MINISTRY OF HEALTH OF UKRAINE
IVANO-FRANKIVSK NATIONAL MEDICAL UNIVERSITY

DEPARTMENT OF MEDICAL INFORMATICS,
MEDICAL AND BIOLOGICAL PHYSICS

MEDICAL INFORMATICS

TUTORIAL

for the Students of Foreign Citizens Training Faculty,
Specialization **"Medicine"**

Ivano-Frankivsk
Misto NV
2025

UDC 61:004.9](075.8)
M 40

Recommended by the Academic board of the Ivano-Frankivsk National Medical University
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This tutorial, tailored for students majoring in 222 “Medicine,” is structured in alignment with the curriculum requirements of the “Medical Informatics” course. Designed to support the credit-module system, the material is suitable for both traditional and distance learning formats. The manual provides comprehensive practical activity descriptions and step-by-step guidelines, final module control questions, a detailed breakdown of points allocation for each module, a curated list of recommended literature, and core information on each topic essential for mastering the course content.

This manual is an essential resource for students specializing in 222 “Medicine,” facilitating their understanding and successful completion of the course. This manual is suitable for students specializing in 222 “Medicine”.

Discussed and approved at the meeting of the Department of Medical Informatics, Medical and Biological Physics on August 28, 2024, protocol No. 1.

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ISBN 978-617-8435-01-1

Introduction

This book, *Medical Informatics*, is a helpful guide created by the team at Department of Medical Informatics, Medical and Biological Physics of Ivano-Frankivsk National Medical University. It is designed to meet the growing demands of modern healthcare. We believe that medical science and practice today can only succeed with the use of advanced computer technologies, which are essential for improving medicine.

These technologies help organize and optimize medical practice, manage medical information efficiently, and support the development of new diagnostic and treatment methods. They also make healthcare institutions run more smoothly. Personal computers have opened up new ways to share and access important medical information.

Additionally, international computer networks and digital libraries connect local healthcare practices with the latest global advances in medical science. Because of this, future doctors need to know not only medical knowledge but also how to use computers and software effectively.

Healthcare is becoming increasingly digital, using tools and methods to collect, process, send, and store medical information. This happens through the use of information, communication, and digital technologies in medical treatment and prevention.

This *Medical Informatics* course is designed to help future doctors develop the skills they need to use these technologies professionally in their careers.

We hope this textbook will introduce you to the exciting field of medical informatics, helping you learn more about computer technologies and modern healthcare software. With this knowledge, you will be ready to work confidently and effectively in the changing world of medical practice.

Authors

Safety Techniques for Personal Computer Use

In the IT lab, there are various electronic devices connected to a 220 V alternating current power supply. To ensure safety and efficiency during your sessions, follow these guidelines:

Before Starting:

1. Use a computer station only after receiving permission from the instructor.
2. Position the monitor so its center is slightly below your eye level.
3. Maintain a distance of 40–80 cm from the screen, adjusted to the size of on-screen objects.
4. Ensure your gaze is perpendicular to the center of the monitor.
5. Rest your fingers comfortably on the keyboard.
6. Position your arms so they form approximately a 90° angle at the elbows.
7. Place the keyboard 10–30 cm from the edge of the table, tilted at a 5°–15° angle.
8. Sit with your back supported by the chair and maintain an upright posture.
9. Keep your feet flat on the ground or a footrest for stability.
10. Clear your desk of unnecessary items to prevent clutter.
11. Ensure your hands are clean and dry before using the computer.
12. Use a special cleaning cloth for the monitor, keyboard, mousepad, and mouse, but only with the instructor's permission.
13. Inspect all computer equipment for visible damage or issues.
14. Power on the computer only after receiving the teacher's approval.

During Work:

1. Keep your desk organized and free from unnecessary items.
2. Maintain proper posture: avoid leaning too close to the screen, slouching, or straining your hands.
3. Take short breaks every 15–20 minutes to perform eye and muscle relaxation exercises, especially if you feel fatigued.
4. Report any computer malfunctions to the instructor immediately. Do not attempt to fix issues yourself.
5. Avoid touching the back of the monitor, the system unit, or power cables.
6. Handle removable media, such as USB drives, carefully to avoid damage.
7. Avoid touching the monitor screen to prevent smudges or damage to the anti-glare coating.
8. Do not open the computer's casing or modify connections without explicit authorization from the instructor.

After Work:

Turn off the computer and tidy up your workspace, but only after receiving the instructor's permission.

The goal of the course ***Medical Informatics*** is to help future doctors gain the professional knowledge, skills, and general and specialized competencies required by the Educational-Professional Program for the specialty 222 "Medicine" at the second (master's) level of higher education in the field of Health Sciences (code 22). Approved by the Academic Council of IFNMU, this program ensures that students can effectively use information, communication, and digital technologies in their professional work and social interactions.

The organization of the teaching process is provided according to the credit module rating system which matches the requirements of the Bologna declaration.

The discipline program "*Medical Informatics*" is divided into 4 content modules.

Content module 1. **Fundamental Concepts of Medical Informatics and the Role of Computers in Medical Practice.**

Content module 2. **Medical Data and Methodologies for Processing and Analysis.**

Content module 3. **Medical Knowledge and Decision-Making.**

Content module 4. **Patient-Centered Systems and Institutional Information Systems in Healthcare.**

Forms of Ongoing Assessment:

Theoretical Knowledge: Assessed through tests, individual questioning, and discussions.

Practical Skills: Evaluated through individual monitoring of practical tasks.

POINTS DISTRIBUTION

Students learn all topics with the teacher's guidance. Points for individual work are awarded at the end of each class and count toward the final grade for the ***Medical Informatics*** course.

Assessment Tools for Each Topic	**Number of points for each topic**
Test evaluation of various levels	0-3
Completion of practical tasks and individual questioning	0-12
Total Score per Topic	**0-15**
Eligibility for the Final Module Assessment (Sum of points for current activity)	**64 (8*8)**

To be eligible for the final module assessment, students must accumulate a minimum of **64 points** from ongoing activities (calculated as 8 topics × 8 points each).

THEMATIC PLAN OF PRACTICAL CLASSES
on MEDICAL INFORMATICS

for II-year Students of Foreign Citizen Training Department (specialty "Medicine")

№	Topic	Number of hours
MODULE 1. Fundamentals of Information Technologies in Healthcare and Analysis of Medical-Biological Data.		
Content module 1. *Fundamental Concepts of Medical Informatics and the Role of Computers in Medical Practice.*		
1.	Fundamental Concepts of Medical Informatics, Personal Computer Configuration, Safety Protocols, Basics of Windows Operating System, and Working with Medical Documents	2
2.	Processing and Analysis of Graphical Medical-Biological Data	2
3-4.	Management of Medical-Biological Data	2+2
Content module 2. *Medical Data and Methodologies for Processing and Analysis*		
5.	Statistical Processing and Analysis of Medical Data	2
6.	One-Way Analysis of Variance (ANOVA)	2
7.	Correlation and Regression Analyses	2
8.	Analysis of Biosignals, Processing Methods, Visualization of Medical-Biological Data, and Medical Image Processing and Analysis	2
9.	**Final Assessment of Module 1**	2
	TOTAL	**18**
MODULE 2. Medical Knowledge and Decision-Making in Medicine		
Content module 3. *Medical Knowledge and Decision-Making.*		
10.	Formalization and Algorithm Development for Medical Tasks	2
11.	Computer Modeling and Solving of Physico-Chemical Problems	2
12.	Formal Logic in Diagnostic, Treatment, and Disease Prevention Tasks	2
13.	Development of Mathematical Models Based on Medical-Biological Research Results	2
14.	Modeling and Solving Marketing Problems in Medicine	2
15.	Clinical Decision Support Systems, Prediction Tools, and Decision Support System Modeling	2
Content module 4. *Patient-Centered Systems and Institutional Information Systems in Healthcare*		
16.	Information Resources in Healthcare, Evidence-Based Medicine, and Fundamentals of Telemedicine	2
17.	Types of Information Systems in Healthcare, Hospital Information Systems, and Their Evolution	2
18.	Ethical and Legal Principles of Information Management in Healthcare, **Final Assessment of Module 2, and Comprehensive Course Evaluation**	**2**
	Total	**18**
	Total number of practical hours in the discipline,	**36**

CONTENT

Topic 1: FUNDAMENTAL CONCEPTS OF MEDICAL INFORMATICS, PERSONAL COMPUTER CONFIGURATION, SAFETY PROTOCOLS, BASICS OF WINDOWS OPERATING SYSTEM, AND WORKING WITH MEDICAL DOCUMENTS.

Actuality: A word processor is a flexible software program for creating, storing, and printing written documents. In contemporary times, word processors have emerged as some of the most extensively utilized software on computers, with Microsoft Word standing out as the preferred choice for many users.
In their routine operations, medical practitioners often create various documents, including, but not limited to, medical histories, letters, research articles, and reports. Therefore, it becomes indispensable for future healthcare professionals to acquire proficiency in working with text editors, enabling them to create and modify text and tables effectively.
In this hands-on session, we will explore executing the tasks utilizing the renowned text-processing software Microsoft Word.

Educational aims of the lesson:

To know:

1. Capabilities of the Microsoft Word processor.
2. General concepts of **MS Word** text editor.
3. Features of **MS Word** tables.

To be able to:

1. Create a text file.
2. Type text.
3. Edit, format, and save documents.
4. Create and format tables using MS Word.

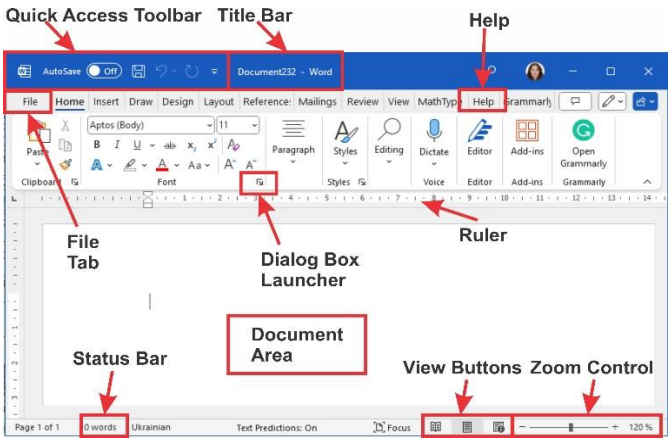
The list of questions for the survey:

1. Text editors and word processors.
2. **MS Word** program window.
3. Typing and formatting text.
4. Search, copy, and replace text fragments.
5. Correction of mistakes.
6. Saving and printing text documents.
7. Creation of tables.
8. Editing and formatting of tables.

The list of required practical skills:

1. Creating a text file.
2. Typing a text.
3. Editing, formatting, and saving **MS Word** documents.
4. Creating and formatting tables using **MS Word**.

Brief theoretical information
Microsoft Word processor



Microsoft Word is a software package developed by Microsoft corporation for word processing applications. With the finest document formatting tools, Word helps you organize and write your documents more efficiently. Word also includes powerful editing and revising tools so that you can collaborate with others easily. A word processor lets you change words or phrases, move whole sections of text from one place to another, store blocks of text, and align margins, all in a few seconds. Using MS Word, you can create complex documents containing text, tables, and diagrams.

Parts of MS Word Window

[from https://support.microsoft.com/en-us/word]

Title Bar: The title bar displays the document's name at the top of the window.

Quick Access Toolbar: Positioned in the top left corner, this toolbar includes commonly used commands like *Save*, *Undo*, and *Redo*. You can customize it by adding additional commands to enhance efficiency, offering quick access to frequently utilized features.

Ribbon: The Ribbon consists of seven horizontal tabs, each hosting a toolbar with various command buttons, menus, and input boxes organized into groups. Some groups feature dialog launchers, indicated by a downward-pointing arrow, which opens related dialog boxes when clicked. At any time, only the toolbar of the active tab is visible. Upon opening Word, the Home tab is active by default. Clicking on other tabs brings their respective toolbars to the forefront for use.

Ribbon Visibility: You can toggle the visibility of the Ribbon by clicking the icon  . Clicking this icon reveals the Ribbon again.

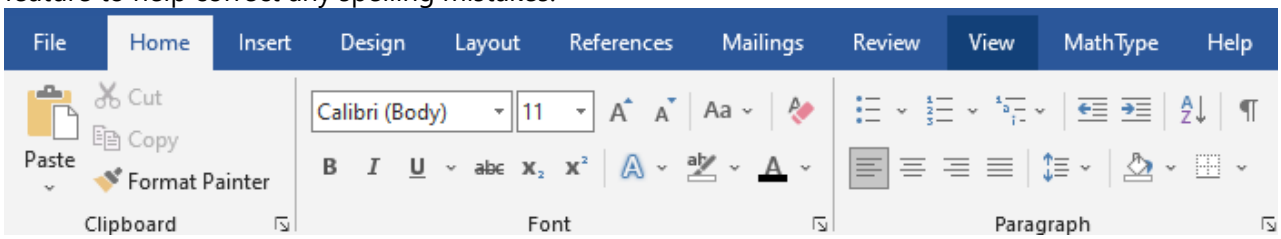
Ruler: The ruler is used to adjust margins and indents, aiding in creating documents with precise dimensions.

Microsoft Word Ribbon Tabs [1]

Ribbon Tab Name	Command Groups	Features
Home	Clipboard, Font, Paragraph, Styles, and Editing	The Home tab provides options to edit aspects of the basic formatting of your document, such as the font (type, size, color, etc.), text alignment, and creating bulleted or numbered lists.
Insert	Pages, Tables, Illustrations, Apps, Media, Links, Header & Footer, Text, and Symbols	The Insert tab provides options to place visual enhancements in your documents, such as pictures, tables, and charts.
Page Layout	Themes, Page Setup, Page Background, Paragraph, and Arrange	The Layout tab provides options for more advanced formatting of your documents, such as margins, page orientation (i.e., portrait/landscape), and size
References	Table of Contents, Footnotes, Citation & Bibliography, Captions, Index, and Table of Authorities	The References tab provides options for using various citations in your documents, such as footnotes, bibliographies, and captions.
Mailings	Create, Start Mail Merge, Write & Insert Fields, Preview Results, and Finish	The Mailings tab provides options for sending out your document, such as selecting recipients and inserting a greeting line.
Review	Proofing, Language, Comments, Tracking, Changes, Compare, and Protect	The Review tab provides options for editing your document's content, such as a Spelling and Grammar check, a translator, and inserting comments in specific areas
View	Views, Show, Zoom, Windows, and Macros	The View tab provides options for examining your document, such as a full-screen view, print previewing, and zooming in or out.

Formatting The Document

The **Home tab** in **MS Word** is a central hub for various text-formatting options. Here, you can choose a font style and size, modify text color, or apply bold, italic, and underlining enhancements. Additionally, you can align text, create stylish text objects with **WordArt**, and search for or replace text. For more detailed formatting choices, the **Font dialog box** is available. Lastly, the **Home tab** provides a spell-check feature to help correct any spelling mistakes.



Editing Margins

Microsoft Word documents start with *1-inch margins* by default, but you might need different settings for specific projects. You can choose from Word's preset margin options or set custom margins yourself.

Using Pre-Formatted Margins:

1. Click on the **Layout tab**.
2. Click the **Margins** button for a drop-down menu with preset options.
3. Choose the margin setting that suits your needs, and Word will automatically apply it.

Customizing Your Margins:

1. Start with the first two steps under Pre-Formatted Margins.
2. At the bottom of the menu, click on **Custom Margins**. This will open a dialog box.
3. Enter your preferred margins for each side of the page.
4. Click **OK** to apply your custom settings.

You can apply these changes to the entire document or move forward from the current page.

Working with Tables in MS Word

Tables in Word are an efficient way to organize data compactly and clearly. Word offers several tools to enhance your tables and make them more functional.

Creating a Table

MS Word gives you a couple of ways to create a table [1, 2].

1st way. Go to the **Insert** tab and click on **Table**. A small grid will appear (see **Fig. 1**). Move your mouse over the grid to choose the number of columns and rows you want for your table. For example, if you select four columns and three rows, Word will create a table of that size. Once you've chosen the dimensions, click, and the table will appear in your document. Each box on the table is called a "cell." To edit a cell, click inside it and type or make changes as needed.

Fig. 1

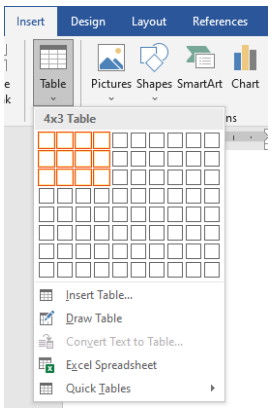
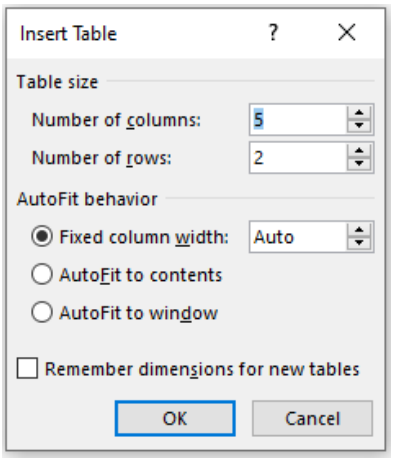


Fig. 2



2nd way. Go to the **Insert** tab and click on the **Table** option. From the drop-down menu, select **Insert**

Table. A dialog box will appear (see **Fig. 2**), allowing you to specify the number of rows and columns for your table. For example, you can create a table with five columns and two rows as shown in Fig. 2. Once you've set the dimensions, confirm, and your table will appear in the document (in this case table will consist of five columns and two rows).

3rd way. A third way to create a table in Word is by drawing it. This method allows you to design a table with cells of different sizes and shapes, rather than uniform rectangles, making it more flexible for your needs. Go to the **Insert** tab and click on the **Table** option. From the drop-down menu, select **Draw Table**. Use your cursor to draw the table structure you want directly in the document. This allows you to customize the table layout to suit your purpose.

Adding and Deleting Rows and Columns in a Table

To Add a Row or Column:

Method 1:

1. Right-click on the table.
2. Hover over **Insert** to see options for adding rows or columns.
3. Choose the desired option to insert a row or column.

Method 2:

1. Click on the row or column near where you want to insert a new one.
2. Go to the **Layout** tab on the **Ribbon**.
3. Use the buttons in the **Rows & Columns** group to add a row above or below, or a column to the left or right of the selected one.
   - For example, clicking **Insert Below** will add a new row just below the selected row.

To Delete a Row or Column:

Method 1:

1. Place your cursor in the row or column you want to remove.
2. Right-click and select **Delete Cells** from the menu.
3. In the dialog box that appears, choose **Delete entire row** or **Delete entire column**, then click OK to confirm.

Method 2:

1. Select the row or column you want to delete.
2. Go to the **Layout** tab on the **Ribbon**.
3. Click the **Delete Rows** or **Delete Columns** option in the **Delete Table group**.

To Apply a Table Style:

1. Click anywhere inside the table.
2. Go to the **Design** tab on the **Ribbon**.
3. In the **Table Styles group**, click the **More** drop-down arrow to view all available styles (see **Fig. 3**).
4. Select the style you like, and it will be applied to your table.

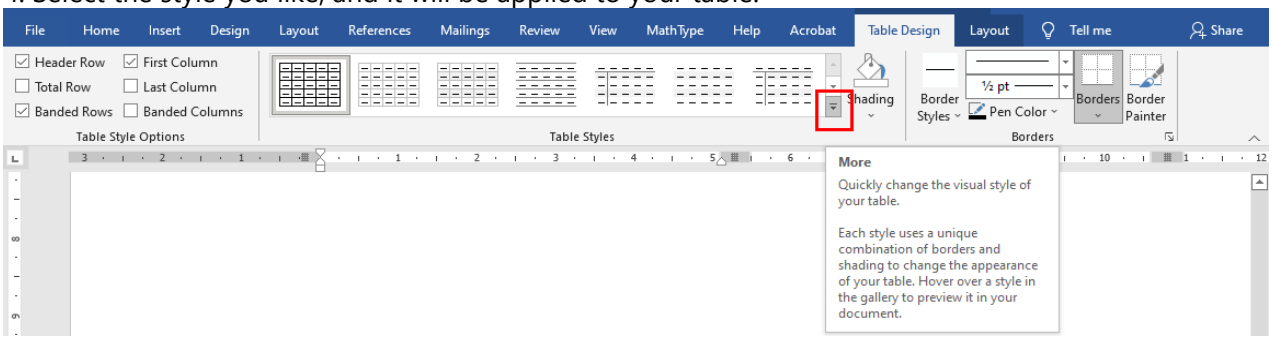


Fig. 3

Adding Borders to a Table:

1. Highlight the cells where you want to add borders.
2. Go to the **Design** tab. Choose the **Line Style**, **Line Weight**, and **Pen Color** you prefer (see **Fig. 4**).
3. Click the **Borders** drop-down menu.
4. Pick the border type you want from the list (see **Fig. 5**).
5. The selected borders will be applied to the highlighted cells.

When you select a table in **Word**, two extra tabs, **Design** and **Layout**, appear under **Table Tools**. The

Layout tab lets you make changes like adding rows and columns, merging or splitting cells, resizing cells, evenly distributing rows/columns, aligning text, or changing text direction.

Converting Text to a Table

1. Highlight the text you want to turn into a table.
2. Go to the **Insert** tab and click **Table**.
3. From the drop-down menu, choose **Convert Text to Table**. A dialog box will open (see **Fig. 6**).
4. In the **Separate text** section, select how the text should be divided into columns (e.g., by tabs, commas, or other separators).
5. Click **OK**. Your text will now appear as a table.

