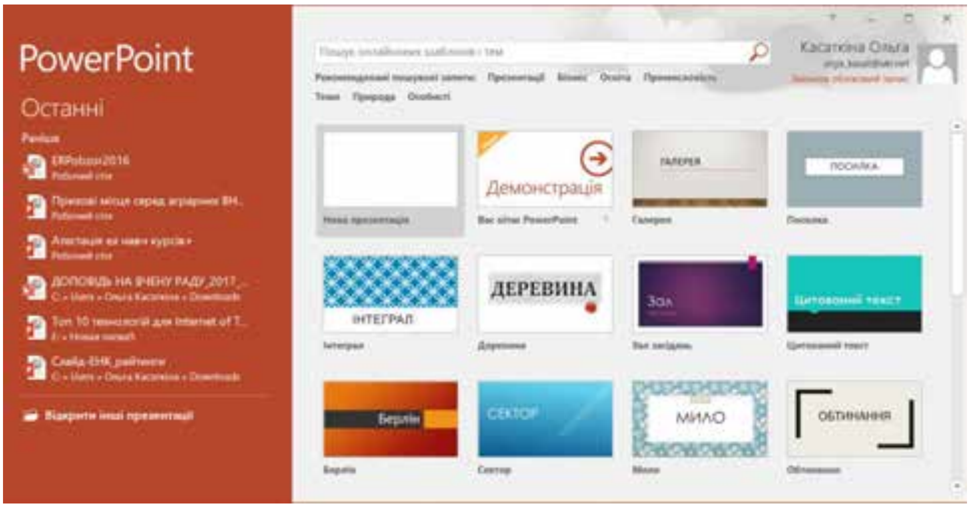


Fig. 6.1 - The window for creating a new presentation in POWERPOINT.

6.2. New capabilities of the POWERPOINT program

Simple speaker mode

Presenter mode allows you to view notes on the monitor while the audience only sees the slides. In previous releases, it was difficult to determine exactly what would be displayed on a particular monitor. In the improved speaker mode, such a problem no longer exists, which greatly simplifies work with this mode.

Fig. 6.2 – The view of the presentation in *the Simple mode of the speaker* .

- **Using speaker mode on one monitor.** Presenter mode no longer requires multiple monitors. Now in speaker mode you can train without connecting additional equipment.
- **Zoom on the slide.** Click the magnifying glass icon to zoom in on charts, diagrams, or any other elements you want to draw your audience's attention to.
- **Go to the slide.** Use the slide navigator to navigate to other slides in your presentation.
- **Automatic tuning.** PowerPoint can automatically determine your computer settings and select the correct monitor for Presenter mode.

Create and share online interactive presentations

Office Mix is a new free solution for PowerPoint that lets you create and share interactive presentations or " mixes " online. Mixes play like Internet videos, but with support for animations, dynamic links, and more.

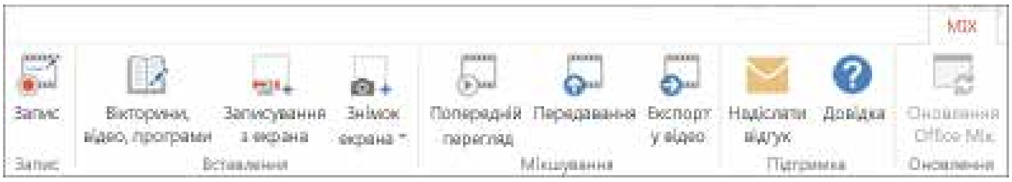


Fig. 6.3 - " Mixes " menu bar in POWERPOINT.

To get Office Mix , download and install the free add-in. When you open PowerPoint, you'll see a new **Mix tab** . You can record audio or video notes for each slide in your presentation. You can embed quizzes, featured videos, and more. Easily record the information displayed on the screen while adding audio notes . When you're ready, preview your mix , then upload it to OfficeMix.com to share it. The OfficeMix.com portal offers analytics, which you can view to learn audience statistics and quiz results.

Convenient work with widescreen screens

Most televisions and video systems in today's world are widescreen and support HD, as does PowerPoint. The program features a 16:9 layout, and new themes are designed to take advantage of widescreen displays.

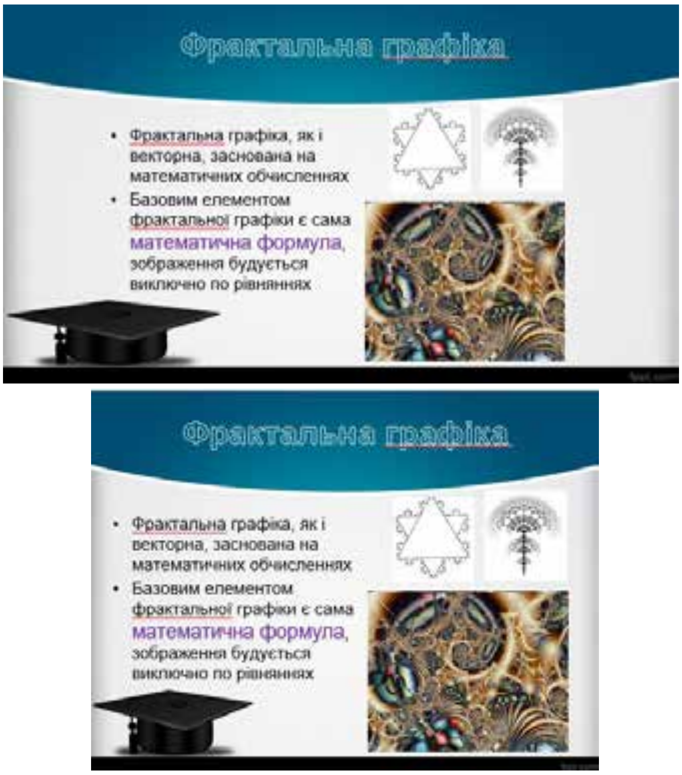


Fig. 6.4 – Options for using different layouts of slides in Powerpoint .

Start a network meeting from PowerPoint

Now there are several ways to make a PowerPoint presentation over the Internet. You can send a link to the slides or start a full Lync meeting in which the presentation is displayed with audio and instant messaging. Participants can join the presentation from any location, on any device using Lync or the Office presentation service.

Fig. 6.5 – Options for displaying a PowerPoint presentation on different devices.

Improved designer tools

Theme options

Themes now come in multiple options, such as different color palettes and font families. In addition to standard size themes, PowerPoint 2016 also includes new wide-format themes. Select a theme and its variant from the home screen or from the Designer tab.