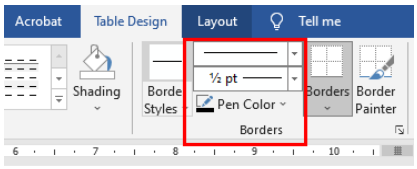


Fig. 4

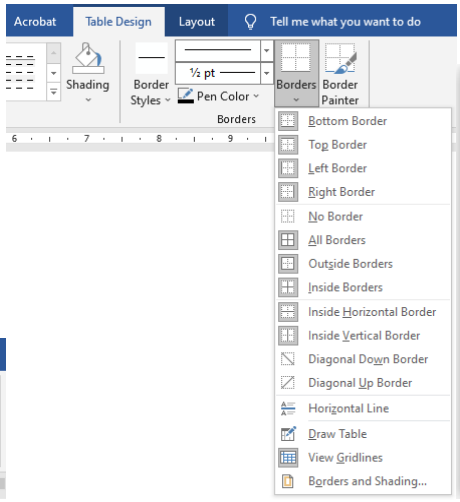


Fig. 5

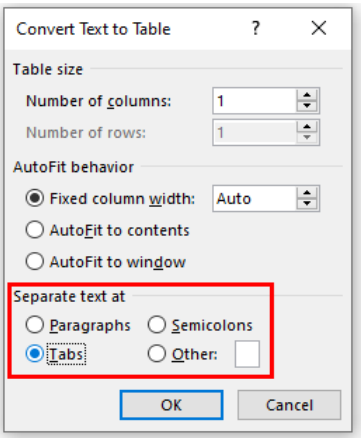


Fig. 6

Lists in Microsoft Word

Lists are a helpful way to organize information in a document, making it easier to read and understand. **Microsoft Word** offers tools for creating numbered and bulleted lists, which can also be customized to fit your needs.

How to Create a List

While Typing:

1. Go to the **Home** tab and find the **Paragraph** section.
2. Click the drop-down arrow next to **Numbering** or **Bullets**  .
3. Choose a style from the menu that appears.
4. Type your first item, then press **Enter** to automatically add the next number or bullet.
5. When you're done, click the **Numbering** or **Bullets** button again to stop the list.

From Existing Text:

1. Highlight the text you want to turn into a list.
2. In the **Home** tab, under the **Paragraph** section, click the **Numbering** or **Bullets** button  .
3. The text will automatically be formatted into a list.

Special List Options

Creating Multi-Level Lists:

Add a Second Level:

1. Select a list item and click **Increase Indent**  in the **Paragraph** section on the **Home** tab.
2. This will indent the item and change its numbering or bullet style.
3. To return to the main level, click **Decrease Indent**  .

Customizing Bullets or Numbers:

1. If the default styles don't work for you, click the drop-down arrow  next to **Bullets** or **Numbering** on the **Home** tab.
2. Choose a different style from the list. The current style will be highlighted.
3. Click **OK** to apply the new style.

Working with Columns in Microsoft Word

Columns can improve the layout of your document, making it more organized and easier to read. They are especially useful for materials like newspapers, newsletters, and flyers.

How to Create Columns:

1. Highlight the text you want to format into columns.
2. Go to the **Layout** tab and click the **Columns** button 

. A menu will appear.
3. Select the number of columns you want from the options provided.

How to Modify or Remove Columns:

To Remove Column Formatting:

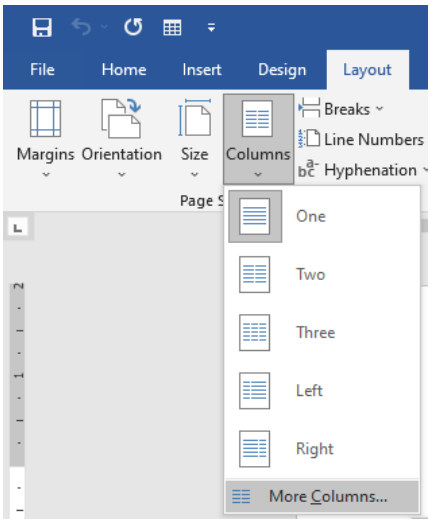
1. Place the cursor anywhere in the text with column formatting.
2. Go to the Layout tab and click the Columns button.
3. From the menu, select One to return the text to a single-column layout.

To Adjust Column Settings:

1. Click the **More Columns...** 

option at the bottom of the **Columns** menu (see **Fig. 8**).
2. In the dialog box that appears, you can set the number of columns and adjust their spacing.
3. For manual adjustments, use the **Ruler** at the top of the document to drag the *indent markers* and fine-tune spacing and alignment.

By following these steps, you can effectively create, edit, and manage columns to enhance the look and readability of your document.



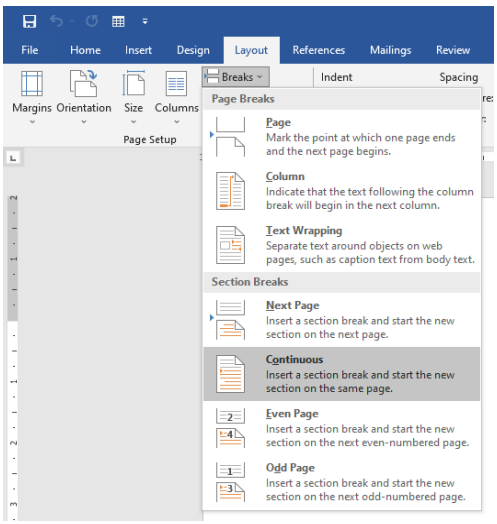


Fig. 7 **Fig. 8**

Page Breaks and Section Breaks

You can organize your document into distinct sections, each with unique formatting, such as different page orientations, margins, or columns. For instance, you might want to insert a two-column section within your document. Initially, a new document consists of a single section, but you can add more as needed.

Section Breaks:

Section breaks allow you to separate parts of your document to format each section individually. For example, you might want to apply a two-column layout to only one section without affecting the rest of the document. Word provides several types of section breaks (**Fig. 8**):

- **Next Page:** This break inserts a section break and starts a new page.
- **Continuous Break:** This break inserts a section break but continues the new section on the same page.
- **Even-Odd Page Break:** This break inserts a section break that starts the new section on the next even or odd-numbered page, depending on where the break is placed.

To Insert a Break:

1. Position the cursor at the spot where you want the break.
2. Go to the **Layout tab**, click the Breaks command (**Fig. 8**), and choose the appropriate break type from

the drop-down menu.
3. The break will be added; you can start formatting the new section as needed.

Practical tasks for students.
Instructions for the execution of practical work

1. *Start a computer* and wait for the **Windows OS** to load.
2. After completing the loading of **Windows OS** *start the* ***Microsoft Word*** *processor*.
3. *Save the document on Desktop* (select the **File** tab, then click **Save** or click the **Save** icon on the **Quick Access toolbar.** Type *Lesson 1_Your surname* in the highlighted **File name** text box, click **Desktop** in the left part of the **Save** window, and click the **Save** button).

Attention: *Don't forget to click the icon* ***Save*** *on the* ***Quick Access toolbar*** *every few minutes during the lesson to avoid losing your work.*

4. Perform the following tasks:

Task №1. *Copy the following text from the file* ***text-1.txt*** *and paste it into a new MS Word document. You can find the file by following the link:*

https://ifnmu.sharepoint.com/:t:/g/KMIMtBF/EeBa3DySFMhMiX2EyS7hpkgBDGky9RwuCWlHLvqTDgsPxQ

Ivano-Frankivsk National Medical University
Department of Medical Informatics, Medical, and Biological Physics
Lecture 6
Blood as Complex Fluid, Flow of Suspensions
Introduction
Blood Composition and Physiology
General Information
Composition of Blood
Rheological Parameters of Blood
Viscosity
Determinants of Whole Blood Viscosity
Introduction
Blood is the most complicated fluid. While flowing, it interacts with vessel walls both mechanically and chemically. The physical mechanisms determining the dynamics of a concentrated suspension's flow are very complicated.
Blood Composition and Physiology
General Information
Human blood is a liquid tissue that makes up about 1/13 of the total body mass and accounts for 5 to 6 litersin an average adult male.
Blood performs two major functions:
transporting through the body:
oxygen and carbon dioxide,
food molecules (glucose, lipids, amino acids),
ions (e.g., Na+, Ca2+, HCO3−),
wastes (e.g., urea),
hormones,
heat.
defending the body against infections and other foreign materials.
When blood is centrifuged, it separates into 2 portions:
Composition of Blood
Blood is composed of fluid plasma, solids (erythrocytes, leukocytes, platelets), and other elements either carriedto or away from cells.

Text after formatting:

Ivano-Frankivsk National Medical University
Department of Medical Informatics, Medical, and Biological Physics

Lecture 6

Blood as Complex Fluid, Flow of Suspensions

1. Introduction

Blood is the most complicated fluid. While flowing, it interacts with vessel walls both mechanically and chemically. The physical mechanisms which determine the dynamics of a concentrated suspension's flow are very complicated.

2. Blood Composition and Physiology

2.1. General Information

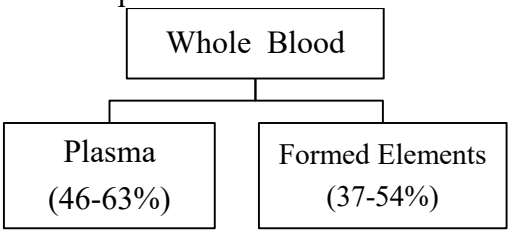
Human blood is a liquid tissue that makes up about 1/13 of the total body mass and accounts for 5 to 6 litersin an average adult male.

Blood performs two major functions:

1) transporting through the body:
- oxygen and carbon dioxide,
- food molecules (glucose, lipids, amino acids),
- ions (e.g., Na^+, Ca^{2+}, HCO^{3-}),
- wastes (e.g., urea),
- hormones,
- heat.

2) defending the body against infections and other foreign materials.

When blood is centrifuged, it separates into 2 portions:



2.2. Composition of Blood

Blood is composed of fluid plasma, solids (erythrocytes, leukocytes, platelets), and other elements either carriedto or away from cells.

****

Task №2. *Correct the document.*

Make sure you are at the top of the document. Select the **Review** tab, then click the **Spelling and Grammar** command, or press the **F7** button. Make corrections if necessary. Click the **Change** button if the highlighted selection is correct and the **Ignore** button to ignore a correctly spelled word.

****

Task №3. *Format the document as it is given above* (**Text after formatting**).

Instructions on text formatting

Page margins.

To specify exact page margins, select the Layout tab, then click the **Margins** command. Select **Custom Margins...** from the drop-down menu, and by clicking in the appropriate text boxes or on the arrows next to the numbers, adjust the following margins: top: 1,5 cm; bottom: 1,5 cm; left: 1,5 cm; right: 1,25 cm. Click **OK** to apply the changes.

Font Style, Size, Alignment, and other formatting effects.

To change font style and size using the **Home** tab commands (**Fig. 9**).

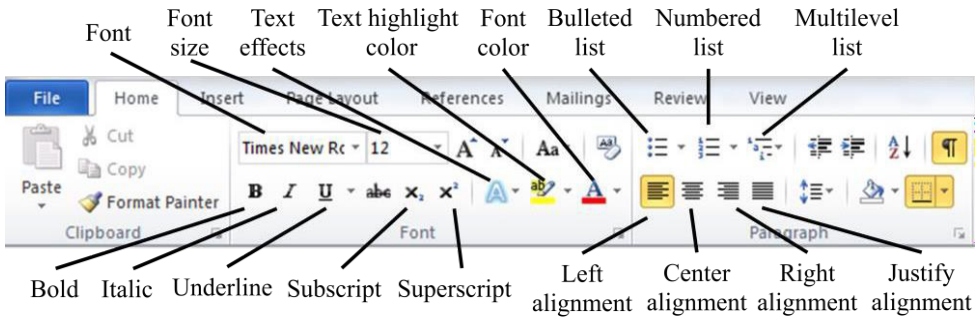


Fig. 9

***Note**: - Before applying formatting, select the text fragment you want to modify.*
To undo the last operation, press the **Ctrl+Z** *key combination on the keyboard or click* **Undo** *command on the* **Quick Access Toolbar**.

to the whole text, except the title and words "Lecture 6" apply font:

Times New Roman, size: **12** and alignment: **justify**;

- to the text title and words "Lecture 6," apply font: **Arial**, size: **12,** and alignment: to the **center**;
- to the text title and names of the paragraphs, apply **Bold** style;
- to the words "Ivano-Frankivsk State Medical University" and "Chair of Medical ComputerScience with Biophysics course" apply alignment to the **center**;
- for creating upper and lower indexes (Na^+, Ca^{2+}, $HCO3^-$) click **Superscript** and **Subscript** commands on the **Home** tab.

Making a list.

For making a numbered or bulleted list highlight (using a mouse) text fragment that should be converted into a list, click the drop-down arrow next to the **Numbering** or the **Bullets** command on the **Home** tab. A menu of list styles will appear. Select the list style you want to use.

Note**: For changing the automatically inserted list marker (for example* **3.) on the needed one (for example* **2.1.***) you should click on the* **3***. and type* **2.1.** *and press the* ***Space Bar*** *on the keyboard.*

Creating a scheme

• Press **Enter a** few times afterward "When blood is centrifuged, it separates into 2 portions:", then

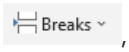
• select the **Insert** tab, click the **SmartArt** command 

in the **Illustrations** group. Select **Hierarchy** → **Organization Chart** → **OK**. Change the size and number of boxes as in the example above.

• To the words inside the **Text Boxes** apply font: **Times New Roman**, size: **12,** and alignment: to the **center**  .

***Note**: You can change the color of lines by clicking on it and selecting the **Format** tab, then clicking **Shape Outline** and selecting the desired **color** (in our case, **Black**) and **weight** from the drop-down menu.*

Inserting breaks and dividing text into columns

• Press **Enter** after the words "Determinants of Whole Blood Viscosity" in the plan of lecture 6. On the **Layout** tab, click the **Breaks** command 

, then select **Continuous** from the drop-down menu that appears (**Fig. 8**).

• Press **Enter** after the words "suspension's flow is very complicated" (the end of the paragraph called **Introduction**). Click the **Breaks** command, then select **Continuous** from the drop-down menu that appears.

• Select the text between two breaks (all **Introduction** paragraphs), on the **Layout** tab click the **Columns** command 

. Select **Two** from the drop-down menu that appears (**Fig. 7**).

****

Task №4. *Create a table according to the example below.*

Factors	Object of study	Contents of substance	
		SI System	Traditional System
Proteins			
Protein	Plasma	60-82 g/l	6,0-8,2 g%
Protein electrophoresis fraction:	Plasma		
Albumin		53-65 %	
▪1-globulin		2,5-5 %	
▪2-globulin		7-13 %	
▪-globulin		8-14 %	
▪-globulin		12-22 %	
Albumin	Whey	35-47 g/l	3,5-4,7 g%
Prealbumin	Whey	0,1-0,4 g/l	10-40 mg%
Hemoglobin	Unadulterated blood	120-160 g/l	12-16 g%
Hemoglobin 2	Unadulterated blood	1,8-3,5 % of hemoglobin	0,5-10 % of hemoglobin 0,4-1,5 % of hemoglobin
Hemoglobin carboxyl	Unadulterated blood		
Methemoglobin	Unadulterated blood		

Creating a table

• For inserting a table place the insertion point in the necessary place, then select the **Insert** tab, click the **Table** command  and choose **Insert Table** from the drop-down menu. In the **Insert Table** window (**Fig. 2**) set the necessary number of columns and rows in the table. Click **OK**, and the table will appear in the document.

• For merging cells select needed cells then click the right button of the mouse and choose **Merge Cells** from the menu that appears.

• For inserting the symbols ***α***, ***β,*** and ***γ*** into the table on the **Insert** tab click the **Symbols** command 

.

Click **More Symbols...**. Then, choose a necessary symbol and press the buttons **Insert** and **Close**.

****

Task №5. *Format the table according to the example below.*

Factors	Object of study	Contents of substance	
		SI System	Traditional System
Proteins			
Protein	Plasma	60-82 g/l	6,0-8,2 g%
Protein electrophoresis fraction:	Plasma		
Albumin		53-65 %	
α1-globulin		2,5-5 %	
α2-globulin		7-13 %	
β-globulin		8-14 %	
γ-globulin		12-22 %	
Albumin	Whey	35-47 g/l	3,5-4,7 g%
Prealbumin	Whey	0,1-0,4 g/l	10-40 mg%
Hemoglobin	Unadulterated blood	120-160 g/l	12-16 g%
Hemoglobin 2	Unadulterated blood	1,8-3,5 % of hemoglobin	0,5-10 % of hemoglobin 0,4-1,5 % of hemoglobin
Hemoglobin carboxyl	Unadulterated blood		
Methemoglobin	Unadulterated blood		

Instructions on the table formatting

- to the word "Proteins," apply font: **Times New Roman;** size: **12**; alignment: **Justify**; style: **Italic** and **Underlining** (for changing the underline style, click the arrow in the bottom right of the **Font** group on the **Home** tab, click the **Font** tab, and then select the needed style from the **Underline style** dialog box);
- for title use: font: **Courier New**; style: **Bold;** size: **12**, alignment to the **center**;

***Note**: For vertically centering text, select the needed text, then select the **Table Tools Layout tab** in the **Alignment group** and click the **Align center** command* .

- for the whole text in the table, except the title and word "Proteins," use **Times New Roman** font, size **12,** and **Justify** alignment;
- to set the **first line indent,** select the needed words and drag the **upper indent marker**
- on the ruler near the top of the screen to the needed position);
- for shading cells, select needed cells, click the **Table Design** tab, **Shading** command, and choose the needed color (**White, Background 1, Darker 25 %**) (**Fig. 10**);
- for title rows of the table and the row containing the word "Proteins," change the line width to **1,5 pt** (click Layout tab, **Page Borders** command, select Borders tab, click **All** icon choose $1\frac{1}{2}$ **pt** in **Width:** dialog box);
- for the outer borders of the table, set the line style and width of **1,5 pt** (click **Design** tab, **Line Style** command, choose the needed style, then **Line Weight** command, choose $1\frac{1}{2}$ **pt,** then draw the outer lines of the table by dragging the pencil pointer).
- Show the results of your work to the teacher.

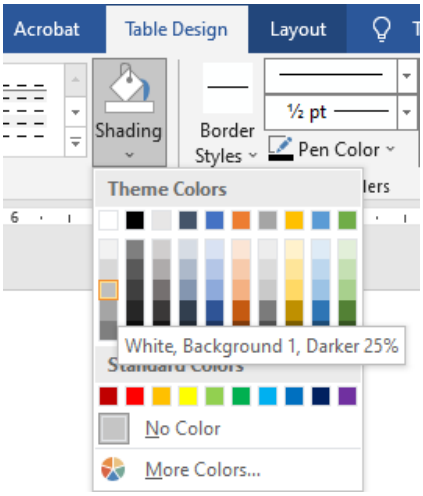


Fig. 10

***Attention**: After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:

Word help & learning. Microsoft.com. https://support.microsoft.com/en-us/word

1) Microsoft Word 2010: A User's Manual for Professors in the Humanities, 2011.

2) Insert a table - Microsoft support. (n.d.). Microsoft.com. Retrieved November 24, 2024, from https://support.microsoft.com/en-us/office/insert-a-table-a138f745-73ef-4879-b99a-2f3d38be612a

3) Health Informatics Online for Nelson and Staggers: Health Informatics: an Interprofessional Approach. Elsevier Science Health Science, 2017.

4) Добровольська А. М. Медична інформатика. Тестові завдання. Івано-Франківськ: Видавець Супрун В. П., 2018. 224 с.

5) Basham, S. (2021). Microsoft Word in easy steps: Also covers Word in Microsoft 365 suite. In Easy Steps Limited.

6) John, P. (2021). Microsoft Office 365 for Beginners & Advanced Learners: a Step-by-Step Practical Guide to Mastering Word, Excel & PowerPoint 365. Independently published.

Additional:

1) Добровольська А. М. Медична інформатика. Практикум. Івано-Франківськ: Сімик, 2013. 440 с.

2) Бондаренко Т.І. Основи медичної інформатики. Практикум: навчальний посібник. Всеукраїнське спеціалізоване видавництво «Медицина», 2018. 128с.

3) Медична інформатика в модулях: Практикум. 2-ге вид., випр. / За ред. І. Є. Булах. Київ: ВСВ "Медицина", 2009. 208 с.

Topic 2: PROCESSING AND ANALYSIS OF GRAPHICAL MEDICAL-BIOLOGICAL DATA.

Actuality: In the field of medicine, it's commonly needed to graphically illustrate results derived from initial data, develop visual diagrams, and perform calculations using specialized formulas. Presenting data in the form of charts and graphs clarifies relationships within the data, facilitating the identification of patterns or anomalies. This process is crucial for deriving meaningful insights. **Microsoft Excel** is a leading spreadsheet tool that stands out in organizing, analyzing, and displaying numerical data effectively. Consequently, proficiency in Excel is critical for healthcare professionals aiming to excel in their fields.

Educational aims of the lesson:

To know:

1. General concepts of **MS Excel** spreadsheets.
2. Types of diagrams and graphs.

To be able to:

1. Create, edit, and format spreadsheets in **MS Excel.**
2. Build diagrams and graphs using **MS Excel**.
3. Edit and format diagrams and graphs.

The list of questions for the survey:

1. Essential parts of the **MS Excel** Window.
2. **MS Excel** tabs: File, Home, Insert, Page Layout, Formulas, Data, Review, View.
3. Work with sheets.
4. Data inputting and editing.
5. Entering and copying formulas.
6. Formatting cells and ranges.
7. Saving files.
8. Work with objects in **MS Excel**.
9. Types of diagrams and graphs.
10. Diagrams and graphs construction.
11. Editing and formatting diagrams and graphs.

The list of required practical skills:

1. Creating, editing, and formatting spreadsheets in **MS Excel**;
2. Building diagrams and graphs using **MS Excel**;
3. Editing and formatting diagrams and graphs.

Brief theoretical information

Microsoft Excel basic window

The main parts of the **Microsoft Excel** window are [1] (**Fig. 1**):

Title Bar. The title bar displays the name of the current workbook. It also holds the **Quick Access toolbar** and the Excel Window controls that you can use to modify the Excel window. If the Excel Window is in restore mode, then you can use the Title bar to move the window around.

Quick Access toolbar. The Quick Access Toolbar gives you easy access to common commands such as Save, Undo, and Redo.

Excel Window Controls (Minimize, Maximize/Restore & Close buttons).

Help button. The help button provides you with a shortcut to open the Excel help window.

Ribbon. The ribbon holds the various commands and features in Excel, arranged on a series of eight tabs: File, Home, Insert, Page Layout, Formulas, Data, Review, and View. The Home tab contains the most frequently used commands in Excel.

Formula Bar. The Formula Bar displays the contents of the selected cell in a spreadsheet, along with a reference to the active cell or the range of the current selection of cells. You can also use the Formula Bar to enter content such as data, formulas, or functions into the spreadsheet.

Status Bar. This bar displays various messages as well as the status of the Num Lock, Caps Lock, and Scroll Lock keys on your keyboard. It also shows summary information about the range of cells that are selected. Right-click the status bar to change the information that's displayed.

The name box appears on the left side of the Formula Bar and displays the active cell address or the name of the selected cell, range, or object.
Worksheet Tab. Each worksheet has a tab that appears below the workbook and displays the name of the worksheet.
Scroll Bars appear along the right side and bottom of the workbook window and enable you to scroll through the worksheet.

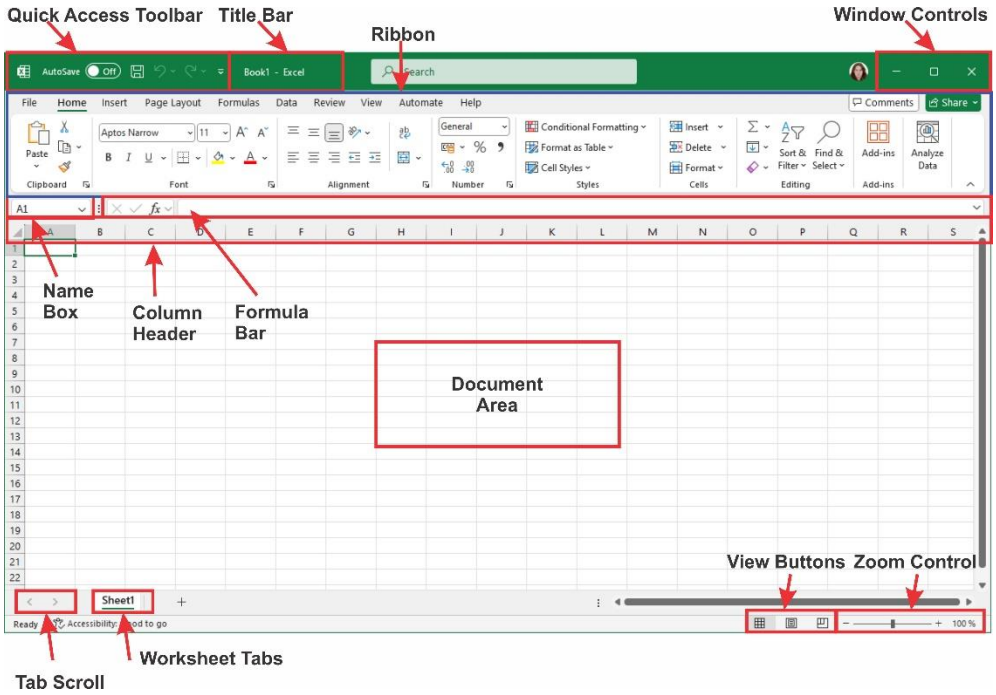


Fig. 1

MS Excel Ribbon Tabs [from https://support.microsoft.com/en-us/excel]

Name	Description
File	Opens the Backstage view, where you can manage files (e.g., save, open, print) and customize MS Excel program settings
Home	The default tab with commonly used commands like formatting, editing, and basic tools
Insert	Provides tools to add elements to a worksheet, such as charts, tables, or images
Page Layout	Includes options to adjust the worksheet's appearance, such as margins, orientation, and themes
Formulas	Contains tools for inserting formulas, naming ranges, and checking formulas for errors
Data	Offers commands to manage, sort, filter, and connect to external data sources
Review	Includes features for spelling checks, tracking changes, adding comments, and protecting your worksheet
View	Allows you to change how the worksheet is displayed, including zoom options and layout views

Equations

MS Excel can make calculations automatically once the cells have been properly programmed. This feature can be used to make a single calculation, like in a calculator, or can be done on an entire row or column of data using the same formula. Any equation starts by typing **"="** into the cell; this tells Excel that you want to calculate something.
Almost **any equation can be made by clicking on the cells** that you want to use, with the correct mathematical operators (multiply, divide, add, subtract, etc.). Excel automatically places the cell you click while in equation mode into the equation.

Common mathematical operators are:

OPERATION	ARITHMETIC OPERATOR	EXAMPLE	DESCRIPTION
ADDITION	+	= A1 + A2	Adds values in cells A1 and A2
SUBTRACTION	-	= A1 - A2	Subtracts the value in cells A2 from the value in cell A1
MULTIPLICATION	*	= A1 * A2	Multiplies the values in cells A1 and A2
DIVISION	/	= A1 / A2	Divides the value in cell A1 by the value in cell A2
EXPONENTIATION	^	= A1 ^ 3	Raises the value in cell A1 to the third power

[from: https://www.projectcubicle.com/what-is-the-symbol-in-excel-excel-formulas/]

Absolute and Relative Cell References in Excel

Cell references are essential for building formulas in Excel. They enable formulas to automatically update when the values in referenced cells change, and they facilitate the adaptation of formulas as cells are copied or moved. There are two main types of cell references: **relative** and **absolute**, and each behaves differently when replicated across other cells.

Relative References: By default, cell references in Excel are relative. This means that when a formula is copied to another cell, the reference changes based on the new cell's position relative to the original. For example, copying the formula **=A1+B1** from row 1 to row 2 changes the formula to **=A2+B2**. This adaptability makes relative references useful for performing the same calculations across various rows or columns.

Absolute References: In contrast, absolute references remain fixed regardless of where the formula is copied. They help maintain constant references to specific rows or columns within a formula. To create an absolute reference, you add a dollar sign **($)** before the column letter, row number, or both within the formula. For instance**, $A$1** always refers to cell **A1**, even if the formula is copied to a different location.

Understanding these differences enhances your ability to manage data efficiently in Excel, ensuring that your formulas behave exactly as intended when applied across your worksheets.

$A$2	The column and the row do not change when copied
A$2	The row does not change when copied
$A2	The column does not change when copied

When writing a formula, you can press the **F4** key on your keyboard to switch between relative and absolute cell references. This is an easy way to quickly insert an absolute reference.

Functions

A **function** is a **pre-defined formula** that helps to perform standard mathematical functions. Functions save you the time of writing lengthy formulas. You could use an Excel function called **Average**, for example, to quickly find the average value of the range of numbers. Or you could use the **Sum** function to find the sum of a cell range. **Excel** contains many different functions.

Each function has a specific order, called **syntax**, which must be strictly followed for correct function work.

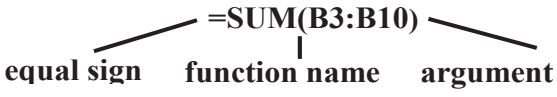
Syntax Order:

All functions begin with the **equals sign** (**=**).

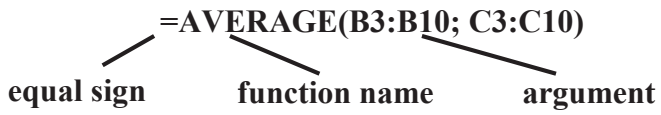
After the **=** sign, the **function name** (e.g., Sum) follows.

One or more **arguments –** numbers, text, or cell references – are enclosed by parentheses. If there is more than one argument, they are separated from each other by a comma or semicolon, depending on the settings.

An example of a function with **one argument** that adds a range of cells (from B3 to B10):



An example of a function with **more than one argument** that calculates the average value of numbers in the cells ranges **B3:B10**, and **C3:C10**:



Excel has hundreds of different **functions** to assist with your calculations. Building formulas can be difficult and time-consuming. Excel's functions can save you a lot of time and headaches.

Excel Functions

There are many different functions in **Excel** [2].

Excel functions (alphabetical) https://support.microsoft.com/en-us/office/excel-functions-alphabetical-b3944572-255d-4efb-bb96-c6d90033e188

Some of the most common functions include:

MATHEMATICAL			
ABS	Returns the absolute value of a number	**LOG10**	Returns the base-10 logarithm of a number
COS	Returns the cosine of a number	**PI**	Returns the value of pi
SIN	Returns the sine of the given angle	**POWER**	Returns the result of a number raised to a power
TAN	Returns the tangent of a number	**RADIANS**	Converts degrees to radians
EXP	Returns e raised to the power of a given number	**SQRT**	Returns a positive square root
LN	Returns the natural logarithm of a number	**SUM**	Adds its arguments
STATISTICAL			
AVERAGE	Returns the average of its arguments	**FDIST**	Returns the F probability distribution
COUNT	Counts how many numbers are in the list of arguments	**FTEST**	Returns the result of an F-test
MAX	Returns the maximum value in a list of arguments	**MEDIAN**	Returns the median of the given numbers
MIN	Returns the minimum value in a list of arguments	**MODE**	Returns the most common value in a data set
CORREL	Returns the correlation coefficient between two data sets	**NORMDIST**	Returns the normal cumulative distribution
CHIDIST	Returns the one-tailed probability of the chi-squared distribution	**PEARSON**	Returns the Pearson product moment correlation coefficient
CONFIDENCE	Returns the confidence interval for a population mean	**STDEV**	Estimates standard deviation based on a sample
CHITEST	Returns the test for independence	**TDIST**	Returns the Student's t-distribution
FISHER	Returns the Fisher transformation	**DEVSQ**	Returns the sum of squares of deviations
LOGICAL			
AND	Returns TRUE if all of its arguments are TRUE	**NOT**	Reverses the logic of its argument

FALSE	Returns the logical value FALSE	**OR**	Returns TRUE if any argument is TRUE
IF	Specifies a logical test to perform	**TRUE**	Returns the logical value TRUE
FINANCIAL			
ACCRINT	Returns the accrued interest for a security that pays periodic interest	**ISPMT**	Calculates the interest paid during a specific period of an investment
DISC	Returns the discount rate for a security	**FV**	Returns the future value of an investment
DATE & TIME			
DATE	Returns the serial number of a particular date	**TIME**	Returns the serial number of a particular time

You don't need to memorize all the functions, but it's helpful to understand their potential applications. You can easily find specific functions by browsing categories in the **Function Library**, which is accessible via the **Formulas tab**.

To insert a function from the Function Library:

1. Select the cell where you want the function to be placed.
2. Click the **Formulas tab** on the **Ribbon** to open the **Function Library**.
3. Within the **Function Library**, choose the category that fits the function you need.
4. Select the function you want to use from the category menu.
5. The **Function Arguments** dialog box will open, allowing you to input or select the cells that will serve as arguments in the function.
6. Click **OK** to confirm.
7. The function will compute, and the result will be displayed in the selected cell.

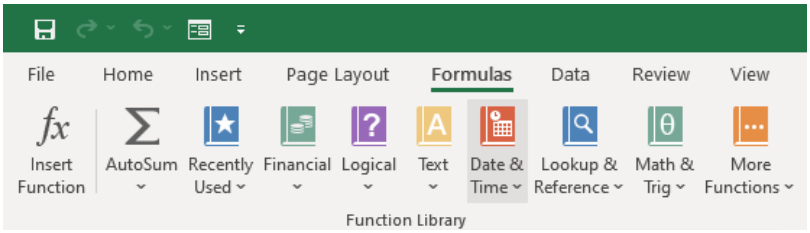


Fig. 2

To Create a Simple Formula that Adds the Contents of Two Cells (**Fig. 3, a**):

Click the cell where the answer will appear (**C5**, for example).

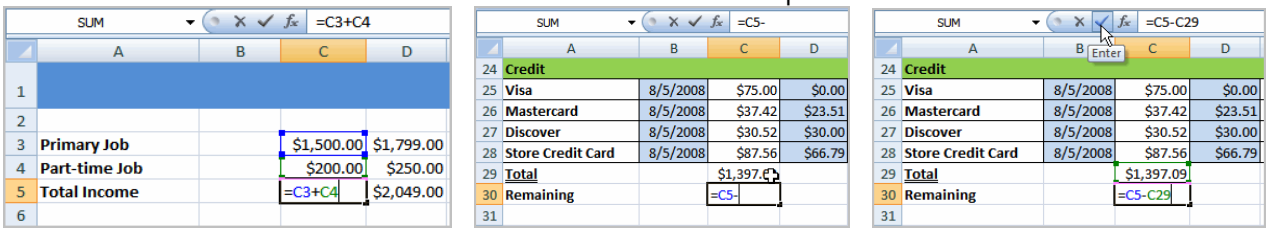
Type the **equals sign (=)** to let Excel know the formula is being defined.

Type the cell number that contains the first number to be added (**C3**, for example).

Type the **addition sign (+)** to let Excel know that an add operation is to be performed.

Type the cell address that contains the second number to be added (**C4**, for example).

Press **Enter** or click the **Enter button** on the Formula bar to complete the formula.



a) **b)** **c)**

Fig. 3

To Create a Simple Formula using the Point and Click Method (**Fig. 3, b, c**):

Click the cell where the answer will appear (**C30**, for example).

Type the **equals sign (=)** to let Excel know the formula is being defined.

Click on the **first cell** to be included in the formula (**C5**, for example).
Type the **subtraction sign (-)** to let Excel know that a subtraction operation is to be performed.
Click on the **next cell** in the formula (**C29**, for example).
Press **Enter** or click the **Enter button** on the Formula bar to complete the formula.

Copying Functions in Excel

You can easily copy a function to nearby cells:
1. Hover your mouse over the cell with the function until you see the small square at the bottom-right corner (the fill handle).
2. Click, hold, and drag the fill handle over the cells where you want to copy the function.
3. Release the mouse, and Excel will calculate the new values based on the relative rows or columns.

Working with Charts in Excel

When a workbook has a lot of data, charts can make the information easier to understand by presenting it visually. Charts help highlight trends, comparisons, and relationships in your data. Excel offers a variety of chart types to suit different purposes [3]:
Line Chart: Displays data trends over time by connecting points with a line. Ideal for showing changes or patterns.
Column Chart: Uses vertical bars to represent values across different categories. Great for comparing data over time.
Bar Chart: Similar to a column chart but uses horizontal bars instead of vertical ones. Useful for comparing data across categories.
Area Chart: Highlights trends over time and shows the contribution of each part to the whole.
Pie Chart: Represents parts of a whole as slices of a circle. Effective for showing percentages or proportions.
Other Charts: Excel also includes specialized charts like **Doughnut**, **Scatter** (XY), **Bubble**, **Radar**, **Surface**, and **3D** options such as **Cone**, **Cylinder**, and **Pyramid charts**.

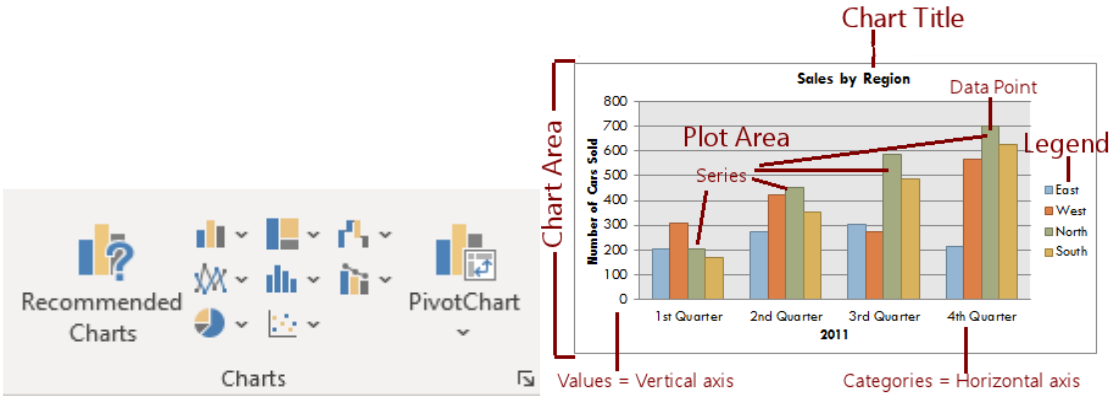


Fig. 4

Understanding the Parts of a Chart

Charts in Excel have several key components (see **Fig. 4**):
Title: The main heading that describes the chart.
Legend: Explains what the colors or symbols in the chart represent.
Axis: Includes the vertical (Y-axis) and horizontal (X-axis) lines that structure the chart.
Data Series: The actual values displayed in the chart, often drawn from rows or columns in your data.
Value Axis: Represents the numerical scale or units of the data.
Category Axis: Identifies the labels or categories for each data series.

Creating a Chart in Excel

1. Prepare the Data: Enter and organize the data in your spreadsheet. Highlight the cells you want to include in the chart.
2. Insert the Chart:
- Go to the **Insert** tab at the top of the screen.
- In the **Charts group**, select a chart type (e.g., line, bar, or pie) from the available options.
- Click the chart icon you prefer, and Excel will add it to your sheet.

Customizing Chart Design

Once the chart is selected, the **Chart Design** tab will appear, offering tools to personalize its look:
Chart Style: Adjust the overall appearance of the chart.
Layout and **Colors:** Modify the layout or apply a color scheme to enhance its visual appeal.

Chart Options

1. Adding Titles:
- Go to the **Chart Design** tab.
- Click **Add Chart Element** to add or edit the chart title and labels.

2. Changing Chart Type:
- In the **Chart Design** tab, click **Change Chart Type** to switch to a different chart style without starting over.

3. Formatting the Chart Area:
- Right-click on the chart's border and select Format **Chart Area** to adjust the chart's border, fill, shadows, and other design elements.

4. Moving the Chart:
- Click on the chart to select it.
- In the **Chart Design** tab, click **Move Chart**.
- In the dialog box, choose where to move the chart, such as creating a new worksheet.
- Click **OK** to confirm.

These steps allow you to create, modify, and organize charts effectively, making your data presentation clear and visually appealing.

Practical tasks for students.
Instructions for the execution of practical work

1. Start a computer and wait for the loading of **Windows OS.**
2. Start **Microsoft Excel** program: **Start** → **ALL Programs** → **Microsoft Office** → **Microsoft Excel**.
3. *Save the document on Desktop* (select the **File** tab, then click **Save** or click the **Save** icon on the **Quick Access toolbar.**

Attention: *Don't forget to click the icon* ***Save*** *on the* ***Quick Access toolbar*** *every few minutes during the lesson to avoid losing your work.*

4. Perform the following tasks:

Task №1. ***Prepare the pharmacy invoice form and construct the pie chart.***
Create a new electronic table as shown in ***Fig. 5***:
• select cells **A1:E1** on the **Sheet1**, on the **Home** tab, in the **Alignment** group, click **Merge and Center** ;
• in the same way, merge cells **B9:D9**;
• type text into cells **A1:E2** and **A3:D9** according to **Fig. 5**;

Note: *To change the width of columns to fit the contents, select the column or columns you want to change, then double-click the boundary to the right of a selected column heading.*
To change the width of one column, drag the boundary on the right side of the heading until the column is the width you want.

Calculate the Total price for each kind of medication:
• click the cell **E3** and type the formula **=C3*D3** (select cell **E3**, press **=**, click cell **C3**, press ***** (asterisk), click cell **D3**, press **Enter)**;
• select cell **E3** and copy the formula to the cells **E3:E8** by drag and drop method (click cell **E3**, drag the lower left corner of the cell down to cell **E8**).

Calculate the total:

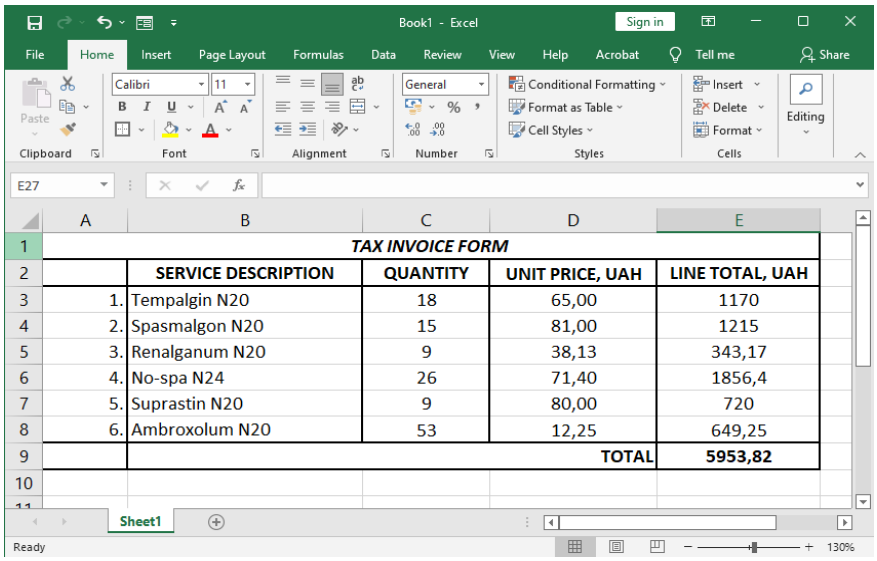
• select cell **E9**, on the **Formulas** tab in the **Function Library** group, and click **Autosum** Σ
(If you do everything right, in cell **E9** write a formula **=SUM(E3:E8)**). Press **Enter.**
*Format the table according to **Fig. 5**.*

Formatting instructions:
Font: **Arial**;
Size: cells **A3:E8** – **11**, cells **A1:E2**, **B9:E9** – **12**;
Style: cells **A1:E1** – **Bold Italic**, cells **B2:E2**, **B9:E9** – **Bold,** other cells – **Regular**;
Alignment: all table area, except cells **B3:B8** – **Center**, cells **B3:B8** – **Left**.

Detailed formatting instructions:

• select cells **A1:E9**, on the **Home** tab, in the **Font** group, select **Arial** in the **Font** box Arial;
• select cells **A3:E8**, on the **Home** tab, in the **Font** group, select **11** in the **Font Size** box 11;
• select cells **A1:E2**, on the **Home** tab, in the **Font** group, select **12** in the **Font Size** box;
• in the same way change the **Font Size** of cells **B9:E9** to **12**;
• select cells **A1:E1**, on the **Home** tab, in the **Font** group, click **Bold** B**, Italic** I;
• select cells **B2:E2**, on the **Home** tab, in the **Font** group, click **Bold** B**;**
• select cells **B9:E9**, on the **Home** tab, in the **Font** group, click **Bold** B**;**
• select cells **B3:B8**, on the **Home** tab, in the **Alignment** group, click **Align Text Left**;
• select cells **B2:E2**, on the **Home** tab, in the **Alignment** group, click **Center;**
• in the same way align to the center text in the cells **A3:A8**, **C3:E8,** and **E9**;

*Apply cell borders to the table according to **Fig. 5***:
• select the cells you want to format, and click the down arrow beside the **Borders** button in the **Font** group
on the **Home** tab. A drop-down menu appears, with all the border options you can apply to the cell selection. Click the type of line you want to apply to the selected cells.