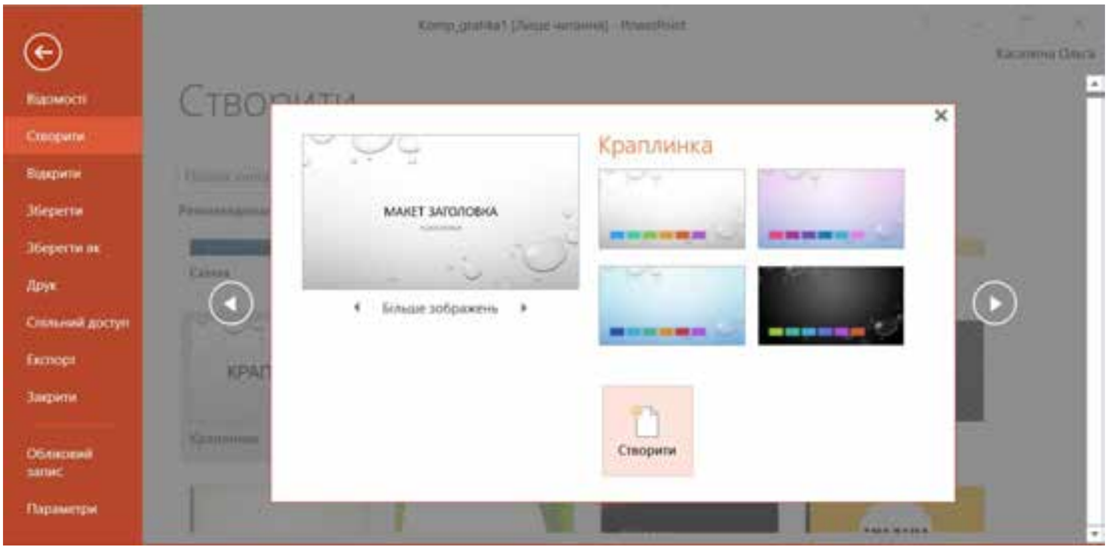


Fig. 6.6 – Choosing a theme and color palette in PowerPoint 2016.

Alignment and uniform arrangement of objects

You no longer need to visually inspect the placement of objects on slides to see if they are properly aligned. Smart guides are automatically displayed when objects such as images, shapes, etc. are placed almost flat, and signal that the objects are placed evenly.

Fig. 6.7 – Automatic arrangement of objects in PowerPoint.

Improvement of the ways of movement

PowerPoint now displays the end point where the object will end up when you create a path. The source image remains in place, and its "ghost" image moves along the path to the end point.

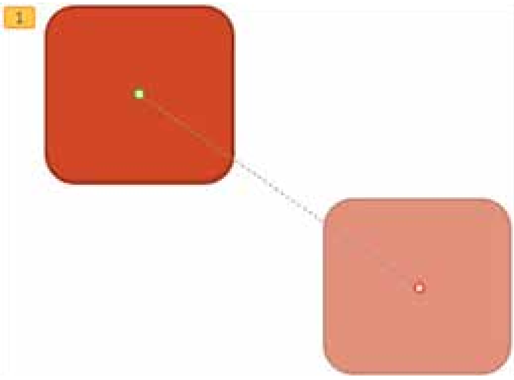


Fig. 6.8 – Creating a path for moving objects in PowerPoint.

Combining common shapes

Select two or more common shapes on a slide and combine them to create new shapes and icons.

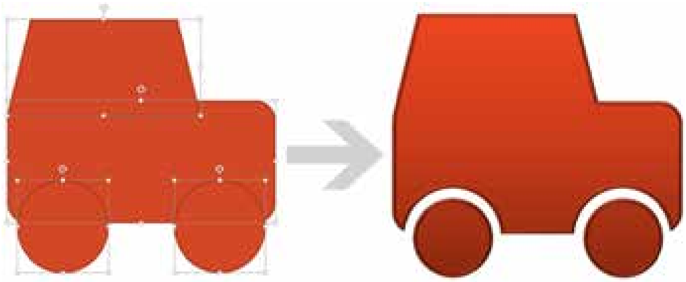


Fig. 6.9 – Grouping of objects in PowerPoint.

Improved video and audio support

PowerPoint now supports more media formats, including MP4 and MOV with H.264 video and AAC audio, as well as other HD content. PowerPoint includes additional built-in codecs , so you don't need to install them separately to ensure that files of a certain format can be played.

Use **Background Playback** to play music while viewing a slideshow.

New eyedropper for matching colors

Now you can take the exact color that the object on the screen has, and then apply it to any shape. The eyedropper automatically selects colors to match.

Fig. 6.10 – the "Eyedropper" tool in PowerPoint.

PowerPoint on touch devices

Now you can work with PowerPoint on most devices, including PCs running Windows 8 and 10. Using standard touch input controls, you can drag, tap, scroll, zoom, and pan your slides and literally feel the presentation.

Sharing and saving

Share and save Office files in the cloud storage on OneDrive or on your organization's website. There, you can open PowerPoint presentations and other Office files, and share them. You can even work simultaneously with colleagues on the same file. The cloud is like a file storage in the sky. It can be accessed at any time while online . Now you can easily store Office files in your own

Fig. 6.11 – Sharing and saving PowerPoint files in the OneDrive cloud .

You can now leave feedback in PowerPoint using the new Notes area. Notes and editorial corrections can be shown or hidden.

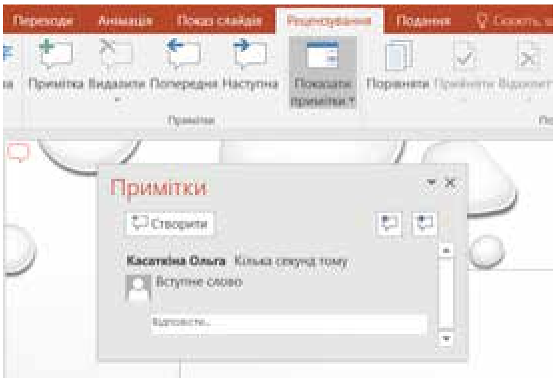


Fig. 6.12 - Saving *Feedback* in the new " *Notes* " area.

Joint work on one presentation

You can work together with colleagues on the same presentation in the desktop version or in the online version of PowerPoint and immediately see the changes that others make.

6.2. The first steps of creating a presentation in PowerPoint

PowerPoint presentations work on the same principle as slide shows. To convey an idea or tell a story, it is better to divide the material into slides. Each slide can be imagined as a blank canvas for drawings, words and figures that will help create a coherent report.