	A	B	C	D	E
1		*TAX INVOICE FORM*			
2		SERVICE DESCRIPTION	QUANTITY	UNIT PRICE, UAH	LINE TOTAL, UAH
3	1.	Tempalgin N20	18	65,00	1170
4	2.	Spasmalgon N20	15	81,00	1215
5	3.	Renalganum N20	9	38,13	343,17
6	4.	No-spa N24	26	71,40	1856,4
7	5.	Suprastin N20	9	80,00	720
8	6.	Ambroxolum N20	53	12,25	649,25
9				TOTAL	5953,82
10					

Fig. 5

*Create a pie chart and format it according to **Fig. 6**:*
• select cells **B3:B8, press and hold down CTRL while you click** cells **E3:E8** (at the selecting of nonadjacent ranges of cells hold down **CTRL**);
• click the **Insert** tab in the **Charts** group, select **Pie** chart category;
• from the drop-down menu, select **Exploded pie in 3-D** chart type, the chart will appear in the worksheet.
Note**: Once you insert a chart, a set of **chart tools** arranged into three tabs will appear on the **Ribbon

(***Design, Layout, Format***). *These are only visible when the chart is selected. You can use these three tabs to modify your chart.*

• *change the position of the legend* (from the **Chart Elements**  , click the **Legend** 
command, select **Bottom** from the drop-down menu);

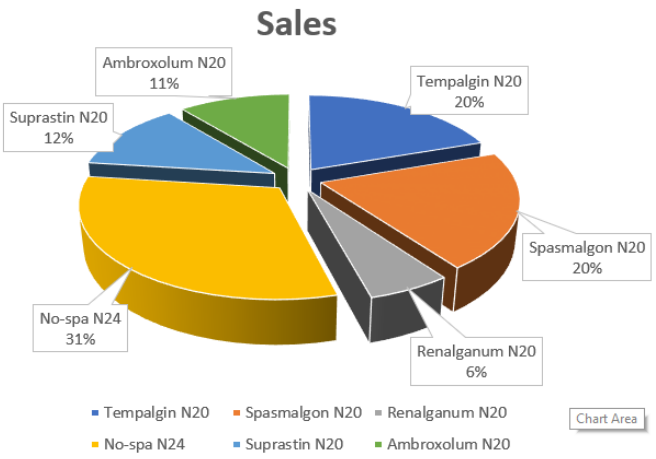


Fig. 6

• *add a title to the chart*;

• *add data labels to the chart* (from the **Chart Elements**  , click the **Data Labels** 
button in the **Data Labels** group, and select **Outside End** from the drop-down menu);

****

Task №2. *Draw the graph of the function of two variables* $z = x^2 - y^2$ *for values of* ***x*** *and* ***y*** *that lie within the interval* ***[-2; 2]*** *and change with step* ***0.2***.

For this purpose, it is necessary to:

Create the table with function values at values of x and y on intervals [-2; 2] with step 0.2:

• type in the cell **B1** the value **-2** and press **Enter**;

• click on the cell **B1** and click the **Fill** button  in the **Editing** group of the **Home** tab;

• select **Series…** from the drop-down menu;

• in the opened window, choose **Series in: *Rows***, **Type: Linear**, **Step value: 0,2**, **Stop value: 2**. Click **OK** (**Fig. 7**);

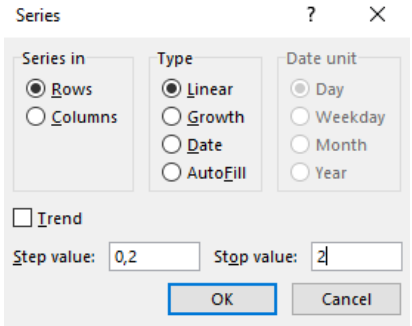


Fig. 7

• type in cell **A2** the value **-2** and press **Enter**;

• click on the cell **A2** and click the **Fill** button  in the **Editing** group of the **Home** tab;

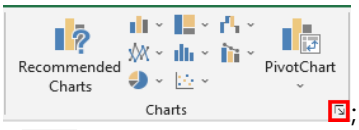
• select **Series…** from the drop-down menu;

• in the opened window choose: **Series in: *Columns***, **Type: Linear**, **Step value: 0,2**, **Stop value: 2**. Click **OK**;

• type the formula **=B1^2-A2^2** in cell **B2** and copy it into range **B2:V22.**

*Draw the graph (**Fig 8**)*:

• select cells **A1:V22**;

• click the **Insert** tab, in the **Charts** group, select **Other Charts** category 

;

• from the **All Charts** menu, select **Surface** → **Wireframe 3-D Surface**  chart type, the chart will appear in the worksheet.

Format the graph according to Fig 8:

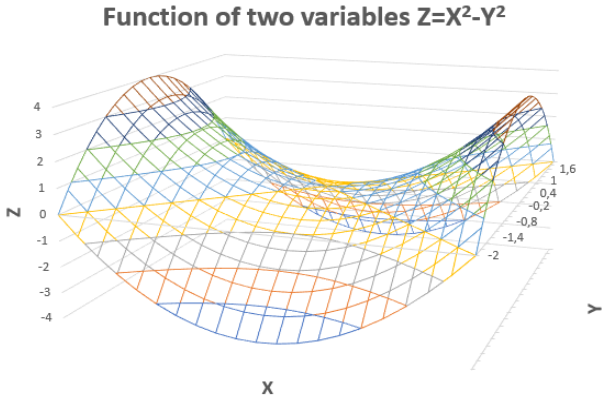


Fig. 8

Note: *To format text as superscript or subscript, select the characters that you want to format on the Home tab, in the Font group, click the Format Cell Font dialog box launcher*  , *and under Effects, select the Superscript or Subscript check box.*

****

Task №3. *Construct by yourself the surface for function* $z = x^2 * y^2$.

5. Click **File** → **Save.**

6. Show the teacher the results of your work.

7. Close **MS Excel** document.

Attention: *After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

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Topic 3: WORKING WITH MS ACCESS. PART I.

Actuality: Because information is so important in most organizations, computer scientists have developed a large body of concepts and techniques for managing data. Microsoft Access is a Database Management System offered by Microsoft. Microsoft Access offers the functionality of a database and the programming capabilities to create easy-to-navigate screens (forms). It helps healthcare professionals analyze large amounts of information and manage data efficiently.

Educational aims of the lesson:

To know:

1. **MS Access** basic concepts;
2. the database window structure;
3. **MS Access** objects (tables, queries, forms, and reports).

To be able to:

1. create and edit databases;
2. create and work with tables, queries, forms, and reports;
3. search and sort information in the database.

The list of questions for the survey:

1. Start the **MS Access** program.
2. **MS Access** Window. **MS Access** tabs.
3. Database creation.
4. Types and properties of the fields.
5. Key field (primary key).
6. Working with the tables.
7. Database sorting and filtration.
8. Creation of queries.
9. Creation of forms.
10. Creation of reports.

The list of required practical skills:

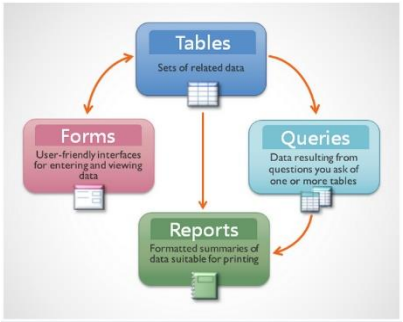
1. Database creation and edition.
2. Creation and working with tables, queries, forms, and reports.
3. Sorting and searching of information in database.

Brief theoretical information

What is a Database?

A **database** is a way to store and organize data on a computer [1]. It allows users to quickly enter, access, and analyze information. Databases are so common that we use them every day without realizing it. For example, when a receptionist at a doctor's office types your details into a computer or a store employee checks if an item is in stock, they are using a database.

Database Management System (DBMS)



A **Database Management System (DBMS)** is software that enables users and applications to interact with databases to store, retrieve, and analyze data efficiently. It serves as an intermediary between the database and its users', ensuring data is organized and accessible.

Common examples of DBMSs include: **Oracle Database; MySQL; Microsoft SQL Server; PostgreSQL; MongoDB; SQLite; Microsoft Access.**

Microsoft Access [https://support.microsoft.com/en-us/access] is a relational DBMS that combines a graphical user interface with software development tools. It supports two primary file formats:

.mdb: Used in Access versions 2003 and earlier, **.accdb**: Introduced with Access 2007 and used in later versions.

A **Microsoft Access database** consists of several key elements, known as database objects. These objects include:

- ***Tables;***
- ***Forms;***
- ***Queries;***
- ***Reports;***

When a database is created, one or more of these objects are stored in a single database file.

FirstName	LastName	Office	Mobile
Dahlia	Landon	(510) 555-9821	(650) 555-8103
Mark	Tristener	(510) 555-3218	
Jennifer	Veladoner	(510) 555-1031	(415) 555-1496

Tables. Tables are the foundation of a database, where all data is stored. Each table is typically dedicated to a specific topic, like products, customers, or suppliers. Tables can be connected to one another to efficiently retrieve and analyze data.

By storing information in a structured way, Access ensures data is only saved once. This avoids duplication and makes the database more efficient.

Tables in Access are organized like Excel spreadsheets, with:

Columns (Fields): Representing categories of data, such as "Name" or "Price."

Rows (Records): Representing individual entries, with each row containing data for one item.

Each record is made up of one or more fields, depending on how the table is designed. This structure helps in organizing and managing information effectively.

Query. A query allows you to search and retrieve specific data from one or more tables based on criteria you define, such as filtering certain fields or conditions. The results are displayed in a customizable format. You can create queries using the **Query Wizard** or by manually designing them in the **Query Design** view.

Form. A form is used to view, add, or edit data in one or more tables. It can serve as a menu for navigating your database or as a tool for entering data directly. Forms pull data from tables and display it in a user-friendly way, making it easier to interact with the database.

Report. A report organizes and presents data in a printable format, using a layout you can customize. Reports are ideal for analyzing and sharing information, and you can format them similarly to a **Microsoft Word** document to control how the final output looks.

Primary Keys

Every table in **Access** needs at least one **field** that **uniquely** identifies each record. This is called the **primary key**. The ***primary key*** ensures that each **record is unique** and helps link tables together. It's essential for combining data across tables in queries or generating reports. The primary key acts as a gateway to efficiently access and relate data within the database.

Sorting Records in a Database

Access: Sorting and filtering records. https://edu.gcfglobal.org/en/access/sorting-and-filtering-records/1/

Sorting is a simple way to organize and quickly find information in a database. You can arrange records in ascending order (A-Z) or descending order (Z-A). For example, you can sort by last name, first name, zip code, company, or contact type (e.g., family, friend, or relative). You can also combine sorting, such as sorting by contact type and then by last name within each category. Viewing sorted data is easiest in **Datasheet View**.

Sorting vs. Filtering

Sorting: Organizes data into a specific order, either alphabetically or numerically.

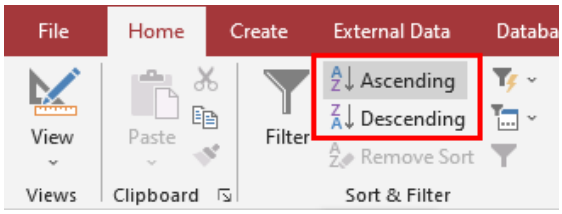
Filtering: Hides unnecessary data, allowing you to focus only on what you need.

How to Sort Data

Choose Sorting Order:

Ascending: Select this to arrange text from A to Z or numbers from smallest to largest.

Descending: Choose this to arrange text from Z to A or numbers from largest to smallest.



Apply the Sort:
Highlight the field you want to sort. Click the **Ascending** or **Descending** command.
Save the Sort: Once sorted, the records will remain in this order until you sort them again or remove the sort.
Remove the Sort: To clear the sorting, click the Remove Sort command.
Sorting and filtering are powerful tools to help you organize and manage your data effectively.

Using Filters to View Specific Data

Filters help you focus on specific information by showing only the records that meet your criteria. When you apply a filter, it temporarily hides records that don't match your conditions, making it easier to work with the data you need.

How to Create a Simple Filter

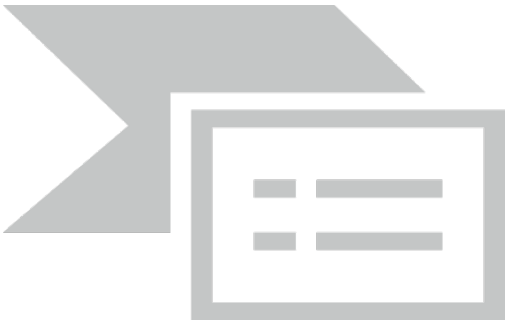
Choose the Field to Filter: Click the drop-down arrow next to the field you want to filter.
Set Filter Criteria: A menu with a checklist will appear. Check or uncheck items to decide which data will be displayed.
Select All: Includes all items in the filter. If all are selected, clicking this will deselect everything. **Blanks:** Shows only records where the selected field has no data.
Apply the Filter: Click **OK** to activate the filter.

Turning Filters On and Off

Toggle Filter: To view all records again, click the Toggle Filter button. Click it again to reapply the filter.

Creating a Filter from a Selection

Select Data: Highlight the cell or value you want to use for the filter.
Open Filter Options: Go to the Home tab on the Ribbon, find the Sort & Filter group, and click the Selection drop-down arrow.



Choose a Filter Type:
Contains: Includes only records with data that matches the selected value.
Does Not Contain: Excludes records with data matching the selected value.
Ends With: Includes records where the field ends with the specified value.
Does Not End With: Excludes records where the field ends with the specified value.
Filters make it easy to focus on specific data, allowing you to organize and analyze information efficiently.

Practical tasks for students. Instructions for execution of practical work

1. *Start a computer* and wait for the loading Windows OS.

2. After completing the loading **Windows OS** *start* ***Microsoft Access*** *program* (for this purpose it is necessary to click **Start** button and choose **All apps** → **Microsoft Office** → **Microsoft Access**).
3. Perform the following tasks:

****

Task №1. *Create a database and save it as* ***Polyclinic***.

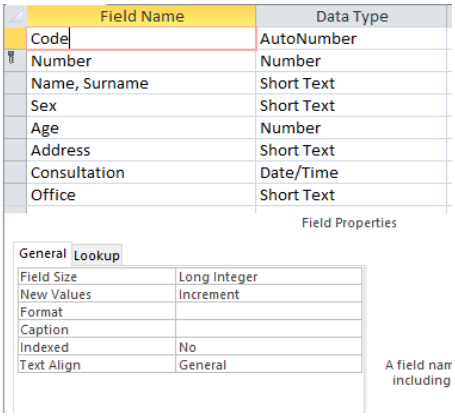
Double-click the **Blank Desktop Database** icon ;
In the **Blank Desktop Database** window in the **File Name** box type ***Polyclinic*** → click folder icon ,

click **Desktop** → click **OK** → click **Create**;

click **Design View** button  on the **Fields** tab;
in **Save As** dialog box, in **Table Name** field type ***Patients*** and click **OK**;
type field names, select corresponding data types and field properties according to **Fig.1**;

	Field Name	Data Type	Field Properties: Field Size
	Code	AutoNumber	Long Integer
	Number	Number	Long Integer
	Name, Surname	Short Text	50
	Sex	Short Text	6
	Age	Number	Long Integer
	Address	Short Text	50
	Consultation	Data/Time	Short Date
	Office	Short Text	50

a



b

Fig. 1

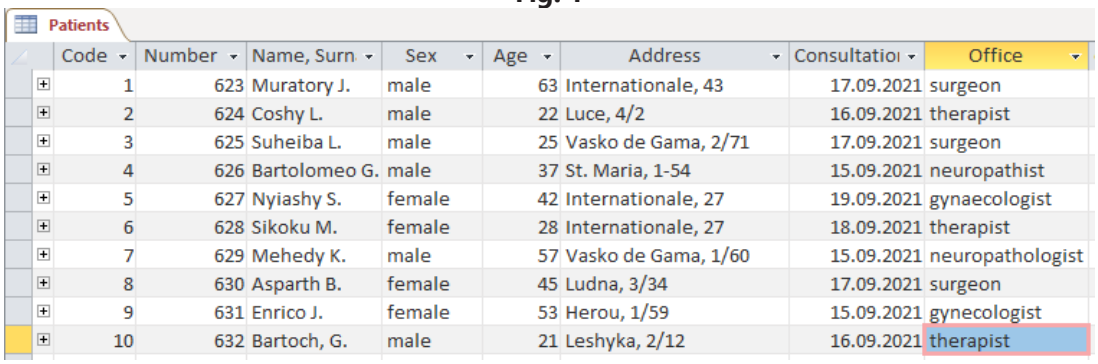


Fig.2

select **Number,** click **Primary Key**  on **Design** tab, click **Datasheet View** button  **,** click **Yes**;
in **Patients** table type an information about patients according to **Fig.2,** click **Save** icon  ;
close **Patients** table.

****

<u>Task №2.</u> *Add data to* ***Polyclinic*** *database and save changes.*

Click **Create** tab, click **Table Design** button  ;
type field names, select corresponding data types and field properties according to **Fig.3, a** (for **Sugar (blood)** field set field properties according to **Fig.3, b)**;

	Field Name	Data type	Field Properties: Field Size
	Code	AutoNumber	Long Integer
	Number	Number	Long Integer
	Date	Data/time	Short Date
	Height	Number	Long Integer
	Weight	Number	Double
	Protein (urine)	Short Text	50
	Hemoglobin	Number	Long Integer
	Sugar (blood)	Number	Single
	Red cells (blood)	Number	Double
	White cells (blood)	Number	Double

a

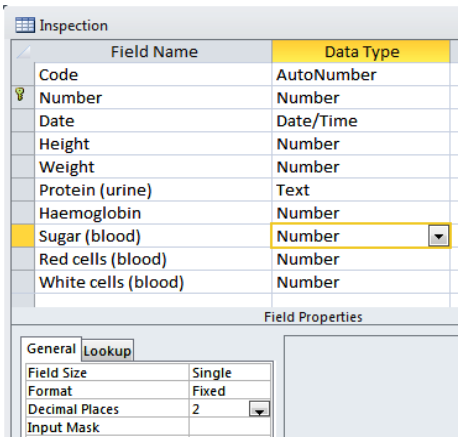


Fig.3

b

Patients | Inspection

Code	Number	Date	Height	Weight	Protein (urine)	Haemoglobin	Sugar (blood)	Red cells (blood)	White cells
1	623	17.09.2021	169	67	no	120	5,09	3,6	8,2
2	624	16.09.2021	158	52	no	132	5,2	4,1	5,2
3	625	17.09.2021	180	71	track	102	5,3	3,6	5
4	626	15.09.2021	178	92	0.99	137	5,1	4,3	10,5
5	627	19.09.2021	155	55	no	99	4,6	4,6	7,6
6	628	18.09.2021	167	60	no	115	5,15	4,2	8,4
7	629	15.09.2021	177	88	no	110	5,5	3,6	8,2
8	630	17.09.2021	170	69	track	88	4,5	3,9	11,6
9	631	15.09.2021	164	70	no	122	5,3	3,7	5,5
10	632	16.09.2021	171	57	no	90	5,1	4	12
(New)	0		0	0		0	0	0	0

Fig.4

select **Number,** click **Primary Key** on **Design** tab**,** click **Datasheet View** button **,** click **Yes**;
in **Save As** dialog box, in **Table Name** field type ***Inspection*** and click **OK**;
in **Inspection** table type an information about patients according to **Fig.4**, click **Save** icon ;
close **Inspection** table.

* * * * * * * * * * * *

Task №3. *Add new data to the **Patients** table, delete them and save changes.*
Open **Patients** table (double-click the name of the **Patients** table in the **Navigation pane** in the left part of the **Access** window);
click **New** button New in the **Records** group on the **Home** tab;
type following data:

11	**633**	**Ferna K.**	**male**	**28**	**St. Maria, 3/41**	**18.09.2021**	***therapist***

click **Save** button Save in the **Records** group on the **Home** tab;
close **Patients** table window;
open **Patients** table, select last record and click **Delete** button Delete in the **Records** group on the **Home** tab(or press **Delete** button on the keyboard), click **Yes**;
click **Save** icon ;
close **Patients** table.
* * * * * * * * * * * *

Task №4. *Create a relationship between **Patients** and **Inspection** tables.*
On the **Database Tools** tab, in the **Relationships** group, click **Relationships** command ;
in the **Show Table** window on the **Tables** tab click **Patients** → click **Add** → click **Inspection** → click **Add** → click **Close**;
in **Relationships** window click **Number** field in **Patient** and drag it to the **Number** field in the **Inspection** and after that click **Create** (**Fig. 5**)**;**
close **Relationships** window with saving changes**.**

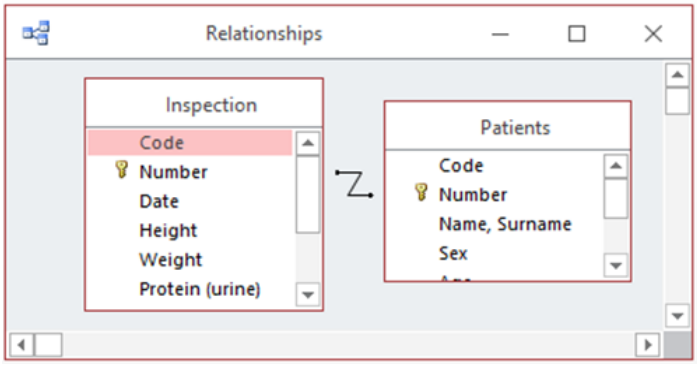


Fig.5

* * * * * * * * * * * * *

Task №5. *Sort data in* ***Patients*** *table in* ***Policlinic*** *database.*
Open **Patients** table;

click **Name, Surname** field in **Patients** table, click **Ascending** command in the **Sort & Filter** group on the **Home** tab;
the table will be sorted by the **Name, Surname** field;
sort data by following**: a) sex; b) age; c) office; d) number.**
* * * * * * * * * * * * *

Task №6. *Find information in* **Polyclinic** *using filters.*
Find patients visited ***therapist*****:**

in **Patients** table click the cell with note **therapist**, click **Selection** command in the **Sort & Filter** group on the **Home** tab, select **Equals "therapist"**;
table displays only patients visited therapist;
click **Toggle Filter** button Toggle Filter in the **Sort & Filter** group on the **Home** tab.
Find patients that correspond to the following conditions:
in **Patients** table**: a) Sex: *male*; b) Consultation: *17.09.2021*; c) Office: *surgeon*.**
in **Inspection** table**: a) Protein (urine): *track*; b) Red cells (blood): *3.6*; c) White cells *(blood): 5*.**
in ***Patients*** *table find patients that correspond to the following conditions simultaneously*:
Sex: *female*; b) Consultation: *18.09.2021*; c) Office: *therapist*.
click cell with note **female** ® click ® click ***therapist*** ® click ® click **18.05.2015** ® click ;
overview result and click **Toggle Filter** ;
close **Patients** table.