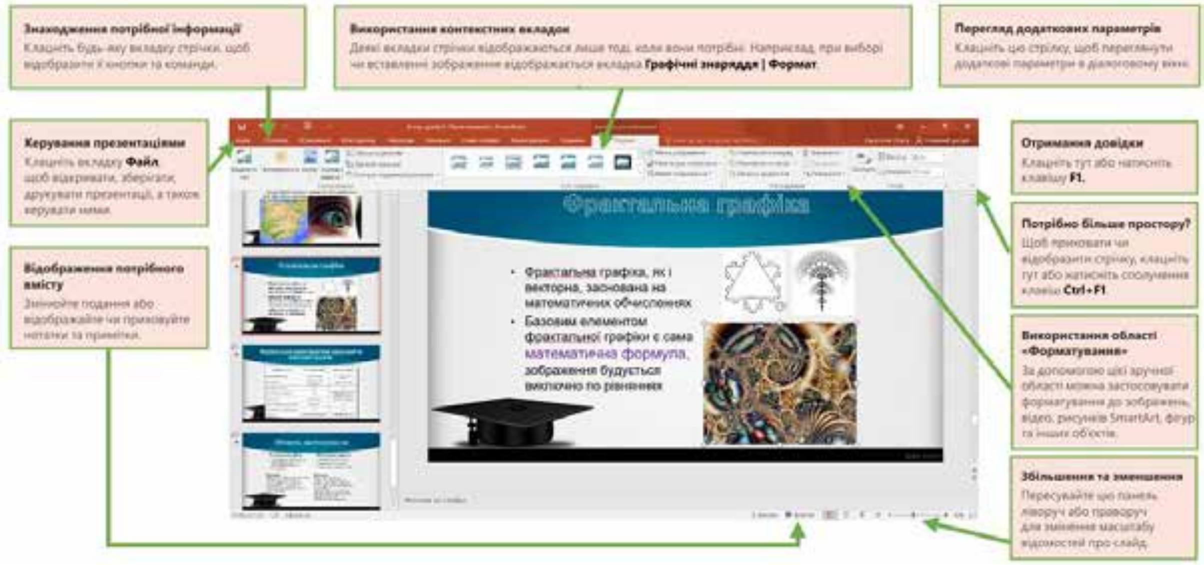
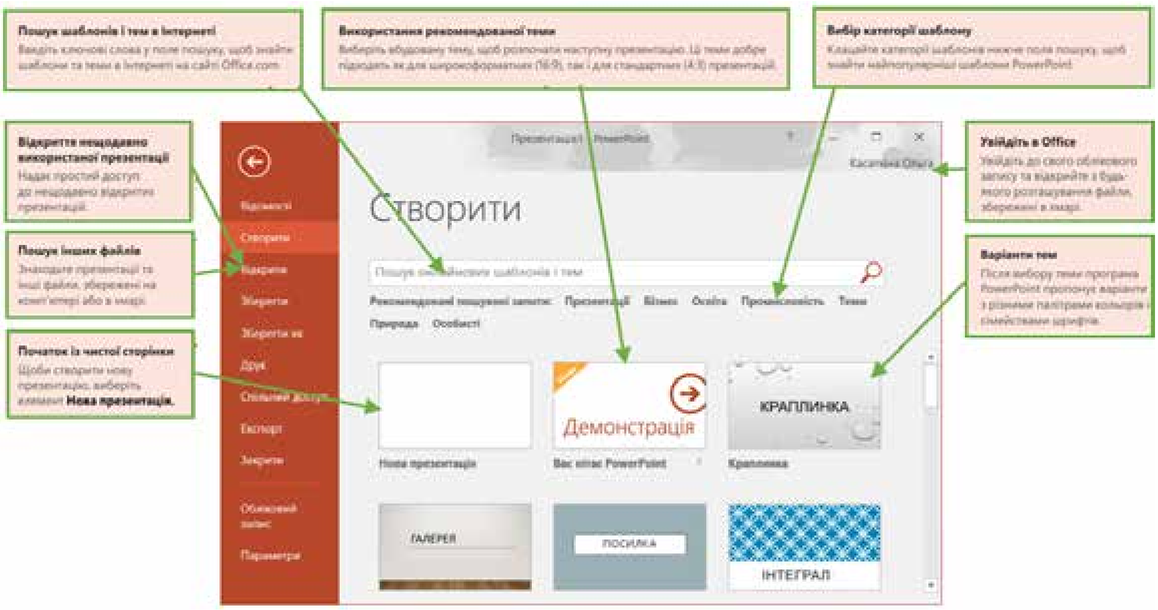


Fig. 6.13 – Elements of the main PowerPoint window.

Choosing a topic

When you open PowerPoint, the built-in topics are displayed. A theme is a slide design with a single style that includes colors, fonts, and special effects like shadows, reflections, and more.

1. Choose a topic.
2. Click **the Create button** or select a color option, and then click the **Create button** .



Insert a new slide

On the **Home tab,** click **Create Slide** and select a slide layout.

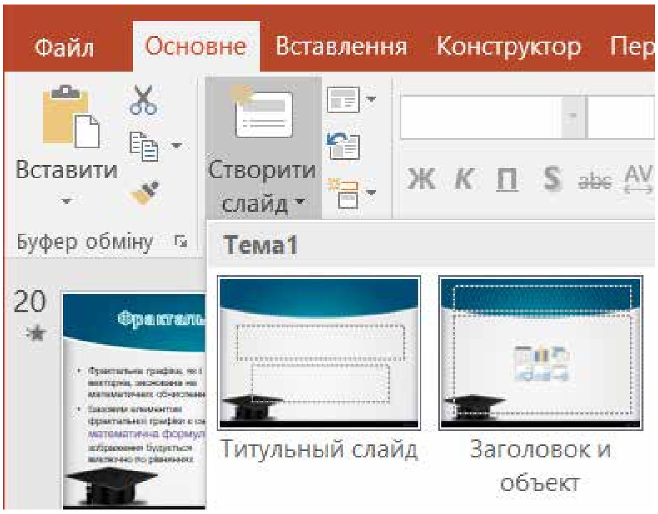


Fig. 6.15 – Creating a new slide in a PowerPoint 2016 presentation.

Save the presentation

1. On **the File tab** , select the **Save command** .
2. Select or navigate to a folder.
3. In **the File name field** , enter a name for the presentation and click **Save** .

Note. If you often need to save files to a certain folder, you can "pin" this path so that it is always available.

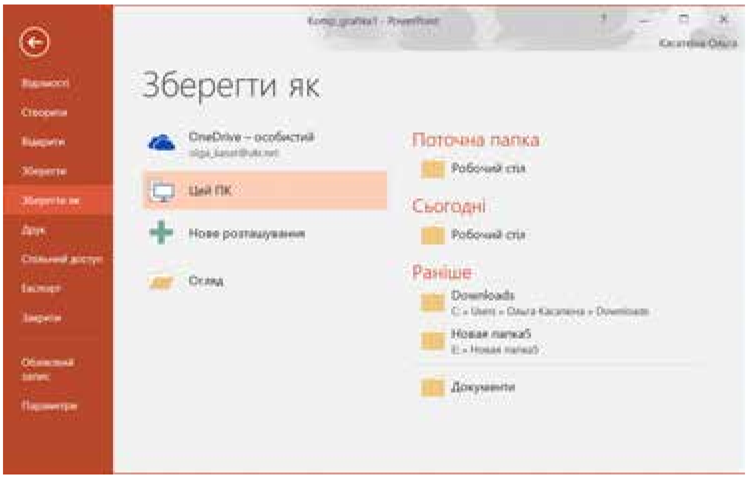


Fig. 6.16 – Saving a presentation in PowerPoint 2016.

Advice. Save your work as you do it. Don't forget to press **Ctrl+S from time to time** .