* * * * * * * * * * * * *

Task №7. *Create a* **Form** *from the* ***Patients*** *table in* ***Policlinic*** *database and save it as* ***Patients***.

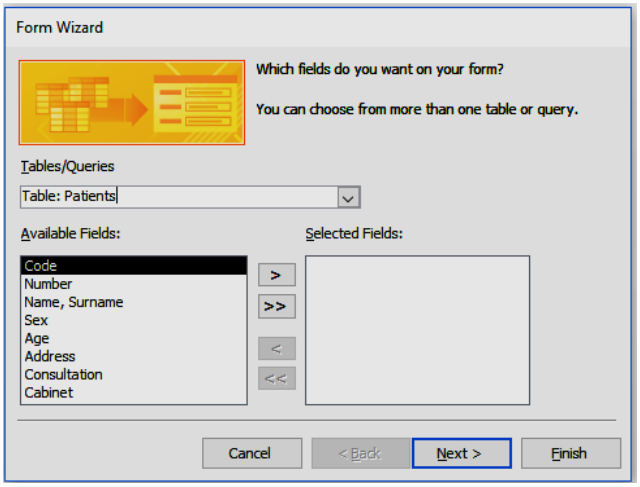


Fig. 6

select the **Create** tab, in the **Forms** group, click **Form Wizard** command ;
in **Form Wizard** window (**Fig. 6**), in **Tables/Queries** field click triangle button and choose ***Table: Patients***, click >> button;
Remark: *As a result, a list of all available fields of* ***Patients*** *table appears in the* ***Selected Fields:*** *box.*
click **Next** button;
in the **What layout would you like for your form?** list click **Justified** → click **Next**;
in the **What title do you want for your form?** box type ***Patients*** → click **Finish**;
using buttons with triangles (and) review the created form;
close ***Patients*** form window.

Task №8. *Find information in* ***Policlinic*** *database using* ***Queries****.*
Find patients that correspond to such conditions simultaneously:
a) Sex: *female*; b) Age: *more than 20 years*; c) Office: *therapist* or *surgeon;* d) Hemoglobin: less than 100; e) Red cells: *less than 4,1*.
select the **Create** tab, in the **Queries** group, click **Query Wizard** command ;
in **New Query** window choose **Simple Query Wizard** option → click **OK**;
in **Simple Query Wizard** window click triangle button in the **Tables/Queries** box and choose **Table: Patients**;
Remark: *As a result, a list of all available fields of* ***Patients*** *table appears in the* ***Available Fields*** *box.*
click **Number** in **Available Fields** box → click > button;
perform the same actions with fields **Name, Surname**; **Sex**; **Age**; **Consultation**; **Office**;
Remark: *As a result, a list of all* selected *fields appears in the* ***Selected Fields*** *box.*
click triangle in the **Tables/Queries** box and choose **Table: Inspection**;
click **Date** in **Available Fields** box → click > button;
perform the same actions with fields **Hemoglobin** and **Red cells (blood)**;
click **Next** button;
in the **What title do you want for your query?** box type ***Blood*** → click **Finish**;
click an **Design View** icon on the **Home** tab;
Remark: *As a result, the* ***Blood Query*** *will be displayed in* ***Design View*** **(*Fig. 7*)**.
type **"female"** in the row **Criteria:** in the field **Sex,** and fill other fields in the row **Criteria:** according to the **Fig. 7 (**in the field **Office** type **"therapist" Or "surgeon")**;

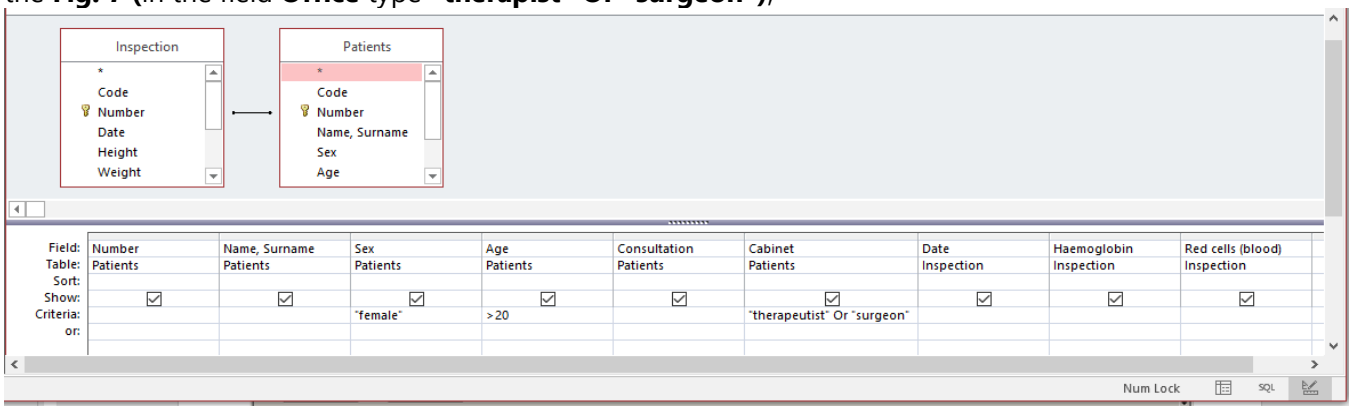


Fig. 7

click **Run** icon on the **Query Tools Design** tab;
review the results of query;
close **Blood** query window.

* * * * * * * * * * * * *

Task №9. *Create a* ***Report*** *from the* ***Inspection*** *table in* ***Policlinic*** *database and save it as* ***Inspection****.*
select the **Create** tab, in the **Reports** group, click **Report Wizard** command ;
in **Report Wizard** window click triangle button in the **Tables/Queries** box and choose **Table: Inspection**, click >> button;
click **Next** button two times;
click triangle button in the **1** box and choose **Number** → click **Next** button;
click **Columnar** option in **Layout** field click **Next** button;
in the **What title do you want for your report?** box type ***Inspection*** → click **Finish**;
using buttons with triangles (and) review the created report;
close ***Inspection*** report window.
Show teacher results of your work.
Close **Microsoft Access** window**.**

Attention*: After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:

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5) McGrath Mike. Access in easy steps: Illustrated using Access 2019. In Easy Steps Limited, 2019. — 192 p. — ISBN 1840788232, 9781840788235..

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7) Poatsy M., Williams J., Rutledge A. Exploring Microsoft Office Access 2019 Comprehensive. Pearson, 2020. — 647 p. — ISBN 978-0135435816.

Additional

1) Добровольська А. М. Медична інформатика. Практикум. Івано-Франківськ: Сімик, 2013. 440 с.

2) Monk E., Brady J., Cook G.S. Problem Solving Cases in Microsoft Access and Excel. Publisher: Course Technology, 2011. 276 p.

3) Ulrich Laurie Ann, Cook Ken. Access For Dummies. For Dummies, 2022. — 435 p. — ISBN 978-1-119-82908-9.

Topic 4: WORKING WITH MS ACCESS. PART II.

Actuality: Because information is so important in most organizations, computer scientists have developed a large body of concepts and techniques for managing data. Microsoft Access is a Database Management System offered by Microsoft. Microsoft Access offers the functionality of a database and the programming capabilities to create easy-to-navigate screens (forms). It helps healthcare professionals analyze large amounts of information and manage data efficiently.

Educational aims of the lesson:

To know:

1. **MS Access** basic concepts;
2. the database window structure;
3. **MS Access** objects (tables, queries, forms, and reports).

To be able to:

1. create and edit databases;
2. create and work with tables, queries, forms, and reports;
3. search and sort information in the database.

The list of questions for the survey:

1. Start the **MS Access** program.
2. **MS Access** Window. **MS Access** tabs.
3. Database creation.
4. Types and properties of the fields.
5. Key field (primary key).
6. Working with the tables.
7. Database sorting and filtration.
8. Creation of queries.
9. Creation of forms.
10. Creation of reports.

The list of required practical skills:

1. Database creation and edition.
2. Creation and working with tables, queries, forms, and reports.
3. Sorting and searching information in the database.

Brief theoretical information

Database design basics

A well-structured database ensures access to accurate and up-to-date information. Since effective design is critical to achieving your objectives when working with databases, it is worth dedicating time to understanding the principles of good database design. This basic knowledge increases the likelihood of creating a database that not only fulfills your current requirements but also adapts seamlessly to future changes.

Basic Rules for Database Design

There are some simple rules to follow when designing a database [1]. **First**, avoid storing the same information in multiple places. This is called redundant data, and it wastes storage space and can lead to mistakes or inconsistencies. **Second**, make sure the information in your database is accurate and complete. If the data is wrong, any reports created from it will also be wrong. This can lead to poor decisions based on those incorrect reports.

What Makes a Good Database Design?

A good database design does the following [2]:

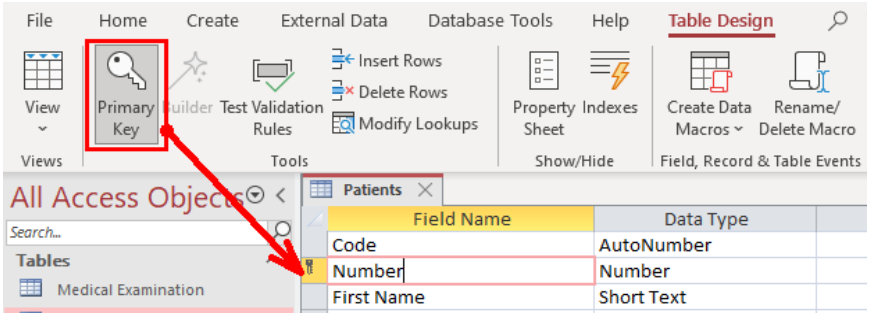
- Organizes your data into tables based on subjects to avoid repeating the same information.
- Allows you to connect and combine data from different tables when needed.
- Ensures your data is accurate and reliable.
- Supports your needs for processing data and creating reports.

Steps to Design a Database

1. Define the Purpose
Start by deciding why you need the database and what you want it to do. This will guide the rest of the process.
2. Gather Information
List all the types of data you need to store, like product names, customer details, or order numbers.
3. Organize Data into Tables
Group your data into main categories, like "Products" or "Orders." Each category becomes its own table.
4. Create Table Columns
Decide what details each table should include. For example, a "Products" table might have columns for Product Name and Price.
5. Choose a Primary Key
Select a unique identifier for each table, like Product ID for the "Products" table or Order ID for the "Orders" table.
6. Link Tables Together
Identify how tables are related and connect them using shared fields. Add extra fields or create new tables if needed to make relationships clear.
7. Test and Improve the Design
Check for mistakes by creating the tables and adding sample data. Try running some queries or reports to see if everything works as expected. Adjust the design if necessary.

Understanding Primary Keys in Access

Primary keys in Access help connect data from different tables, making it easier to combine and analyze. A primary key is a unique identifier for each record in a table. When you include a primary key field in another table, it's called a foreign key, and it links back to the original table.



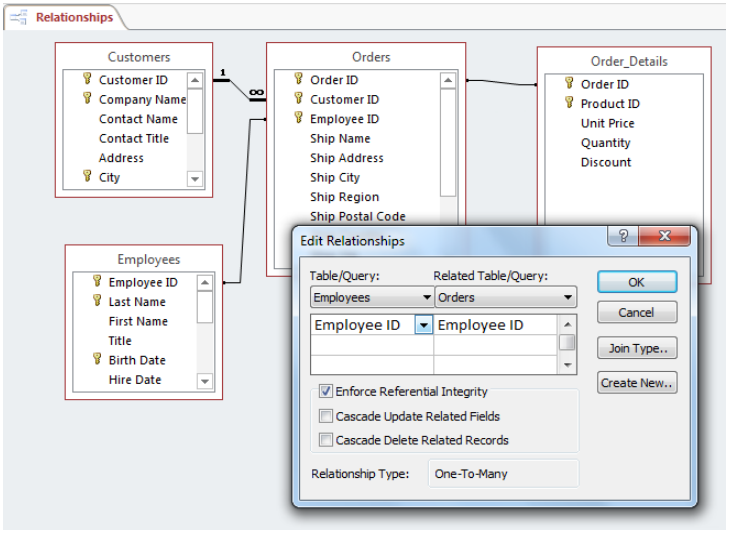
How to Set a Primary Key:
1. Right-click the table in the **Navigation Pane** and choose **Design View**.
2. Click on the field (or fields) you want as the primary key. To select more than one field, **hold Ctrl** while clicking.
3. Go to the Table **Tools Design** tab and click **Primary Key**.

How to Remove a Primary Key:
1. Right-click the table in the **Navigation Pane** and choose **Design View**.
2. Select the field (or fields) you want to remove as the primary key.
3. On the **Design tab**, click **Primary Key** again to remove it.

Guide to table relationships

One of the fundamental principles of any **relational database**, like MS Access, is the **relationship** and **links** between tables that maintain and better manage data inputting, time, and storage.
You can build a Microsoft Access database that is based on just one table, but that table could grow at an alarming rate and you would have problems accessing the correct records at speed, as well as having to input the same data over and over again. An ideal database is free of redundant or duplicate data. To achieve that, you must split your data into many subject-based tables so each subject is presented only once. To do that in Microsoft Access, you place common fields in tables that are related.

10 Key Facts About Table Relationships in Microsoft Access



1. One-to-Many Relationship

In this relationship, one record in the parent table connects to many records in the child table. For example, a doctor (parent) can have multiple patients (child), but you don't need to repeat the doctor's details for every patient.

2. One-to-One Relationship

Here, one record in the parent table connects to one record in the child table. This is less common and usually used to split a large table into two. For instance, you might separate customer details into one table and their contact information into another.

3. Linking Keys

A common practice is to link the primary key from the parent table to a matching field in the child table, called a foreign key. For example, Customer_ID in a Customers table (primary key) could link to the Orders table (foreign key).

4. Matching Data Types

Fields used in relationships must have the same data type. For example, if the parent table has a text field, the child table must also use a text field.

5. Enforcing Referential Integrity

Enabling "Enforce Referential Integrity" in the Edit Relationships dialog prevents orphan records in the child table—entries without matching parent records. For example, it stops creating an order for a non-existent customer.

6. Cascade Update Related Fields

This setting ensures that if a primary key value is updated in the parent table, the corresponding value in the child table is also updated. For instance, fixing a typo in a category name in the parent table automatically updates it in related records in the child table.

7. Cascade Delete Related Records

When this option is enabled, deleting a record in the parent table also deletes related records in the child table. For example, deleting a customer record will also remove all their associated orders.

8. Automatic Query Joins

Setting relationships in tables automatically creates join lines in queries. For instance, linking Customers and Orders tables through Customer_ID will show a join line in query design view when you add these tables.

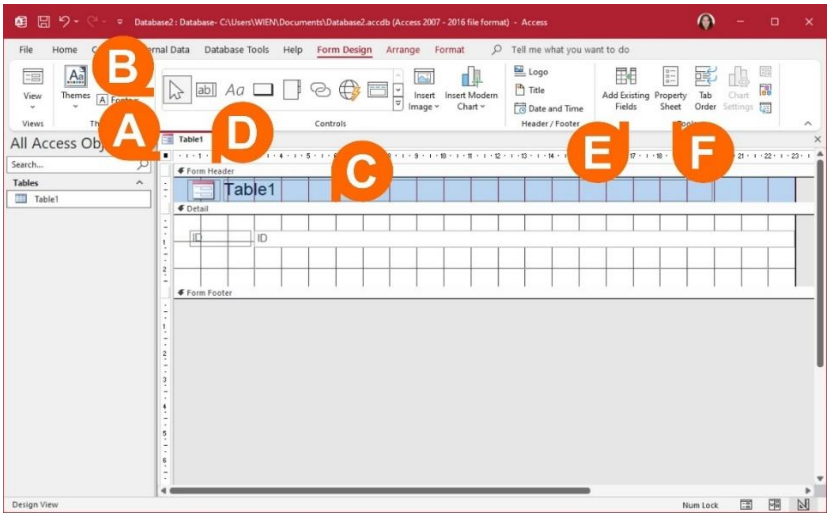
9. Deleting a Field Breaks the Relationship

If you delete a field that's part of a relationship, the relationship is also removed. Access won't maintain a broken relationship.

10. Changing a Primary Key Requires Deleting the Relationship

To change a primary key in a table that is part of a relationship, you must first delete the relationship. Afterward, you can assign a new primary key to the table.

Form Design View Basics



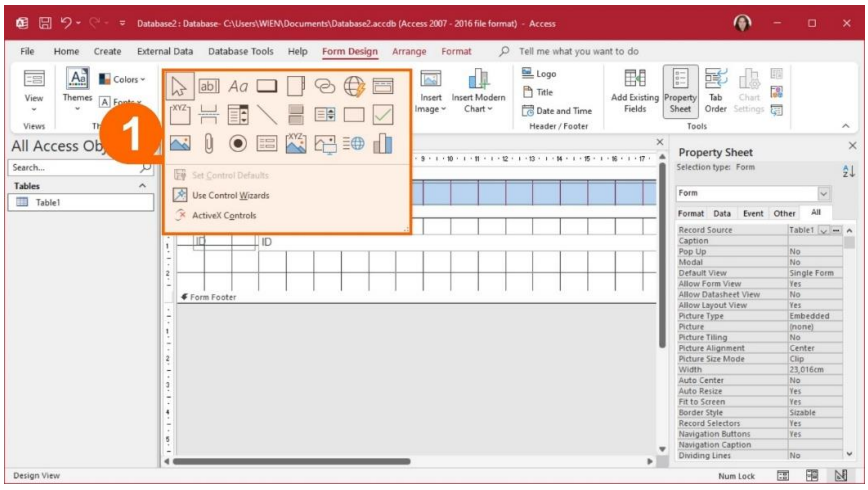
A	**Form Selector**: Click the Form Selector to select the entire form. Double-click it to display the form's properties.	D	**Form header**: The header is the top part of the form where you can add titles or other elements.
B	**Controls group**: Use the controls group to add buttons, text boxes, or other elements to your form. Click a button in the controls section to place a control on the form.	E	**Add Existing Fields button**: Click this button to open the Field List pane, where you can add fields from your database to the form.
C	**Detail divider**: To make the form's header larger, click and drag the divider downward.	F	**Property Sheet button**: Click this button to view and edit the form's properties in the property sheet.

What is a Control?

A **control** is any object you see on a form or report. Examples include text boxes for entering or displaying information, labels for text, or buttons you click to perform tasks like printing a report.

How to Add Controls in Design View.

1. Open **Design View** and select the type of control you want to add from the **Controls group**. Some controls, like buttons or lists, come with a setup wizard to help you.



2. If the **Control Wizard** opens, follow the steps and set the options you need.

Refer to the table below for examples of controls you can add and their purposes.

Types of Controls and How to Use Them	
Select	Use this button to choose a control. To select multiple controls, hold the **Shift** key while clicking each one, or drag a rectangle around them.
Text Box	Adds a box to display data from a table or query, or to enter text directly.
Label	Creates fixed text, like headings, that stays the same for every record. Most controls come with a label by default.
Button	Adds a button to perform actions, like running a macro or Visual Basic function.
Tab Control	Lets you add tabs to the form, similar to tabs in dialog boxes, to organize multiple pages of controls.
Hyperlink	Inserts a link to a webpage or file.
Web Browser Control	Adds a feature to access the computer's web browser within the database.
Navigation Control	Creates controls for navigating the form.
Option Group	Groups multiple option buttons so the user can select only one.
Insert Page Break	Adds a page break to the form.
Combo Box	Creates a drop-down menu for users to enter text or pick from a list.
Chart	Adds a chart to the form.
Line	Allows you to draw a line.
Toggle Button	Adds a button for entering or displaying Yes/No data.
List Box	Adds a box with a list of items for the user to choose from.
Rectangle	Lets you draw a rectangle on the form.
Check box	Adds a box for Yes/No fields, allowing users to check or uncheck.
Unbound Object Frame	Adds an external object (e.g., a spreadsheet or image) that is not linked to a field in the database.
Attachment	Lets you add file attachments to the form.
Option Button	Adds a radio button for single-choice selections, often used within an Option Group.

Practical tasks for students.
Instructions for execution of practical work

1. *Start a computer* and wait for the loading of Windows OS.
2. After completing the loading **Windows OS** *start the* ***Microsoft Access***.
3. Perform the following tasks:

****

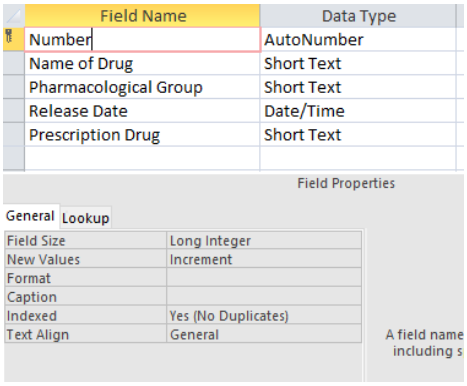
Task №1. *Create a database and save it as* ***Pharmacy Warehouse***.

Double-click the **Blank Desktop Database** icon  ;
In the **Blank Desktop Database** window in the **File Name** box type ***Pharmacy Warehouse***→ click folder icon , click **Desktop** → click **OK** → click **Create**;

click the **Design View** button  on the **Fields** tab;
in the **Save As** dialog box, in the **Table Name** field type ***Medications*** and click **OK**;
type **field names**, select corresponding data types and field properties according to **Fig.1**;

	Field Name	Data Type	Field Properties: Field Size
	Number	Number	Long Integer
	Name of Drug	Short Text	50
	Pharmacological Group	Short Text	50
	Release Date	Date/Time	Short Date
	Prescription Drug	Short Text	4

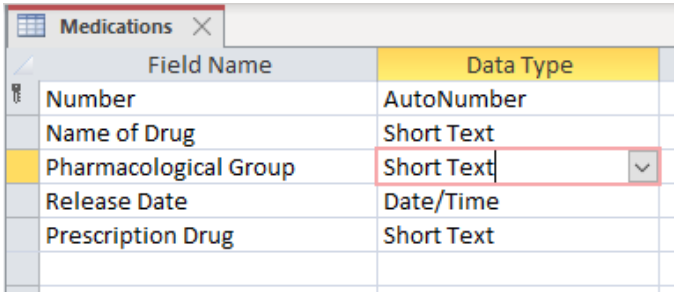
a



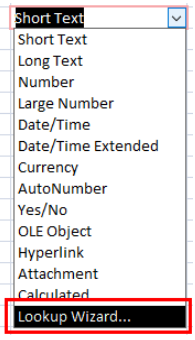
b

Fig. 1

select the **Pharmacological Group** field, select **Data Type**, open the drop-down, and choose **Lookup Wizard**;



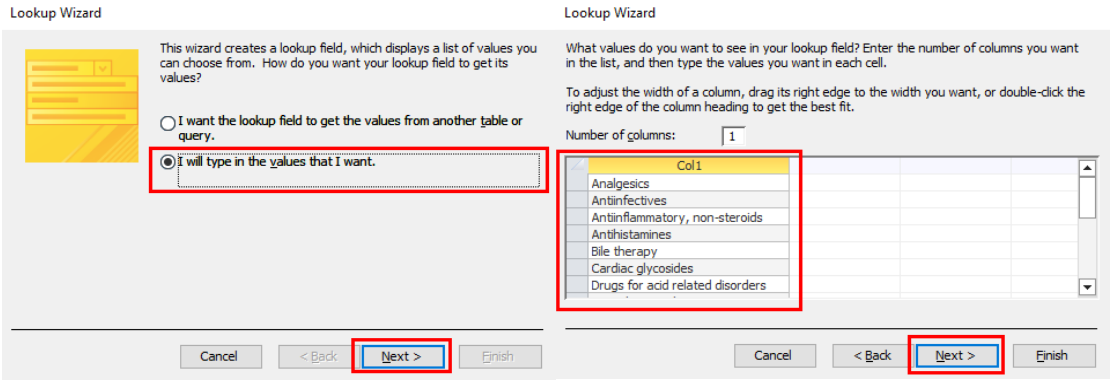
a



b

Fig. 2

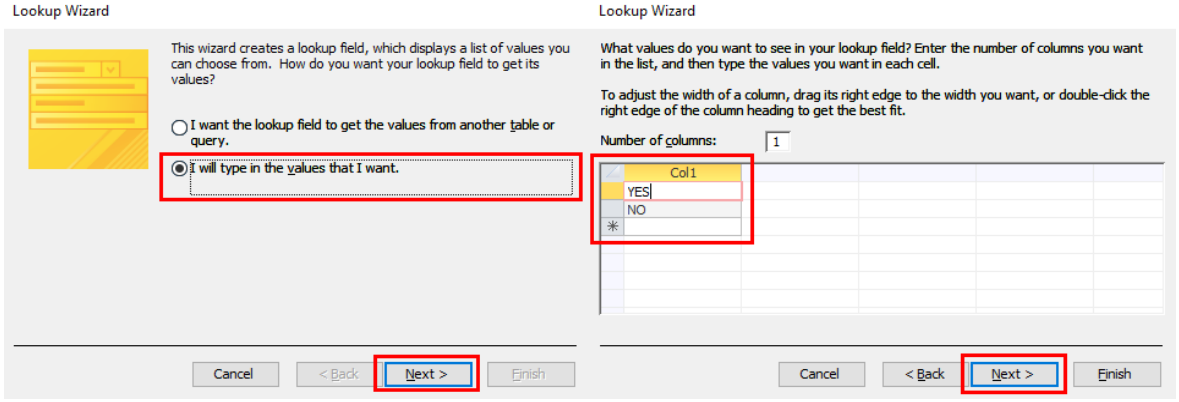
in the **Lookup Wizard** choose the option "**I will type in the values that I want**", and press the **Next** button.
In the **Lookup Wizard** window in **Col 1** type
Analgesics; Antiinfectives; Antiinflammatory, non-steroids; Antihistamines; Bile therapy; Cardiac glycosides; Drugs for acid related disorders; Liver therapy, lipotropics; Vasodilators used in cardiac diseases
like it is shown in **Fig 3** below, press the **Next** button, press the **Finish** button;



a **b**

Fig. 3

repeat the same actions for the **Prescription Drug** field;
In the **Lookup Wizard** window in **Col 1** type **YES; NO;** like is shown in **Fig. 4** below, press the **Next** button, press the **Finish** button;



a **b**

Fig. 4

select **Number,** click **Primary Key** on **Design** tab, click **Datasheet View** button , click **Yes**;
in the **Medications** table type information about medications according to **Fig.5,** click the **Save** icon ;
close the **Medications** table.

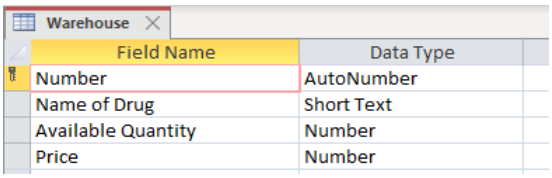
* * * * * * * * * * * * *

<u>Task №2.</u> *Add data to the **Pharmacy Warehouse** database and save changes.*

Click **Create** tab, click the **Table Design** button ;
type field names, select corresponding Data Types and Field Properties according to **Fig. 6, a**;

	Field Name	Data Type	Field Properties: Field Size
	Number	Number	Long Integer
	Name of Drug	Short Text	50
	Available Quantity	Number	Long Integer
	Price	Number	Double

a



b

Fig. 6

select **Number,** click **Primary Key** on **Design** tab**,** click **Datasheet View** button , click **Yes**;
in the **Save As** dialog box, in the **Table Name** field type ***Warehouse*** and click **OK**;
in the **Warehouse** table type information about medications according to **Fig. 7**, you can copy and paste the column **Name of Drug** from the **Medication** table.
click the **Save** icon ; close the **Warehouse** table.

Medications

Number	Name of Drug	Pharmacological Group	Release Date	Prescription Drug
1	Tramadol	Analgesics	30.01.2023	NO
2	Oxycodone	Analgesics	13.12.2022	YES
3	Zantac	Drugs for acid related disorders	20.12.2022	NO
4	Pantoprazole	Drugs for acid related disorders	15.09.2022	NO
5	Losec	Drugs for acid related disorders	12.10.2022	NO
6	Xenleta	Antiinfectives	05.10.2022	YES
7	Baciguent	Antiinfectives	15.07.2022	YES
8	Acetadryl	Antihistamines	23.08.2022	NO
9	Benadryl	Antihistamines	01.02.2023	NO
10	Siladryl	Antihistamines	13.12.2022	NO
11	Minitran	Vasodilators used in cardiac diseases	01.02.2023	YES
12	Nitro-bid	Vasodilators used in cardiac diseases	15.11.2022	YES
13	Nesiritide	Vasodilators used in cardiac diseases	02.11.2022	YES
14	Hepavite capsule	Liver therapy, lipotropics	02.11.2022	NO
15	Primene	Liver therapy, lipotropics	11.01.2023	YES
16	Simepar Capsules	Liver therapy, lipotropics	11.01.2023	NO
17	Bylvay	Bile therapy	14.12.2022	NO
18	Cholbam	Bile therapy	14.12.2022	NO
19	Acuvail	Antiinflammatory, non-steroids	30.11.2022	NO
20	Toradol	Antiinflammatory, non-steroids	30.11.2022	NO
21	Voltaren	Antiinflammatory, non-steroids	30.11.2022	NO
22	Lanoxin	Cardiac glycosides	06.02.2023	YES
23	Digox	Cardiac glycosides	06.02.2023	NO
(New)				

Fig. 5

Warehouse | Medications

Number	Name of Drug	Available Qu	Price	Click to Add
1	Tramadol	150	11,35	
2	Oxycodone	100	31,42	
3	Zantac	200	29,35	
4	Pantoprazole	130	11,5	
5	Losec	140	7,75	
6	Xenleta	10	1457	
7	Baciguent	200	102	
8	Acetadryl	70	1,87	
9	Benadryl	150	9,97	
10	Siladryl	250	17,7	
11	Minitran	10	681	
12	Nitro-bid	130	54,72	
13	Nesiritide	15	1113,58	
14	Hepavite capsule	250	17,08	
15	Primene	230	54,32	
16	Simepar Capsules	50	8,44	
17	Bylvay	120	254,44	
18	Cholbam	100	290,56	
19	Acuvail	100	96,68	
20	Toradol	110	32,35	
21	Voltaren	260	27,45	
22	Lanoxin	30	49,04	
23	Digox	40	81,09	
(New)		0	0	

Fig. 7

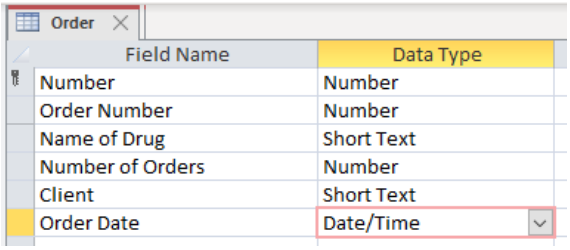
* * * * * * * * * * * * *

Task №3. *Add data to the **Pharmacy Warehouse** database and save changes.*

Click the **Create** tab, click the **Table Design** button  ;
type field names, select corresponding Data Types and Field Properties according to **Fig. 6, a**;

	Field Name	Data Type	Field Properties: Field Size
	Number	Number	Long Integer
	Order Number	Number	Long Integer
	Name of Drug	Short Text	50
	Number of Orders	Number	Long Integer
	Client	Short Text	50
	Order Date	Date/Time	Short Date

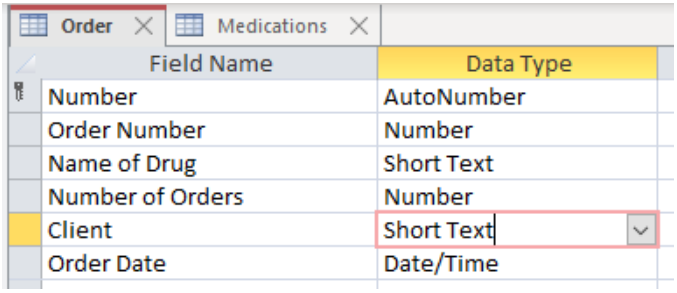
a



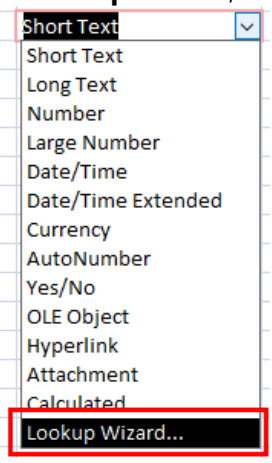
b

Fig. 8

select the **Client** field, select **Data Type**, open the drop-down, and choose **Lookup Wizard**;



a



b

Fig. 9

in the **Lookup Wizard** choose the option "**I will type in the values that I want**", and press the **Next** button.
In the **Lookup Wizard** window in **Col 1** type
Pharmacy 1; Pharmacy 2; Hospital 1; Hospital 2.

select **Number,** click **Primary Key**  on **Design** tab**,** click **Datasheet View** button  **,** click **Yes**;
in the **Save As** dialog box, in the **Table Name** field type ***Order*** and click **OK**;
in the **Order** table type information about orders according to **Fig. 10**, you can copy and paste the column **Name of Drug** from the **Medication** table.

click the **Save** icon  ; close the **Warehouse** table.

Order | Medications

Number	Order Num	Name of Drug	Number of Orders	Client	Order Date	Cli
1	1	Tramadol	10	Pharmacy 1	09.02.2023	
2	2	Oxycodone	20	Pharmacy 1	02.02.2023	
3	3	Zantac	31	Pharmacy 1	03.02.2023	
4	4	Pantoprazole	10	Pharmacy 2	02.02.2023	
5	5	Losec	20	Pharmacy 2	02.02.2023	
6	6	Xenleta	15	Hospital 1	30.01.2023	
7	7	Baciguent	30	Hospital 2	30.01.2023	
8	8	Acetadryl	40	Pharmacy 1	25.01.2023	
9	9	Benadryl	10	Pharmacy 1	25.01.2023	
10	10	Siladryl	20	Pharmacy 1	26.01.2023	
11	11	Minitran	50	Pharmacy 2	06.02.2023	
12	12	Nitro-bid	20	Pharmacy 2	06.02.2023	
13	13	Nesiritide	30	Pharmacy 2	06.02.2023	
14	14	Hepavite capsule	50	Pharmacy 2	07.02.2023	
15	15	Primene	30	Pharmacy 2	07.02.2023	
16	16	Simepar Capsules	20	Pharmacy 1	02.02.2023	
17	17	Bylvay	10	Pharmacy 2	03.02.2023	
18	18	Cholbam	10	Hospital 1	10.02.2023	
19	19	Acuvail	50	Hospital 1	10.02.2023	
20	20	Toradol	50	Hospital 1	10.02.2023	
21	21	Voltaren	20	Hospital 2	13.02.2023	
22	22	Lanoxin	30	Hospital 2	13.02.2023	
23	23	Digox	10	Hospital 2	13.02.2023	
(New)	0		0			

Fig. 10

* * * * * * * * * * * * *

<u>Task №4.</u> *Create a relationship between **Medications, Warehouse,** and **Order** tables.*

On the **Database Tools** tab, in the **Relationships** group, click **Relationships** command ;
in the **Show Table** window on the **Tables** tab click ***Medications*** → click **Add** → click ***Warehouse*** → click **Add** → click ***Order*** → click **Add** → click **Close**;
in the **Relationships** window click the **Name of Drug** field in ***Medications*** and drag it to the **Name of Drug** field in the **Medical Examination** and after that click **Create;**
repeat for **Order** field;
close the **Relationships** window by saving changes**.**

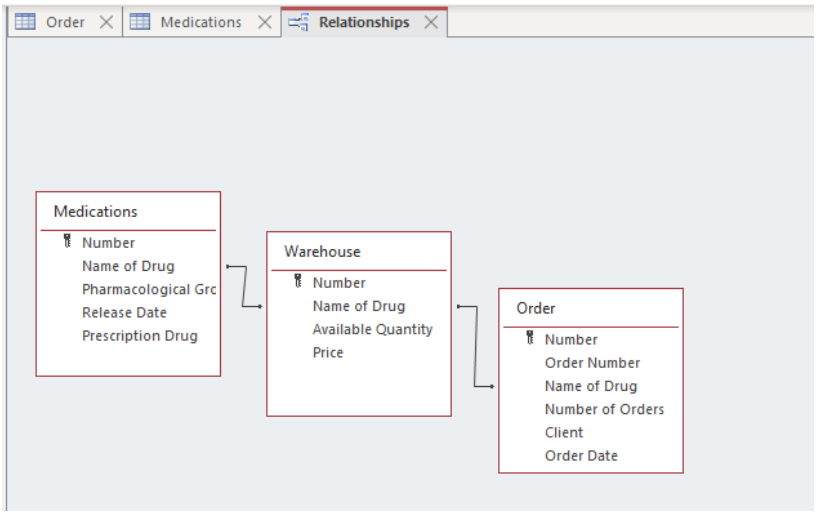


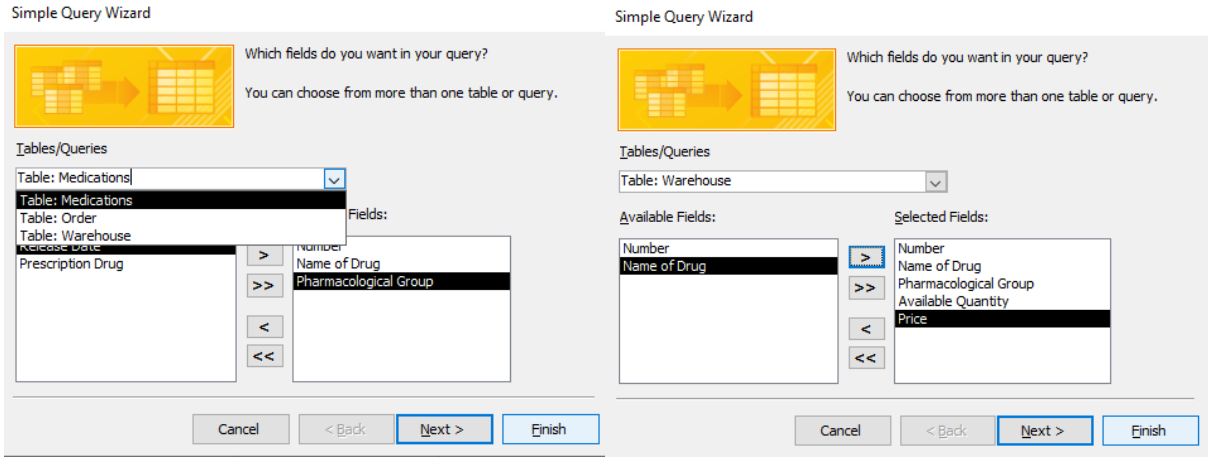
Fig. 11

* * * * * * * * * * * * *

Task №5. *Find information in the **Pharmacy Warehouse** database using **Queries**.*
*Find medications that correspond to such conditions **simultaneously**:*
a) Pharmacological Group: *Antiinfectives*;
b) Available Quantity: *more than 100*;
c) Price: *more than 30;*

select the **Create** tab, in the **Queries** group, click **Query Wizard** command ;
in the **New Query** window choose **the Simple Query Wizard** option → click **OK**;
in the **Simple Query Wizard** window click the triangle button in the **Tables/Queries** box and choose **Table: Medications**;
Remark: *As a result, a list of all available fields of the **Medication** table appears in the **Available Fields** box.*
click **Number** in **Available Fields** box → click > button;
perform the same actions with fields **Name of Drug**; **Pharmacological Group**;

open the Pharmacy Warehouse list of database tables one more time and choose option **Table: Warehouse**



Remark: *As a result, a list of all* selected *fields appears in the **Selected Fields** box.*
click **Available Quantity** in **Available Fields** box → click > button;
click **Price** in **Available Fields** box → click > button;
click the **Next** button;
in the **Would you like a detailed or summary query?** box choose **Detail;**
in the **What title do you want for your query?** box type ***Medications 1*** → click **Finish**;

click a **Design View** icon Design View on the **Home** tab;
Remark: *As a result, the **Medications 1 Query** will be displayed in **Design View** (**Fig. 10**).*
type **" Antiinfectives "** in the row **Criteria:** in the field **Pharmacological Group,** and fill other fields in the row **Criteria:** according to the **Fig. 10 (**in the field **Available Quantity** type **">100";** in the field **Price** type **">30"**

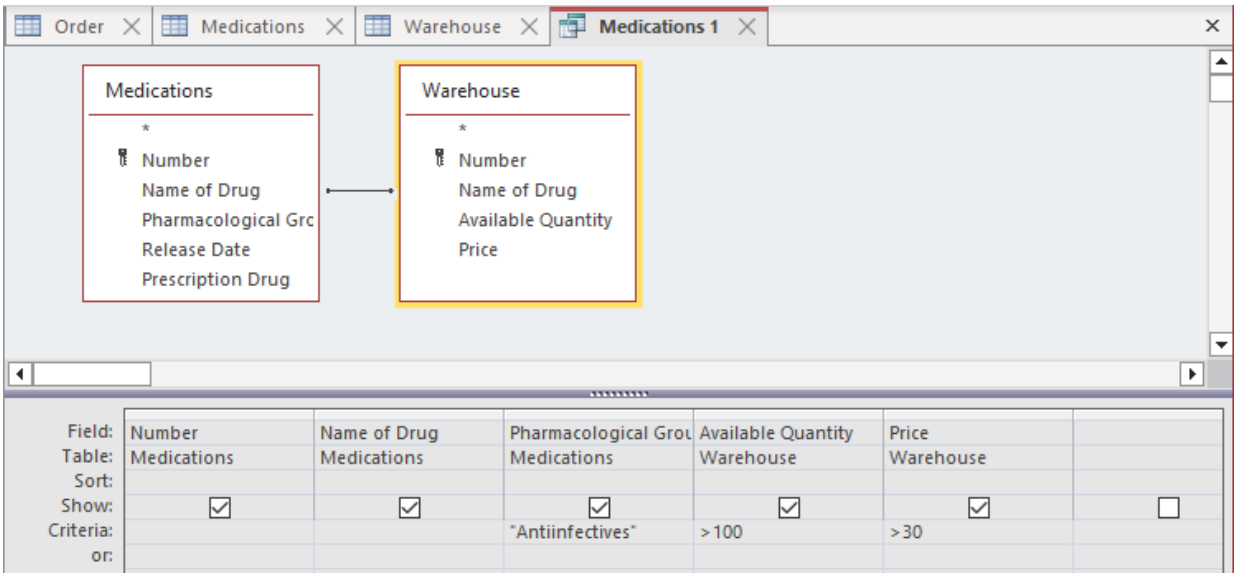
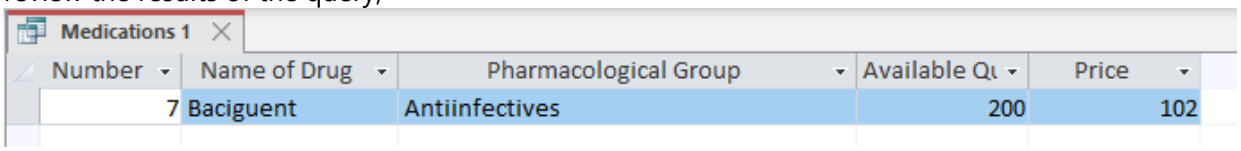


Fig. 10

click the **Run** icon ! on the **Query Tools Design** tab;
review the results of the query;



close the **Medication 1** query window.