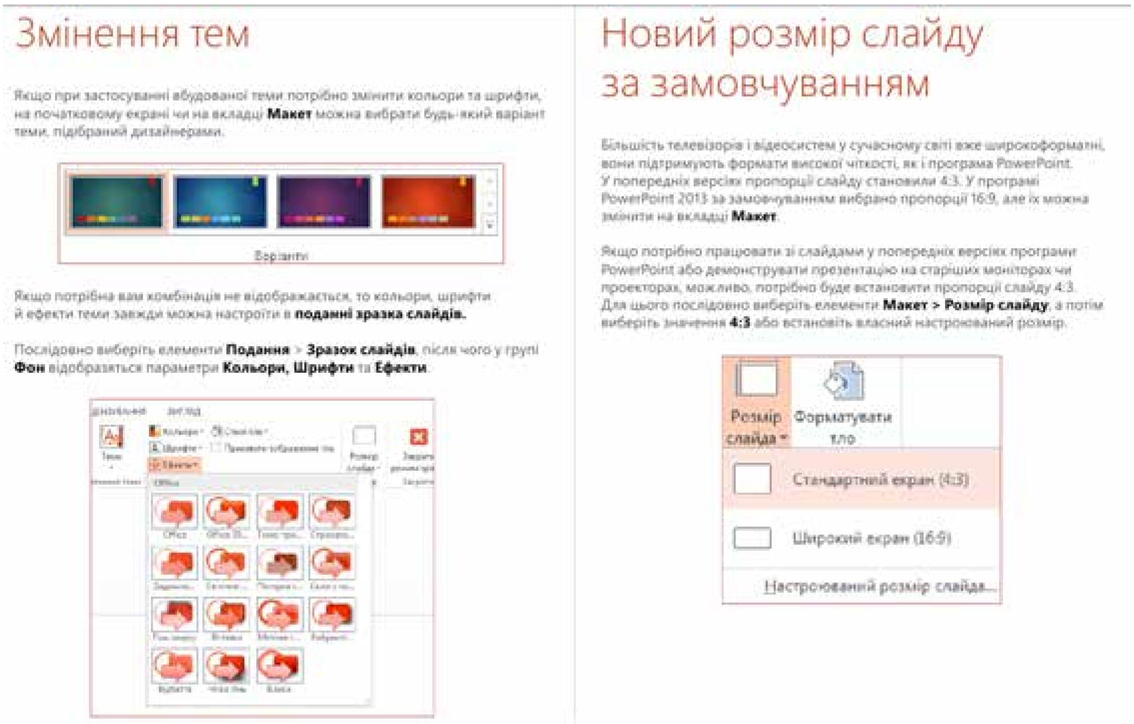


Fig. 6.17 – Changing the theme or slide size of a PowerPoint presentation.

6.3. Working with objects in the PowerPoint program

Adding text

Click on the text space and start entering data.

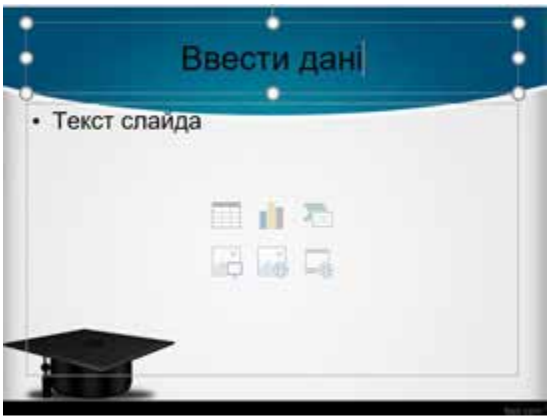


Fig. 6.18 – Entering text in PowerPoint presentations.

Text formatting

1. Highlight the text.
2. On the **Drawing Tools tab,** select **the Format tab** .
3. Do one of the following:
4. To change the text color, select **Text Fill** , and then select a color.
5. To change the color of the outline, select **Text Outline** , and then select a color.

6. To apply shadows, reflections, glows, reliefs, volumetric rotations, transforms, click **Text Effects** , and then select the desired effect.

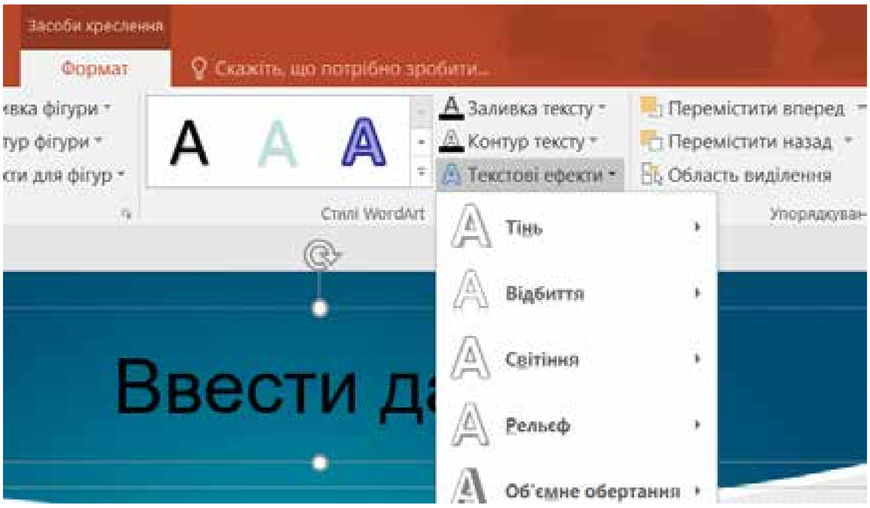


Fig. 6.19 – Editing text in a PowerPoint 2016 presentation.

Adding shapes

1. On the **Insert tab,** click **the Shapes button** .
2. Select the shape you want, click anywhere on the slide, and then drag to create the shape.

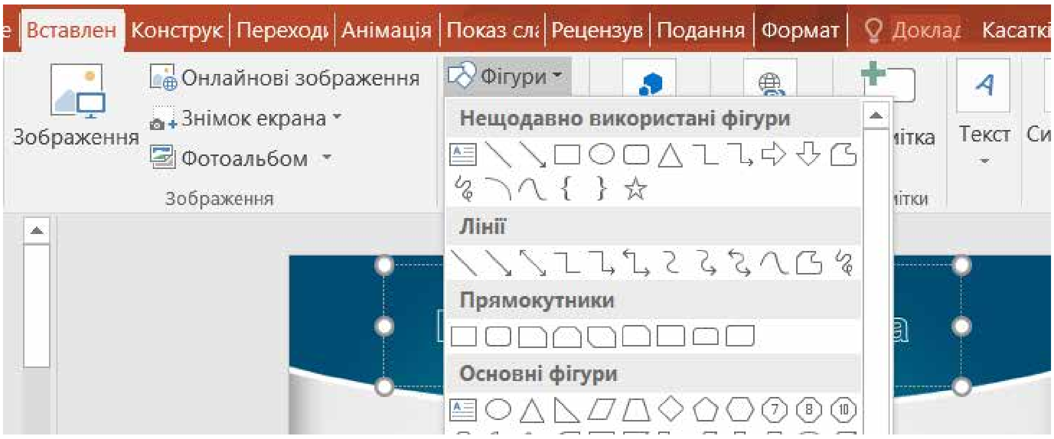


Fig. 6.20 – Adding new shapes in a PowerPoint 2016 presentation.

Advice. To create a regular square or circle (or resize other shapes), hold down the Shift key while dragging .

Adding images

On the **Insert tab** , do one of the following:

- To insert a picture saved on your local drive or internal server, click **Pictures** , locate the picture, and then click **Insert** .

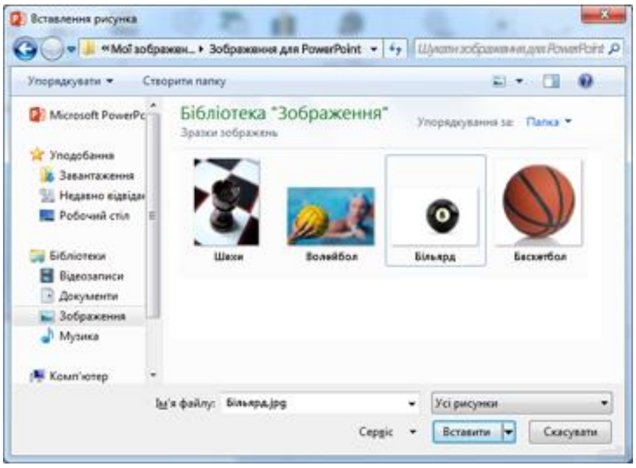


Fig. 6.21 – Adding new images in a PowerPoint 2016 presentation.

- To insert an image from the Internet, select **Online Images** and find the image you want using the search box.

For example, type **Cats** or **Graphic images of cats** in the **Bing Image Search box** .

- Select the picture and click the **Insert button** .

6. 4. Presentation output methods

Conducting a presentation

On the **Slide Show tab** , do one of the following:

- To start the presentation from the first slide, in the **Start Slide Show group** , click **From the beginning** .

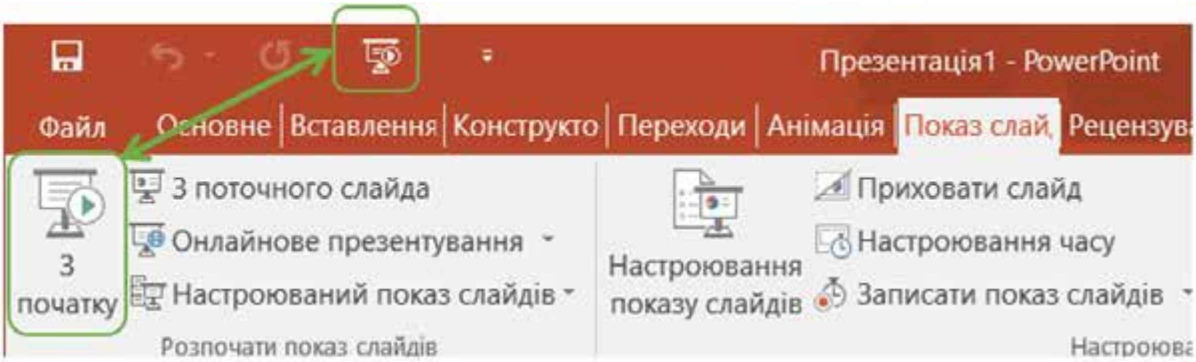


Fig. 6.22 – Presentation presentation in PowerPoint 2016.

- If you're not currently viewing the first slide and want to start from that, click **From Current Slide** .
- If you need to present to people who are in a different location, click **the Online Presentation button** and set up your presentation over the Internet by selecting one of the options below.

Exit slide show view

- That exit the slide show view , press on the keyboard at any time key Esc .

Щоб...	Клацніть...	А потім знайдіть...
Відкрити, зберегти, надрукувати, надіслати, експортувати, перетворити, захистити файли або надати до них спільний доступ	**Файл**	Подання Backstage (клацайте команди в лівій області).
Додати слайди, застосувати макет, змінити шрифти, вирівняти текст або застосувати експрес-стилі	**Головна**	Групи: **Слайди, Шрифт, Абзац, Креслення, Редагування**
Вставити таблиці, зображення, фігури, рисунки SmartArt, об'єкти WordArt, діаграми, примітки, верхній та нижній колонтитули, відео чи аудіо	**Вставлення**	Групи: **Таблиці, Зображення, Ілюстрації, Примітки, Текст, Кліп**
Застосувати тему, змінити колір теми, змінити розмір слайду, змінити фон слайду або додати водяний знак	**Макет**	Групи: **Теми, Варіанти, Настроювання**
Застосування або настроювання хронометражу переходу	**Переходи**	Групи: **Перехід, Час**
Застосувати або настроїти хронометраж анімації	**Анімація**	Групи: **Анімація, Додаткові параметри анімації, Хронометраж**
Запустити показ слайдів, настроїти показ слайдів, зазначити монітори для використання з поданням доповідача	**Показ слайдів**	Групи: **Почати показ слайдів, Настроїти, Монітори**
Перевірити орфографію, ввести та перевірити примітки або порівняти презентації	**Рецензування**	Групи: **Правопис, Примітки, Порівняння**
Змінити подання, редагувати головне подання, відобразити сітки, напрямні та лінійки, збільшити, перемикатися між вікнами PowerPoint і використовувати макроси	**Подання**	Групи: **Подання презентації, Головні подання, Відображення, Масштабування, Вікно, Макроси**

Fig. 6.23 - Menu groups in the PowerPoint program.

Printing of slides of the speaker's presentation

1. On **the File tab,** go to the **Print tab** .
2. In **the Printer section,** select the printer you want to use for printing.
3. In **the Options group** , click the arrow next to **Full Page Slides** , and then under **Print Layout,** click **Notes Pages** .
4. Click the **Print button** .

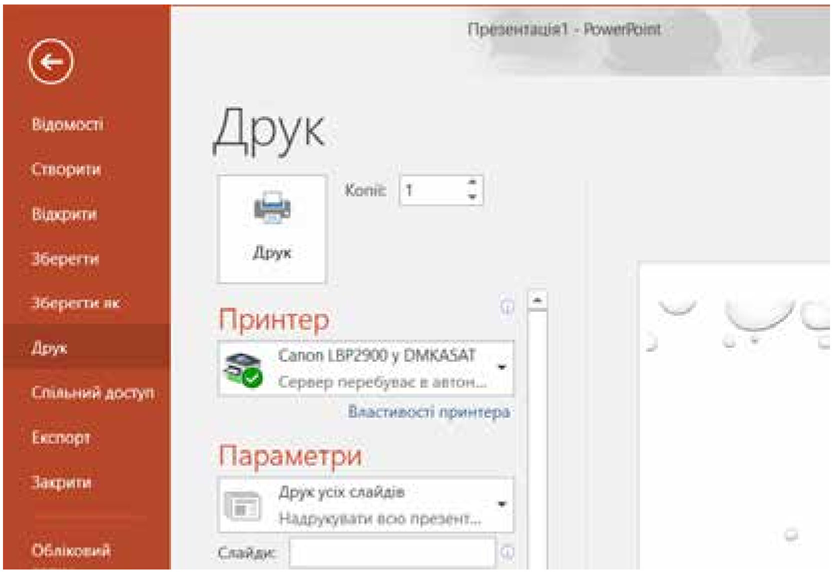


Fig. 6.24 – Printing a presentation in PowerPoint 2016.

Practical work No. 17. Creating PowerPoint presentations.

<u>The purpose of the work:</u> to master the skills of creating presentations in the

PowerPoint program.

<u>Theoretical information</u>

In the presentation process, it is desirable to have auxiliary illustrative material (graphs, tables, photos, etc.) to achieve greater informativeness and visuality of the material. The PowerPoint program is used to create a suitable presentation .

Start the Microsoft program PowerPoint

- download the **Windows operating system** ;
- click on the " **Start" button;**
- in the " **Programs" menu item** , select the **"Microsoft PowerPoint " sub-item;**
- a screen saver will appear in PowerPoint , then the program window with a request for options for working with the presentation (create a new one or open a created one).

Creating a presentation

When you start PowerPoint, a dialog box appears on the screen where:

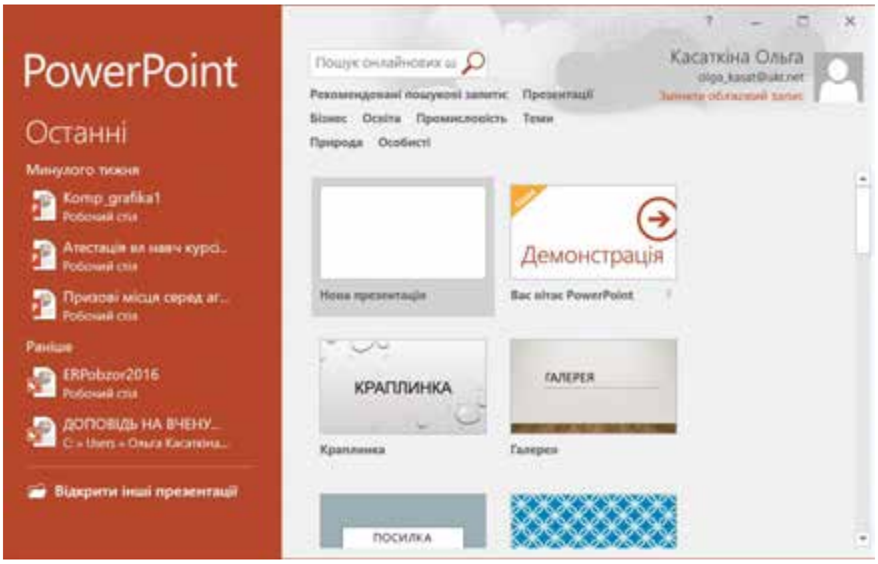


Fig. 6.25 – Creating a presentation in PowerPoint 2016.