Find medications that correspond to such conditions ***simultaneously****:*
a) Pharmacological Group: *Bile therapy OR Cardiac glycosides*;
b) Available Quantity: *more than 100*;

Save the query under the title **Medication 2.**

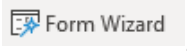
Find medications that correspond to ***such conditions****:*
a) Release Date: *in 2022*;

Save the query under the title **Medication 3.**

For more information, you can review the instruction to
Practical Class #3: MANAGEMENT OF MEDICAL AND BIOLOGICAL DATA. PART I

* * * * * * * * * * * *

Task №6. *In the* ***Pharmacy Warehouse*** *database create a* ***form*** *that will allow you to fill in all database tables. Add the fields* ***Average price by warehouse***, ***Minimum number of orders***, ***Average number of orders***, *and* ***Sum of all orders***. *Add a* ***discount field*** *in which specify* ***Give a 2% discount*** *if the number of orders* ***> 34.***

select the **Create** tab, in the **Forms** group, click **Form Wizard** command 

;
in the **Form Wizard** window (**Fig. 11**), in the **Tables/Queries** field click the triangle  button and choose ***Table: Medications***, click 

button;

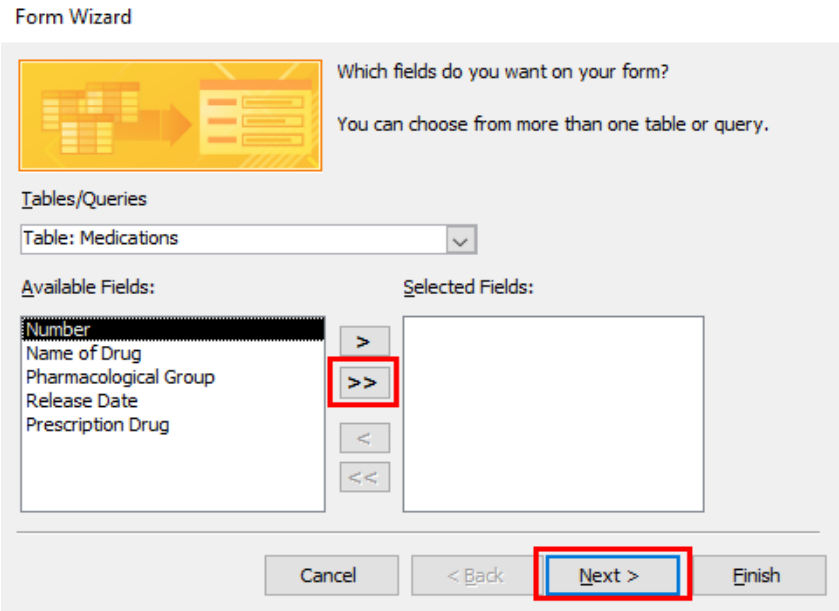
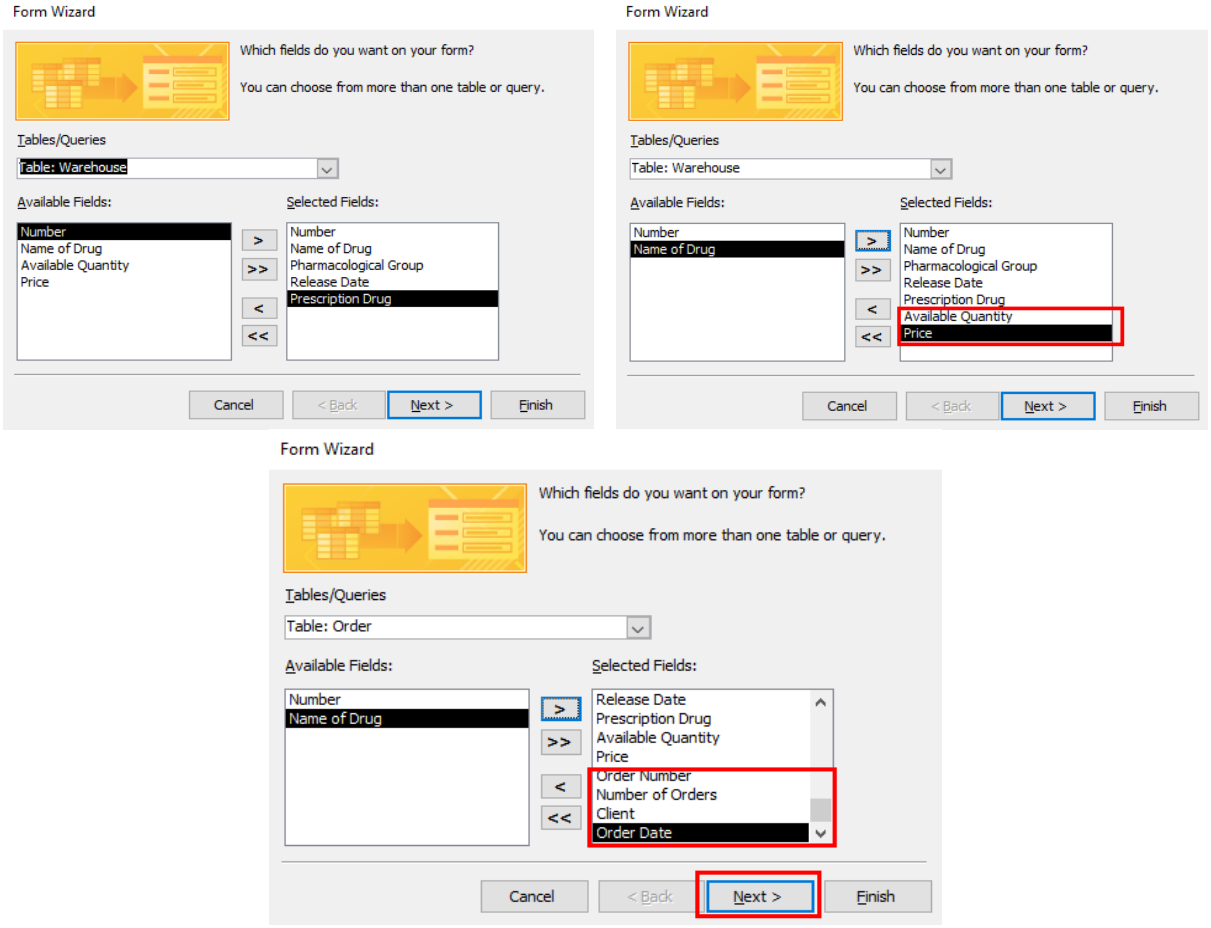


Fig. 11

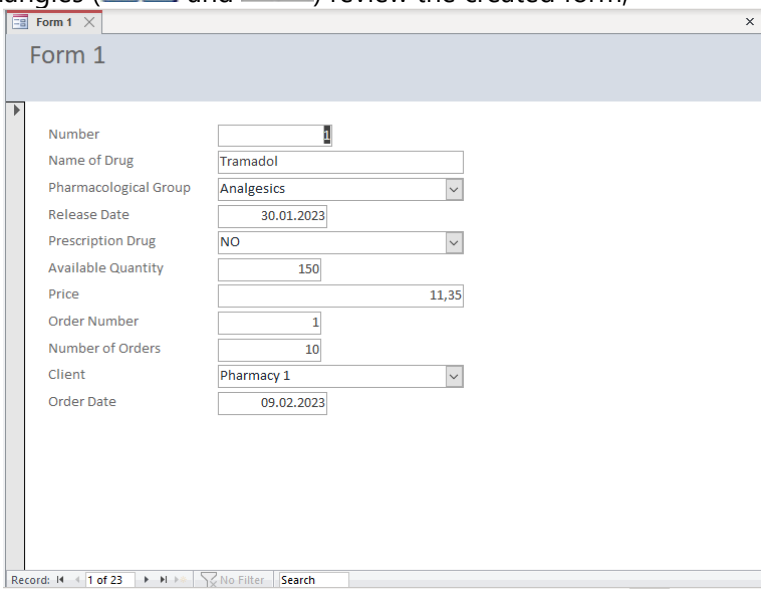
In the **Table / Queries** field choose the **Table: Warehouse** option. Select field **Available Quantity** →; click > button → select field **Price** → click > button

In the same way choose fields **Order Number; Number of Orders; Client; Order Date** form **Table: Order**



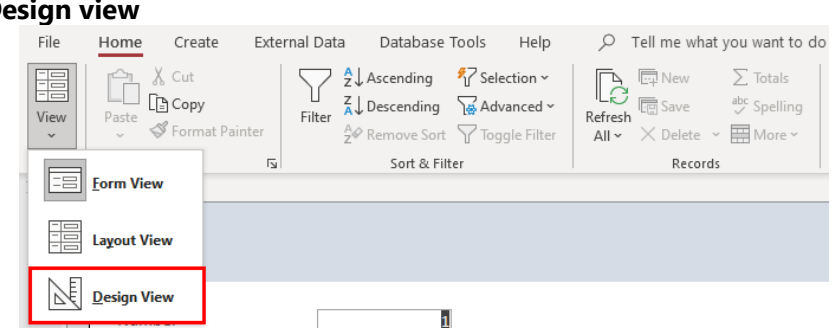
click the **Next** button;
in the **What layout would you like for your form?** list click **Columnar** → click **Next**;
in the **What title do you want for your form?** box type ***Form 1*** → click **Finish**;

using buttons with triangles (and) review the created form;

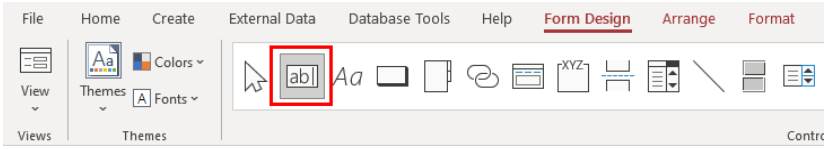


close the ***Form 1*** form window.

Change view to **Design view**



Select the element **Text box** from the **Controls** field



Fill the form according to the example **Fig. 12**

*Discount **=IIf([Number of Orders]>35;"Give a 2% discount";"No discount")**

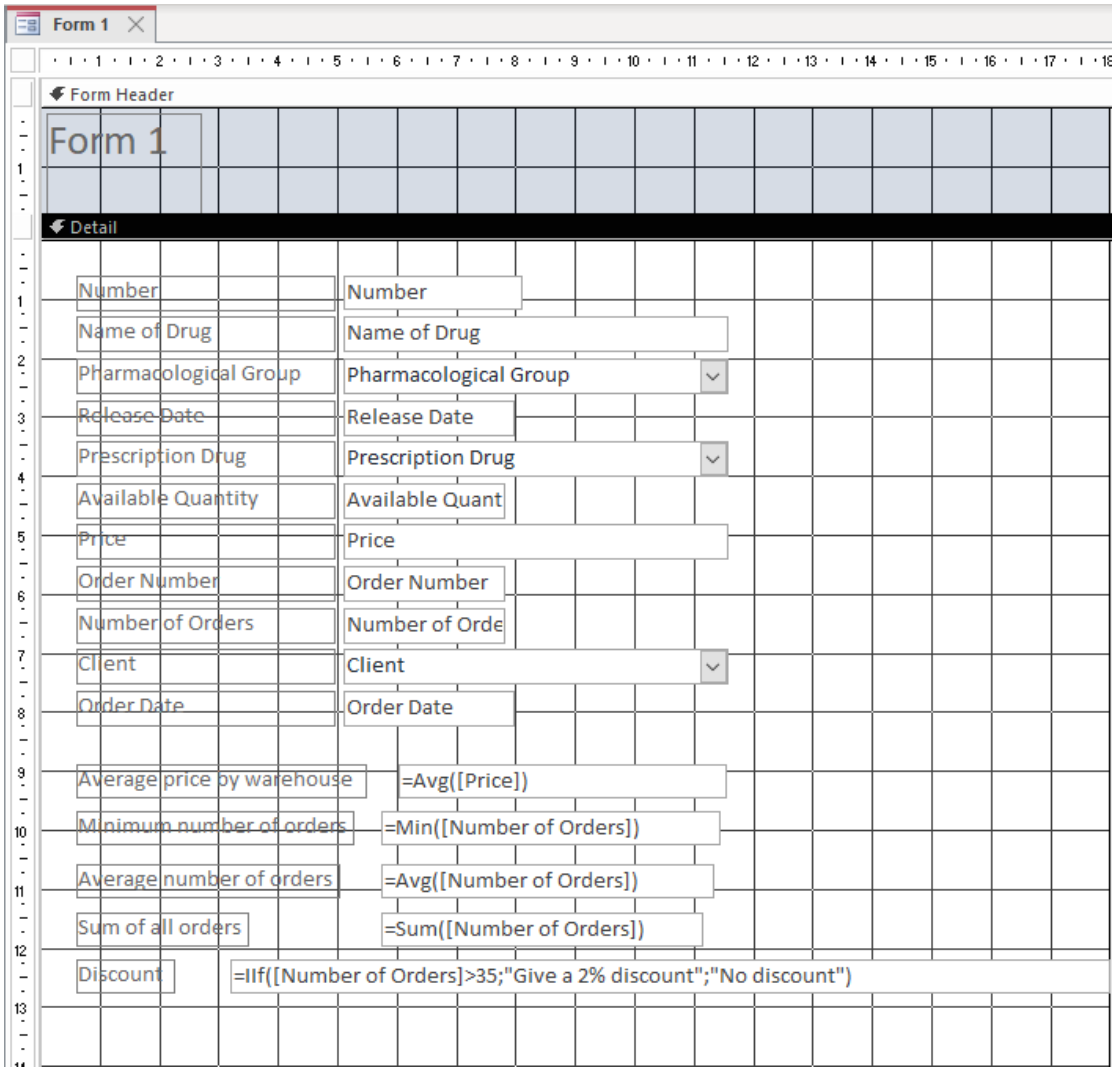
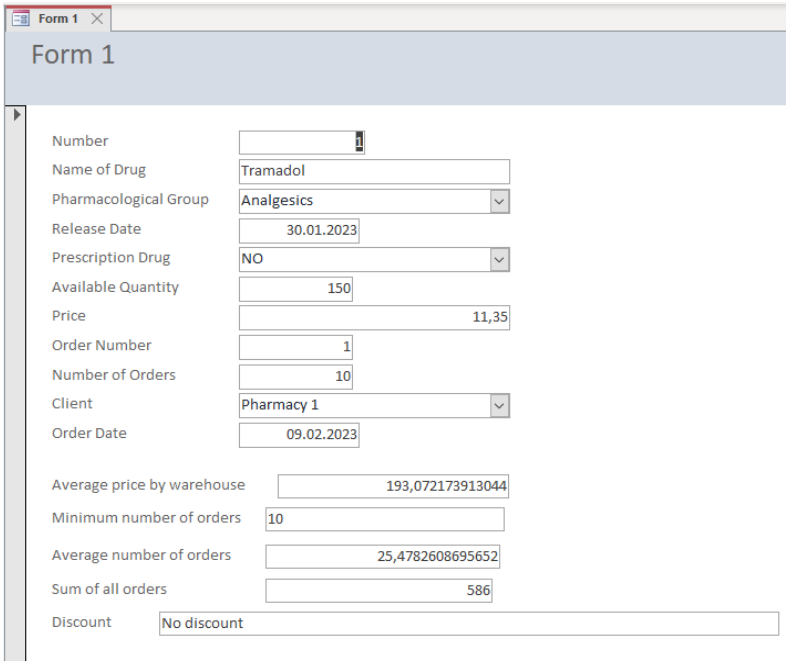


Fig. 12

Click File → Save

Close **Form 1** window

Open the **Form 1** window from the Navigation Pane.

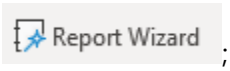


* * * * * * * * * * * *

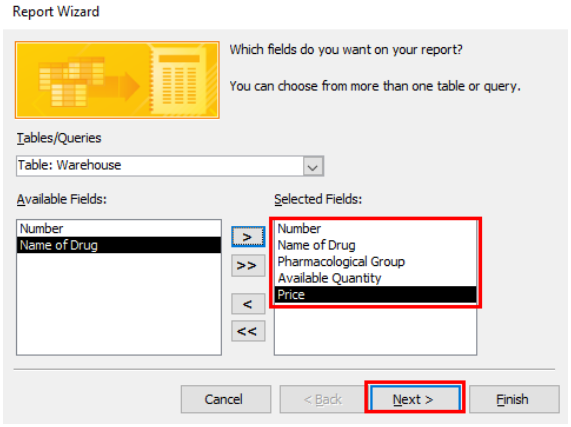
Task №7. *In the **Pharmacy Warehouse** database create a **form** in which to display the **Name of Drug**, **Pharmacological Group**, and **Price**. Add the **Number of Items** field, which counts the number of drug items.*

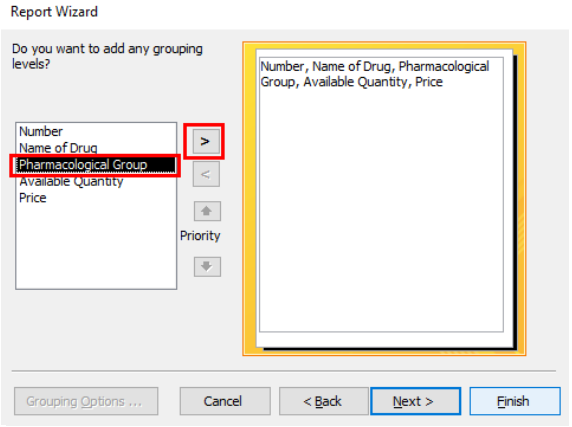
* Number of Items **=Count([Name of Drug])**

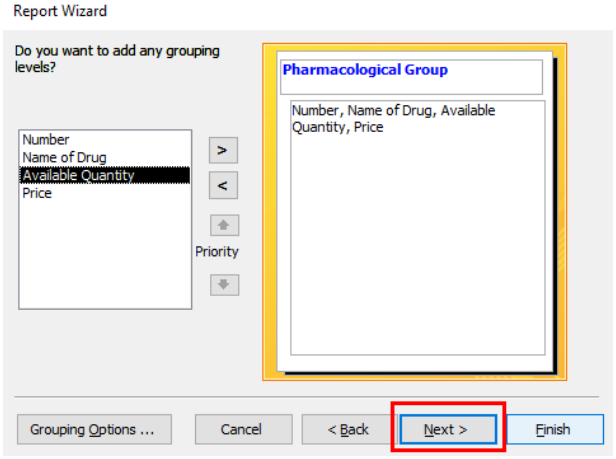
Task №8. *In the **Pharmacy Warehouse** database create a **report** in which to display the **Name of Drug**, **Pharmacological Group**, **Available Quantity**, and **Price**. Group data by the field **Pharmacological Group,** sort data from the lowest price to highest. To each item add the field **Total** (Price * Amount available).*

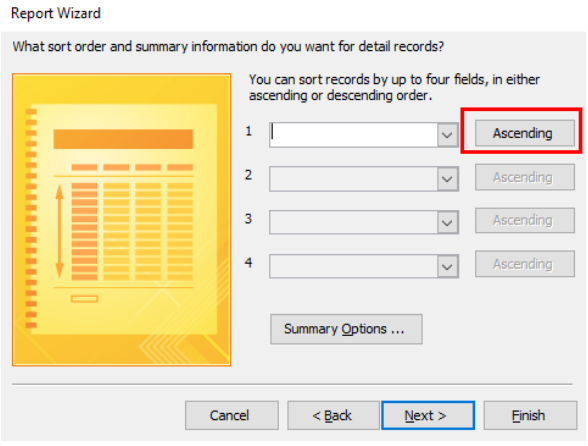
select the **Create** tab, in the **Reports** group, click **Report Wizard** command 

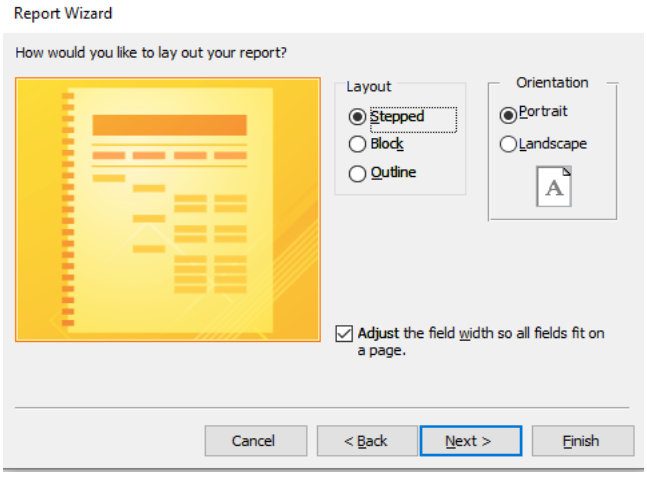
;
in the **Report Wizard** window click the triangle  button in the **Tables/Queries** box and choose **Table: Medications**, choose **Number; Name of Drug;** and **Pharmacological Group**;
select **Table: Warehouse,** choose **Available Quantity; Price;**





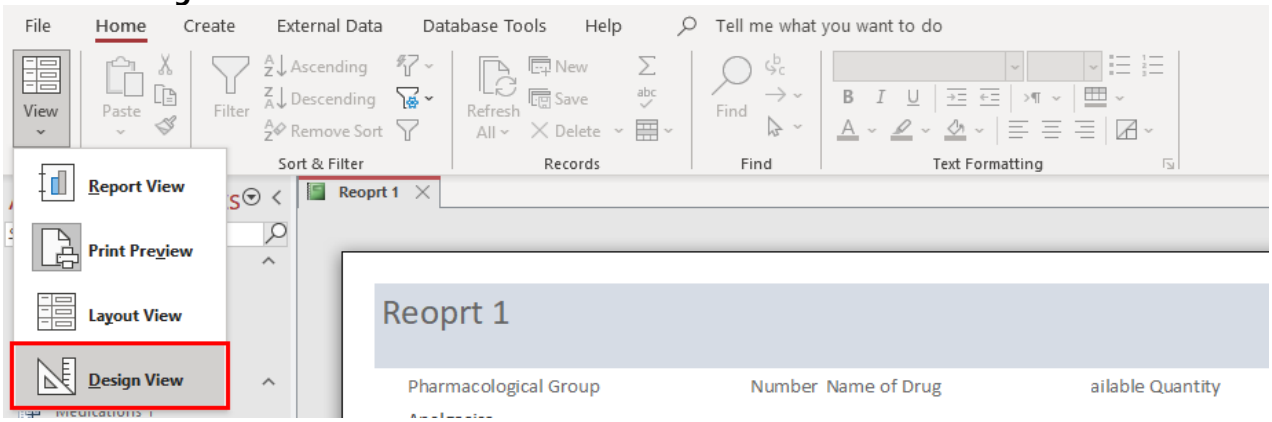




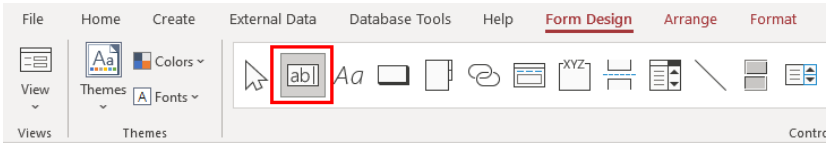


click the **Next** button;
click the triangle/button in the **1** box and choose **Number** → click the **Next** button;
click the **Columnar** option in the **Layout** field click the **Next** button;
in the **What title do you want for your report?** box type ***Report 1*** → click **Finish**;
using buttons with triangles (and) review the created report;
close the ***Medical Examination*** report window.