" Master autocontent " - for opening presentations that were previously created and viewed last or saved elsewhere.

"design templates" - for creating a presentation of your own content and sequence of material, but with automatic background design of presentation slides, the templates of which are in the program library.

"empty presentation" - for creating a presentation with its own content and sequence of material, as well as independent background design of presentation slides.

Self-creation of a presentation

- in the **"File" menu item** , select the **"Create** " sub-item;
- in the left part of the window, among the proposed options, select the **"New presentation" item** ;
- in the **" Main " menu** , select the layout of the first slide;
- the first slide according to the selected structure will appear on the screen;
- highlighting the elements of the slide structure, fill them with appropriate content;
- to create a new presentation slide, in the **"Main" menu item** , select the **"Create a slide** " sub-item;
- in the dialog box that appears, select the layout of the next slide;
- repeat the above procedures for filling and creating slides.

Making presentation slides

To ensure the desired effect from the presentation, the slides are decorated with a suitable colored background, multimedia effects of the appearance and disappearance of the slide, sound accompaniment, etc. To decorate the background of newly created slides or change the existing background, you can use **the "Design template"** or choose the color, texture, pattern of the background of the slide yourself, etc.

Designing the background of the slides using the "Design Template"

- create a slide;
- select **"Theme "** in the **"Designer" menu item** .

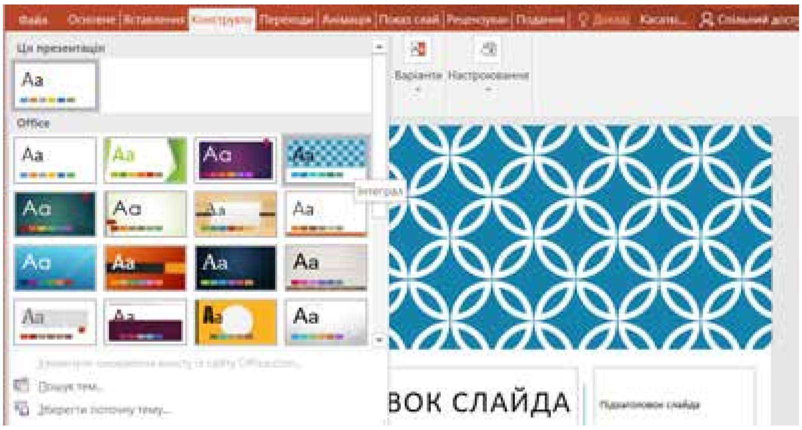


Fig. 6.26 – Choosing a presentation topic in PowerPoint 2016.

Self-designing the background of the slides

- create a slide;
- in the **"Designer" menu item** , select the **"Background format" sub-item** ;

- in the dialog box that appears, open the list of possible background options;
- in the opened list check:
  - **"Solid fill"** - for choosing a plain color of the background of the slide from the color palette;
  - **"Gradient fill"** - for applying a gradient background fill;
  - **"Image or texture"** - for choosing the background texture of the slide, or using your own graphic image as a background;
  - **"Pattern filling"** - for selecting the background pattern of the slide;
  - **" Hide the background image "** - do not display the background image;
  - **" Color "** - to select the main color of the slide background;
  - **"Transparency** " – to select the transparency of the slide background in percentage;
- click the **"Apply" button** - to apply the selected background option to one slide, or **"Apply to all"** - to apply the selected background option to all presentation slides.

Slide presentation modes

PowerPoint allows you to perform operations with slides in different modes. It is advisable to create slides, fill them with content, and set animation effects on slide elements in the **"Normal"** slide presentation mode.

"Slide Sorter" mode allows you to display the presentation on the screen in its entirety, move slides, manage slide change effects, view effects, etc. The finished presentation is viewed in the **"Slide Show" mode** .

To select the presentation mode of the slides, it is necessary to select the sub-item **"Normal"** , **"Structure presentation"** or **"Slide sorter" in the " View"** menu item to select the desired presentation mode

or click on the buttons on the toolbar

.

"Normal" mode

In the normal slide presentation mode, it is most appropriate to perform the following operations:

- ***Fill out slide templates:***
  - select the zone in the slide structure that is planned to be filled;

– set the parameters of the font that will be filled in the title or text area;

– to insert a graphic object from a file in the **"Insert" menu item** , select the **"Image" sub-item** , go to the cascade sub-menu and select the **"From file" item** .

– to insert a graphic object from the clip library, double-click the clip icon and select the desired one;

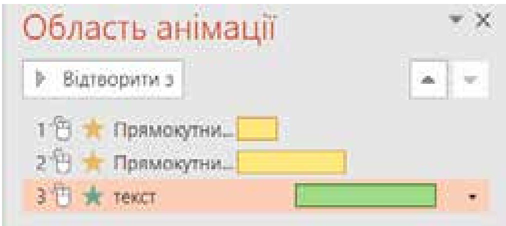
■ ***Set animation for slide elements:***

– in the **"Animation" menu item** , select the **"Animation area" sub-item** .

– in the dialog box that appears, select those slide elements that will appear on the slide field with a certain effect and in a certain sequence. Unchecked slide elements appear simultaneously with the slide background;

– in the **"Timing" tab** , in the **"Animation order" field** , select the element for which the animation must be adjusted. Using the **"Animation" parameter group** , specify the method of starting the animation, as well as the time interval after which the effect will be automatically performed;

– to change the sequence of appearance of slide elements on the working field, it is necessary to highlight the desired element in the list of elements, use the buttons to set the object in the desired place of the display sequence;



– in the **"Effects parameters" tab** , you can also add sound to the effect by specifying the appropriate sound file;

– in the **"Appearance" field** , if the effect is applied to the text, specify the order of text display (all at once, by words or by letters);

– to get acquainted with all the changes made, you need to click on the **"Play" button** . The adjusted effect will be displayed accordingly with all the specified parameters.

<u>**"Slide sorter" mode**</u>

In the slide sorter mode, it is most appropriate to perform the following operations:

■ ***Change the order of slides:***

− select and cut to the clipboard a slide that is planned to be shown in a different sequence;

− set the cursor between the slides where you plan to insert the cut slide;

− insert a slide from the clipboard,

− or drag the desired slide to the desired place using the mouse.

■ ***Add new slides:***

− " Main " menu button " Create slide " ;

− or highlight the slide that precedes the newly created one and press **" Enter "** ;

− or using the context menu button **" New slide ".**

■ ***Copy slides from one presentation to another:***

− set the cursor between the slides, where the borrowed slides will be inserted;

− in the **"Main" menu item** , select the **"Create a slide" sub-item** ;

− in the dialog box that appears, select the item **"Reuse slides"** and find in the structure of drives and folders the file with the presentation from which the slides must be inserted ;

− in the dialog box that appears, in the **"Select slides" field** , mark the necessary slides and press the **"Insert" button** .

■ ***Delete slides:***

− **down the <Ctrl>** key , select the necessary slides;

− press **the <Delete> key** .

■ ***Create slide transition effects:***

− **< Ctrl >** key ;

− in the **"Transitions" menu item** , in the **"Effects" field** , select the desired slide change effect from the list;

− in the **"Timeline" area,** check: " **mouse button click "** - to change slides by clicking the mouse button, **"After"** - to change slides automatically after the time interval indicated on the numerical pointer;

− click the button: **"Apply to all"** - to apply the effect to all slides of the presentation.

■ ***Create an automatic cyclic display of a presentation:***

− pre-install the function of automatic slide change on each slide of the presentation (see the previous point);

− in the **"Slide Show" menu item** , select the **" Presentation settings " sub-item** .

− in the dialog box that appears, in the **"Slideshow" field,** check **"Automatic (full screen)" ("Continuous cycle"** option) . When the **"Slide Show" mode is enabled ,** the presentation will be cyclically repeated until the <Esc> key **is pressed** .

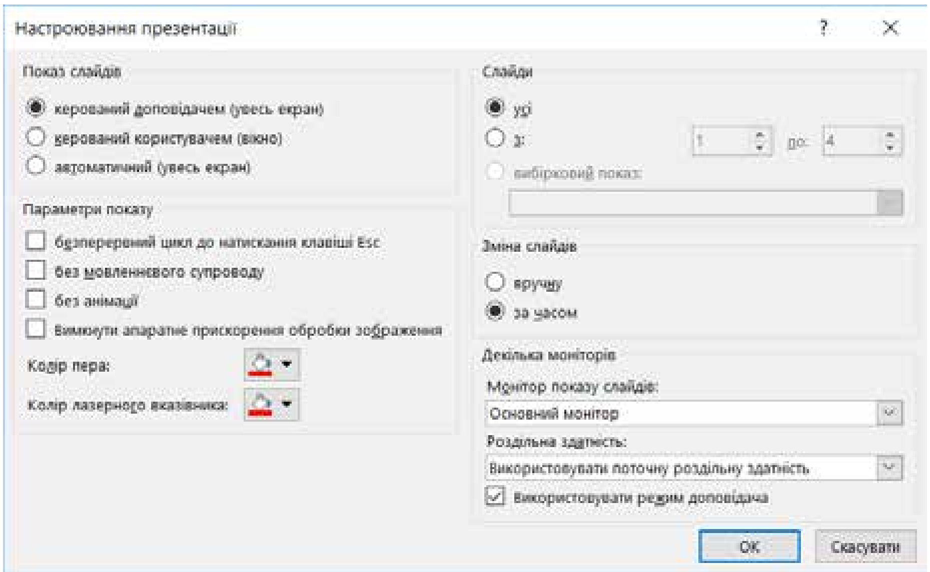


Fig. 6.27 - Setting the cyclic display of animation in PowerPoint 2016.

■ ***Hide slides***

In the event that not all slides of the presentation are required to be shown at the moment, they can be marked as hidden. Hidden slides are displayed in all modes except Slide View. To hide slides, you must:

− select the necessary slides and click on the **"Hide slide" button** from the context menu.

− hidden slide numbers will be placed in a square frame crossed diagonally.

<u>"Slide show" mode</u>

At any stage of creating a presentation in PowerPoint, you can view individual slides or the entire presentation in real-time.

Start the presentation for viewing

Select the slide from which you plan to start showing the presentation in any of the modes, click on the **"From the current " button in the "Slide show "** menu item , and a slide show will be launched on the screen. To exit the slide show mode, use **the <Esc> key** .

After the slide show is finished, the presentation will be displayed in the mode from which it was launched.

<u>Work execution program</u>

1. Choose the topic of the presentation.
2. Prepare the original graphic (sound, video) information in digital form, which will be used when creating a presentation.

3. Download the PowerPoint program .
4. Create a presentation on a specified topic using text, graphics, (sound, video) information in the amount of 6-10 slides.
5. The created presentation can be presented in two display options: the first one is to change the slides by clicking the mouse, the second one is to continuously show the slides in a closed loop with a slide show interval of 4 seconds.

Control questions

1. How to create a presentation based on a content template?
2. How to apply a presentation design template?
3. How to set animation of slide elements?
4. How to design the background of a presentation slide?
5. How to create an automatic presentation presentation?
6. How to create and save a presentation?
7. What is the file format in MS PowerPoint?
8. How many ways to create a presentation?
9. What are Presentation Viewing Modes?
10. How to insert a slide? What is Slide Markup?
11. How to work with tables in MS PowerPoint?
12. What types of organizational charts are highlighted in MS PowerPoint??
13. Inserting objects from libraries. Formulas. Clips Flash videos.
14. Sample slides. Sample notes. Footers.
15. What are the rules for using Animation?
16. Presentation management options.
17. Hyperlinks in slides.
18. Control buttons in the presentation.
19. Presentation display settings.
20. Placing the presentation on the Internet.

LIST OF RECOMMENDED LITERATURE

1. Balyk N.R. bases MySQL data . – Ternopil : Educational book – Bohdan, 2010.- 158 p.
2. Beloshapka VK Informational modeling in examples and problems. - Omsk: From the OGPI, 1992.
3. Bigon M., Harper J. , Townsend K. Ecology . Persons, populations and communities : Trans. with English In two books. Kn . 1. - M.: Mir, 1989.
4. Wentzel E.S. The theory of probabilities. - M.: Nauka. 1964. – 576p.
5. Voytyushenko , N. M. Informatics and computer science technique – K.: Academy , 2006. – 367.
6. Harina S.M. Methodical instructions for performing laboratory work in the discipline "Computational mathematics and programming" for students from the field of study 6.051401-"Biotechnology", part 2. - K.: NAU Publishing Center, 2007. - 88 p.
7. Harina S.M. Methodical instructions for performing laboratory work in the discipline "Computational mathematics and programming" for students from the direction of training 6.051401-"Biotechnology", part 1. - K.: NAU Publishing Center, 2006. - 95 p.
8. Gmurman V.E. Probability theory and mathematical statistics. M.: Higher School, 1978. –360p.
9. Hnedenko B.V. Probability theory course. M.: Nauka, 1965. - 400 p.
10. Horstko A. B., Ugolnytskyi G. A. Introduction to modeling ecological and economic systems. - Rostov : RSU, 1990.
11. E.M. Gursky Probability theory with elements of mathematical statistics. - M.: Higher School, 1971, - 328 p.
12. Danko P.E., Popov A.G., Koshevnyka T.Ya. Higher mathematics in exercises and problems. - M.: Higher School. 1986. - 304 p.
13. Dybkova L.M. Informatics and computer science technique - K.: Akademvydav , 2011, - 464 p.
14. Zhluktenko V.I., Nakonechnyi S.I. Theory probabilities and mathematical statistics. Kyiv : KDEU. 1977.
15. Drought V.A. Equation of a straight line on a plane / Agrarian science and education. T.63. - K.: NAU, 2005. - pp. 73-79.
16. Drought V.A. Characteristics of the set of variational series / Scientific Bulletin of NAU. T.63. - K.: NAU, 2004. - pp. 151-156.
17. Zasukha V.A., Lysenko V.P., Golub B.L. Applied mathematics , 3rd edition, revised and supplemented. K.: Aristeus , 2006 . - 3 3 4 s.
18. Information technologies: study guide / R.O. Tarasenko, S.M. Harina, T.P. Worker . - K.: NAU Publishing Center, 2005. - 200 p.
19. Information technologies: study guide / R.O. Tarasenko, S.M. Harina, T.P. Worker . - K.: Alefa , 2008. - 312 p.
20. Kiryanov D. Self-tutorial Mathcad 15/ Mathcad Prime 1.0 / Kiryanov

Dmitry - St. Petersburg: BHV-Petersburg, 2012. - 432 p.
21. Kuzminska O.H., Popov, O.E. / In format ika . Methodical implementation guide independent work for preparation specialists economic directions extramural forms training - K.: LLC " Agrar Media Group", 2012 - 90 p.
22. Makarova M.V. Informatics and computer science technique – Sumy : University Book, 2008, - 667 p.
23. Malyshevskyi O.V., Kolmakova V.O. Informatics . – Uman: Visavi , 2011. - 201 p.
24. Marmoza A.T. Workshop on mathematical statistics. -K.: Higher School, 1990. -191p.
25. Matyushkin- Gerke A. Educational and applied tasks in the computer science course. Informatics and education, No. 3-4, 5-6, 1992.
26. Merkuryeva E.K. Biometrics in breeding and genetics of agricultural animals. - M.: Kolos, 1970, - 424 p.
27. Nalyvaiko N.Ya. Informatics . - K.: Educational Center of literature , 2011. -576 p.
28. Computational mathematics and programming part 1 (title from the screen) [Electronic resource] Access mode http://elearn.nubip.edu.ua/course/view.php?id=379
29. Computational mathematics and programming part 2 (name from the screen) [Electronic resource] Access mode http://elearn.nubip.edu.ua/course/view.php?id=380
30. Petunyn Y.N. Application of the theory of random processes in biology and medicine. Kyiv: Nauk. dumka, 1981. - 320 p.
31. Pushkar O.I. Informatics : Computer technique Computer technologies./ Ed . O.I. Pushkar - K. Ed. Academy Center , 2001. – 696 p.
32. Ramsky Yu.S. Design and development of databases . – Ternopil : Educational book—Bohdan, 2005.- 115 p.
33. Ryklefs R. Fundamentals of general ecology: Translated. with English - M.: Mir, 1979.
34. Rudenko V.D. bases data in information systems. Study a guide for students pedagogical universities . - K.: Phoenix , 2010. - 240 p.
35. Sadko M.G., Soroka P.M. Educational and methodical manual " Bases data and system database management . - K.: NUBiP , 2014. - 120 p.
36. Seledzinskyi I.F., Vasylenko Ya.P. Foundations Informatics . – Ternopil : Educational book – Bohdan. 2007. – 157 p.
37. Tarasenko R.O., Lysenko V.P., Kasatkin D.Yu. Informational technologies in quality systems , standardization and certification . Kyiv , NAU, 2002. – 82 p.
38. Herharger M., Partoll H. Mathcad 2000. Complete manual . - K.: Izdatelskaya gruppa VN V , 2000. - 460p.
39. Shvidenko M.Z., Mokriev M.V., Matus Y.V., Popov O.E., Tkachenko

O.M., Glazunova O.G. Information and computer format technique : Textbook [for students of special higher teach institutions]/ Shvidenko M.Z., Mokriev M.V. etc. - Kyiv , 2014. - 646 p.
40. Shvidenko M.Z., Morse N.V., Soroka P.M. etc. Modern computer technologies : Educational guide . - K.: NNC " Institute agricultural of Economics of the Ukrainian Academy of Sciences", 2007. - 711 c.
41. Andrews S., Tsochantaridis I., Hofmann T. Support vector machines for multiple-instance learning . In Advances in Neural Information Processing Systems (NIPS), volume 15, MIT Press , 2003, pages 561–568.
42. Angluin D. Queries and concept learning . Machine Learning, 2:319–342, 1988.
43. Angluin D. Queries revisited . In Proceedings of the International Conference he Algorithmic Learning Theory , pages 12–31. Springer Verlag, 2001.
44. Balcan MF, Beygelzimer A, Langford J. Agnostic active learning . In Proceedings of the International Conference he Machine Learning (ICML), pages 65–72. ACM Press, 2006.
45. Baldridge J. and Osborne M.. Active learning and the total cost of annotation . In Proceedings of the Conference he Empirical Methods in Natural Language Processing (EMNLP), pages 9–16. ACL Press, 2004.
46. Chapman BL Enhancing Interactivity and Productivity Through Object-Oriented Author : An Instructional Designer's Perspective // Journal of Interactive Instruction Development , 1994, No. 7(2), pp. 3-11.
47. Craven M., Andrzejewski D., Zhu X. Incorporating domain knowledge into topic modeling via Dirichlet forest priors In Proceedings of the International Conference he Machine Learning (ICML), pages 25–32. ACM Press, 2009.
48. Dougiamas Martin . Computer Science and Education dissertation (Ph.D.) " The use of Open Source software that support a social constructionist epistemology of teaching and learning within Internet-based communities of reflective inquiry " http://moodle.udec.ntu-kpi.kiev.ua/moodle/mod/ resource / view.php?inpopup = true&id =1124
49. Excel 2013. Bible user / Walkenbach John – Moscow: Williams , 2015 . - 933 p.
50. Fishwick PA Computer Simulation : Growth through Extension . - 1994. - http://www.cis.ufl.edu/7Efishwick/paper/paper.html
51. Flexible Distant Learning // Communications and Information Technologies (CIT) Course . Applied Module for Teachers . Chapter 1. - 1999. - http://dlab.kiev.ua/cit/ap_ch1/c1l12_1.htm.
52. Karaliotas Y. Interactivity in the Learning Environment . Distant Education . (Project Report). - UK: Open University . - 1998.
53. Mamitsuka H. and Abe Query learning strategies using boosting and

bagging In Proceedings of the International Conference he Machine Learning (ICML), Morgan Kaufmann , 1998. pages 1–9.
54. Nyberg E., Arora S., Rose´e CP. Estimating annotation cost for active learning in a multi-annotator environment . In Proceedings of the NAACL HLT Workshop he Active Learning for Natural Language Processing , pages 18–26. ACL Press, 2009.
55. Palmer A., Baldridge J. How well does active learning actually work ? Timebased evaluation of cost-reduction strategies for language documentation . In Proceedings of the Conference he Empirical Methods in Natural Language Processing (EMNLP), pages 296–305. ACL Press, 2009.
56. SCORM. Shareable Content Object Reference Model . 2d Edition . – Advanced Distributed Learning , 2004. 96
57. Skinner BF The science of learning and Art of teaching . // Harvard Education Review , Spring , 24, 1954. p. 86-97.)
58. W. Lee , D. Owens Multimedia-Based Instructional Design : Computer-Based Training , Web-Based Training , and Distance Learning . Pfeiffer , 2000.
59. Wortman J., Balcan MF, Hanneke S. The true sample complexity of active learning . In Proceedings of the Conference he Learning Theory (COLT), pages 45–56. Springer, 2008.

Educational edition

IT

Textbook

Sub . to be printed on 26.11.2024.
Format 60x84 $^{1/16}$.
Offset paper. Offset printing.
Mind. printing. sheet 29.50
Edition of 100 approx.

Publishing house and printing: "COMPRINT"
73033, Kyiv a/s 15
e - mail komprint @ ukr . net
Witness CS No. 2 dated August 16, 2000