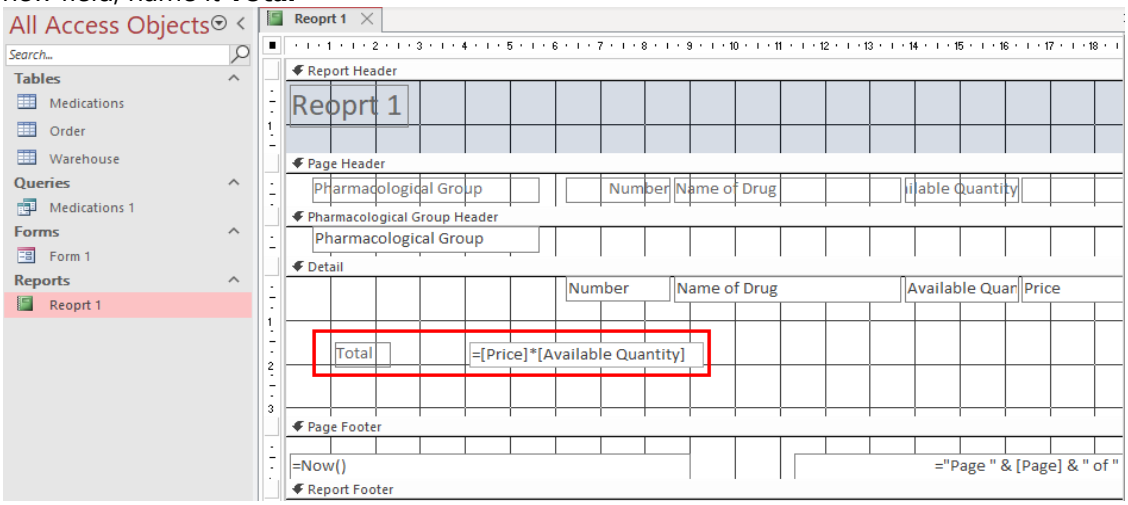
Go to the **Design View**



Select the element **Text box** from the **Controls** field

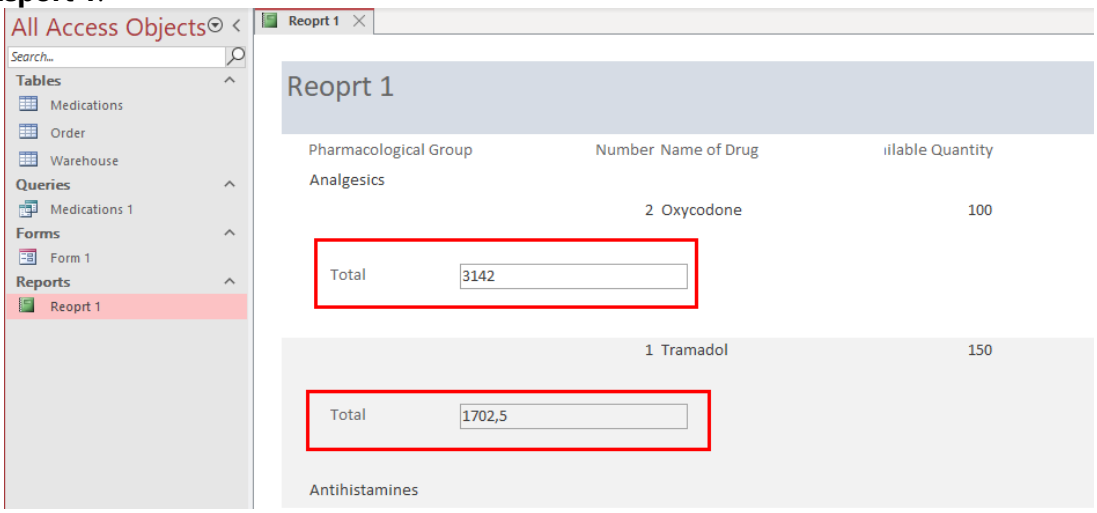


Add a new field, name it **Total**



Save the database and close **Report 1**.

Open **Report 1**.



Close **Microsoft Access** window**.**

***Attention**: After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:

Access help & learning. Microsoft.com. from https://support.microsoft.com/en-us/access

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4) Microsoft 365 support. Access video training. https://support.microsoft.com/en-us/office/access-video-training-a5ffb1ef-4cc4-4d79-a862-e2dda6ef38e6.

5) Microsoft Office 365 All-in-one for Beginners & Power Users 2021: The Concise Microsoft Office 365 A-Z Mastery Guide for All Users. Tech Demystified, 2021. 764 p.

6) McGrath Mike. Access in easy steps: Illustrated using Access 2019. In Easy Steps Limited, 2019. — 192 p. — ISBN 1840788232, 9781840788235..

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8) Poatsy M., Williams J., Rutledge A. Exploring Microsoft Office Access 2019 Comprehensive. Pearson, 2020. — 647 p. — ISBN 978-0135435816.

Additional

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2) Monk E., Brady J., Cook G.S. Problem Solving Cases in Microsoft Access and Excel. Publisher: Course Technology, 2011. 276 p.

3) Ulrich Laurie Ann, Cook Ken. Access For Dummies. For Dummies, 2022. — 435 p. — ISBN 978-1-119-82908-9.

Topic 5: STATISTICAL PROCESSING AND ANALYSIS OF MEDICAL DATA.

Actuality: The purpose of most studies is to collect **data** to obtain information about a particular area of research. The aim of the researcher is to condense these data in a meaningful way and extract useful information from them. **Statistics** encompasses the methods of collecting, summarizing, analyzing, and drawing conclusions from the data. **Medical statistics** is a wide-ranging subject covering a large number of topics. This lesson provides a basic introduction to the underlying concepts of medical statistics and a guide to the most commonly used statistical procedures. A program that provides good capabilities for doing certain basic statistical analyses is MS Excel. Due to the built-in MS Excel functions (Statistical category) conducting of statistical verification of hypotheses in medical-biological researches is considerably simplified and facilitated. Statistical verification of hypotheses is an integral part of clinical studies. That is why the ability to perform statistical analysis of data using MS Excel is important for future medical workers.

Educational aims of the lesson:

To know:

1. theoretical bases of statistical analysis;
2. basic concepts of mathematical statistics;
3. characteristics of random variables;
4. statistical hypothesis;
5. basic steps of hypothesis testing;
6. basic methods and criteria of statistical hypothesis testing;
7. sample homogeneity (Dixon Criteria, three-sigma rule);
8. the nature of type I and type II errors;
9. systematic error in the method;

To be able to:

1. apply possibilities of MS Excel for conducting a statistical analysis in clinical practice and scientific medical-biological investigations;
2. calculate statistical parameters using MS Excel statistical functions;
3. formulate null and alternative hypothesis;
4. solve tasks on statistical testing of hypothesis on equality of distribution parameters and distribution functions of two independent and correlated samples;
5. test the sample data on homogeneity*;*
6. carry out testing hypothesis on equality of distribution centers of two correlated samples;
7. carry out sign test;
8. compare the action of two medicines.

The list of questions for the survey:

1. Creating formulas in MS Excel.
2. MS Excel statistical functions and their arguments.
3. Basic concepts of statistical parameters estimation.
4. Sample mean, variance and standard deviation.
5. Basic laws of random variables distribution.
6. Basic concepts of statistical hypothesis testing: zero and alternative hypotheses.
7. Testing criterion.
8. Critical region.
9. Type I and type II errors.
10. Testing hypothesis about homogeneity of sample data.
11. Testing investigation method on presence of systematic error.
12. Testing hypothesis about equality of distribution centers of two uncorrelated samples:
13. with known variances (large samples);
14. with unknown but equal variances (small samples);
15. with unknown and unequal variances.
16. Testing hypothesis about equality of distribution centers of two correlated samples.
17. Sign test.

The list of required practical skills:

1. Applying possibilities of MS Excel for conducting statistical analysis in clinical practice and scientific medical-biological investigations.
2. Calculating statistical parameters using MS Excel statistical functions.
3. Solving tasks on statistical testing of hypothesis about equality of distribution parameters and distribution functions of two independent and correlated samples.
4. Formulating null and alternative hypotheses.
5. Testing the sample data on homogeneity.
6. Carrying out testing hypothesis about equality of distribution centers of two correlated samples.
7. Carrying out sign test.
8. Comparison of the action of two medicines.

Brief theoretical information

Basic Concepts of Statistics

Data are usually obtained from a **sample** of individuals which represents the **population** of interest.
Population is entire group we want information about.
Sample is a part of a chosen population to be observed**.**
A sample is a subset of the population; the group of participants from which data is collected.
Sample:

- The proportion of the population we actually examine.
- Representative and not biased.
- Random sampling.
- In most situations, studying an entire population is not possible, so data is collected from a sample and used to estimate the phenomenon in the population.

Statistics encompasses the methods of collecting, summarizing, analyzing and drawing conclusions from the data.
It is very difficult to have any 'feeling' for a set of numerical measurements unless we can summarize the data in a meaningful way. A **diagram** is often a useful starting point. We can also condense the information by providing measures that describe the important characteristics of the data. In particular, if we have some perception of what constitutes a representative value, and if we know how widely scattered the observations are around it, then we can formulate an image of the data.

Measures of Central Tendency

1. The Arithmetic Mean.

The **average** is a general term for a measure of **location**; it describes a typical measurement. We devote this chapter to averages, the most common being the mean and median (Table 5.1).
The **arithmetic mean**, often simply called the **mean**, of a set of values is calculated by adding up all the values and dividing this sum by the number of values in the set.

$$\text{population mean: } \mu = \frac{1}{N}\sum_{i=1}^{N} x_i \qquad \text{and} \qquad \text{sample mean: } \bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i ,$$

where x_i is the data value.

2. The Median

The **median** is the middle value when data is arranged from smallest to largest. It splits the data into two equal parts, with half the values below and half above.
Here's how to find the *median*:
- Arrange the numbers in ascending order.
- If there is an odd number of values, the median is the middle value.
- If there is an even number of values, the median is the average of the two middle numbers.

The *median* is not affected by outliers.

3. The Mode

The **mode** is the value that appears most often in a data set. If the data is continuous, the mode is usually found by grouping the data and identifying the group with the highest frequency.

- Some data sets may have no mode if all values appear only once.
- A data set can have more than one mode if two or more values occur with the same highest frequency.

Measures of Variability

4. The Range.

The **range** is the difference between the largest and smallest values in a data set. However, it may not always accurately reflect the spread of the data if there are extreme outliers.

5. The Variance.

Variance measures how much the data values differ from the mean. Larger differences indicate greater variability. To calculate variance:

- Find how far each value is from the mean (its deviation).
- Square these deviations to avoid positive and negative differences canceling each other out.
- Take the average of the squared deviations. This result is the **variance**.

If we have a sample of *n* observations, x_1, x_2, x_3, ... x_n, whose mean is $\overline{x} = \frac{\Sigma x_i}{n}$ we calculate the variance, usually denoted by s^2, of these observations as:

$$s^2 = \frac{\Sigma(x_i - \overline{x})^2}{n-1}$$

6. The Standard Deviation (*SD*)

The standard deviation is the square root of the variance. In a sample of n observations, it is:

$$s = \sqrt{\frac{\Sigma(x_i - \overline{x})^2}{n-1}}$$

We can think of the standard deviation as a sort of average of the deviations of the observations from the mean. It is evaluated in the same units as the raw data.

If we divide the standard deviation by the mean and express this quotient as a percentage, we obtain the **coefficient of variation**. It is a measure of spread that is independent of the units of measurement, but it has theoretical disadvantages so is not favored by statisticians.

7. The standard error of the mean *(SEM)* is the standard deviation of the sampling distribution of the mean. ***SEM*** quantifies how precisely you know the true mean of the population.

The formula for the *standard error of the mean* is: $\sigma_{\overline{x}} = \frac{\sigma}{\sqrt{n}}$.

An estimate of the standard error of the mean: $s_{\overline{x}} = \frac{s}{\sqrt{n}}$.

Confidence Interval

When we take a sample from a population, we calculate a **point estimate** of the value we are studying and its **standard error**, which shows how precise the estimate is. However, standard error alone isn't very meaningful to most people. Instead, we use it to create a **confidence interval**, which **gives a range of values where the true population value is likely to fall**. This range is calculated using the sample data and the probability distribution of the statistics.

Imagine you want to find out the average weight of 8-year-old girls living in Ukraine. Since it's not practical to weigh every 8-year-old girl, you take a random sample of 20 girls. After measuring, you find that their average weight is **30 kilograms**, and the standard deviation of the sample is **4 kilograms**.

This sample mean of 30 kg is a **point estimate of the population mean**, but it doesn't tell you how close it might be to the true average for all 8-year-old girls in Ukraine. To provide more useful information, you calculate a 95% confidence interval, which gives a range where the true population mean is likely to fall.

Steps to Calculate the Confidence Interval:

1. Find the standard error (SE):

The formula for standard error is:

SE = Standard Deviation / √(Sample Size)

SE = 4 / √20 ≈ 0.89 kg

2. Determine the critical value for 95% confidence:

For a 95% confidence level with a reasonably large sample, the critical value *z* is approximately **1.96.**

3. Calculate the margin of error (ME):

$$ME = z \times SE$$

$$ME = 1.96 \times 0.89 \approx 1.75 \text{ kg}$$

4. Find the confidence interval:

Add and subtract the margin of error from the sample mean to find the lower and upper bounds:

Lower Bound = 30 − 1.75 = 28.25 kg

Upper Bound=30+1.75=31.75kg

95% Confidence Interval:

$$28.25 \le \mu \le 31.75$$

What This Means:

You can be **95% confident** that the true average weight of 8-year-old girls in Ukraine is between 28.25 kg and 31.75 kg. If you repeated the sampling process many times, 95% of the confidence intervals you calculate would include the true population mean, though 5% might not.

While interpreting various results from a set of data, a researcher needs to know how sure is he while dealing with the data. Confidence interval is a range within which most plausible values would occur. To calculate confidence interval, one needs to *set confidence level as 90%, 95%, or 99% etc*. **Most commonly used confidence level is 95% (p=95%, p=100*(1-α))**. Confidence interval represents a particular interval within which the data is 95% (or whatever the confidence level chosen) sure or certain for a particular outcome. The formula for confidence interval is given below:

$$\bar{x} - s_{\bar{x}} \cdot t \le \mu \le \bar{x} + s_{\bar{x}} \cdot t$$

Standard error of the mean for *sample* $s_{\bar{x}}$:

$$s_{\bar{x}} = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n(n-1)}}, \quad \text{if } n < 30, \qquad \text{and} \qquad s_{\bar{x}} = \frac{1}{n}\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2} \quad \text{if } n \ge 30.$$

Testing the Difference Between Two Means

At statistical analysis of the biomedical research results often it is necessary to estimate the difference between the means of distributions of two parameters X and Y. Imagine, we know, that $\bar{x} - \bar{y} \neq 0$**.** And we want to know with what probability it is possible to assert that $\bar{x} - \bar{y} \neq 0$**.**

Let *X* – some parameter of control general average (patients before medical treatment), *Y* – homogeneous to *X* parameter of general average (patients after medical treatment).

We have two samples: *X:* (x_1, x_2,… , x_{n_x}) and *Y:* (y_1, y_2, … , y_{n_y}) (n_y can be not equal to n_x)..

Next step is to calculate samples averages and their standard errors:

$$\bar{x} = \frac{\sum_{i=1}^{n_x} x_i}{n_x}; \qquad \bar{y} = \frac{\sum_{i=1}^{n_y} y_i}{n_y};$$

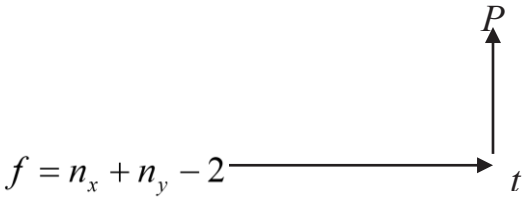
$$s_{\bar{x}} = \sqrt{\frac{\sum_{i=1}^{n_y}(x_i - \bar{x})^2}{n_x(n_x - 1)}}; \quad s_{\bar{y}} = \sqrt{\frac{\sum_{i=1}^{n_y}(y_i - \bar{y})^2}{n_y(n_y - 1)}}.$$

Testing of the difference between two means is conducted with the help a ***Student's t-test***. The ***t-test*** compares the averages and standard deviations of two samples to see if there is a significant difference between them:

$$t = \frac{|\bar{x} - \bar{y}|}{\sqrt{s_{\bar{x}}^2 + s_{\bar{y}}^2}}$$

The given formula is used on condition of large sample, or at $n_y = n_x$.

The numeral value of probability is found from a "Student's distribution" table:



Confidence interval is an interval in which with confidence probability ($P \geq 0{,}95$) general average of random quantity is contained.

Statistical Hypothesis. Hypothesis Testing

We often gather sample data in order to assess how much evidence there is against a specific hypothesis about the population. We use a process known as **hypothesis testing** (or **significance testing**) to quantify our belief against a particular hypothesis.

Hypothesis testing is a procedure, based on sample evidence and probability theory, used to determine whether the hypothesis is a reasonable statement and should not be rejected, or is unreasonable and should be rejected.

Basic steps of hypothesis testing:

Step 1. State null (**H_0**:) and alternative (**H_1**:) hypotheses.

We usually test the **null hypothesis (H_0)** which assumes *no effect* (e.g., the difference in means equals zero) in the *population*.

We then define the **alternative hypothesis (H_1)** which holds if the null hypothesis is not true. The alternative hypothesis relates more directly to the theory we wish to investigate.

Step 2. Choose a *significance level*, α (usually 0.05 or 0.01).

Step 3. Determine the critical (or rejection) region and the non-rejection region, based on the sampling distribution.

Step 4. Based on the sample, calculate the test statistic and compare it with the critical values.

Step 5. Make a decision and state the conclusion.

Types of statistical hypotheses

Null hypothesis, H_0

A **null hypothesis (H_0)** is an idea or statement that assumes no effect, no difference, or no relationship between things. It is often used as a starting point in research or testing, even though it hasn't been proven true.

For *example*, in a clinical trial for a new medicine, the null hypothesis might state that the new medicine works no better than the current one. We write:

- **H_0:** There is no difference between the two medicines on average.

Alternative hypothesis, H_A

An **alternative hypothesis (H_1)** is a statement that a hypothesis test aims to prove. It suggests that there is a difference, effect, or relationship between things.
For *example*, in a clinical trial for a new drug:
The alternative hypothesis might state that the new drug has a different effect compared to the current drug. We write:
H1: The two drugs have different effects on average.

In another case, the alternative hypothesis could claim that the new drug is better than the current drug. We write:
H1: The new drug is better than the current drug on average.

Outcome of testing: "Reject H_0 in favor of H_1" or "Do not reject H_0".

Sample Homogeneity (Dixon Criteria)

When taking repeated measurements of a physical or chemical quantity, some values might be very different from most of the others. In such cases, there is often a strong reason to exclude these unusual values from calculations to avoid affecting the results.

Testing the sample for homogeneity:

1) The N values comprising the set of observations under examination are arranged in ascending order: $x_1 < x_2 < \ldots < x_N$.

2) The statistic experimental *r*-value (r_{exp}) is calculated according to a *Dixon Criteria* table below:

Dixon Criteria for Testing of Extreme Observation

The sample size (volume), n	if smallest value (x_1) is suspected	if largest value (x_n) is suspected
$3 \le n \le 7$	$r_{10} = \frac{x_2 - x_1}{x_n - x_1}$	$r_{10} = \frac{x_n - x_{n-1}}{x_n - x_1}$
$8 \le n \le 10$	$r_{11} = \frac{x_2 - x_1}{x_{n-1} - x_1}$	$r_{11} = \frac{x_n - x_{n-1}}{x_n - x_2}$
$11 \le n \le 13$	$r_{21} = \frac{x_3 - x_1}{x_{n-1} - x_1}$	$r_{21} = \frac{x_n - x_{n-2}}{x_n - x_2}$
$14 \le n \le 25$	$r_{22} = \frac{x_3 - x_1}{x_{n-2} - x_1}$	$r_{22} = \frac{x_n - x_{n-2}}{x_n - x_3}$

3) The obtained r_{exp} value is compared to a critical *Q-value r** (r_{crit}) found in tables.

4) If $r_{exp} > r^*$, then the suspect value can be characterized as an outlier and it can be rejected, if not, the suspect value must be retained and used in all subsequent calculations.

Testing the Hypothesis About Equality of the Centers of Distributions of Two Correlated Data Sets

Let **X** is an object characteristic befor factor action, **Y** is an object characteristic after factor action. Then certain object is described by the pare of characteristics (X_i, Y_i), i=1, 2,..., n. Random variables D_1, D_2, ..., D_n are considered to be independent and submit to the normal law of distribution.
The difference $D_i=X_i-Y_i$ shows change of the i-th object characteristic due to the factor action.
Hypotheses:
H_0: $\mu_D = 0$ – centres of distributions of characteristics X and Y are undisplaced;
H_1: $\mu_D \neq 0$ – centres of distributions of characteristics X and Y are displaced;
α – a significance level.

The testing criterion is ***t-score***: $$t = \frac{\bar{d}}{S_{\bar{d}}},$$

where $s_{\bar{d}} = \sqrt{\frac{\overline{d^2}-\bar{d}^2}{n-1}}$, $\bar{d} = \frac{1}{n}\sum_{i=1}^{n}(y_i - x_i)$, $\overline{d^2} = \frac{1}{n}\sum_{i=1}^{n}(y_i - x_i)^2$.

Random variable ***t*** submits to the Student's distribution with the ***ν=n*-1** degrees of freedom.
If $|t| > t^*$ the null hypothesis has to be rejected in favor of the alternative hypothesis.
Critical value ***t*=t(p=1–α/2;ν=n-1)*** can be found from *Student distribution table*.

Sign Test

The sign test is used for statistical test of hypotheses about significance of influence of some factor on a object characteristics.

Formulate hypotheses:

H_0: changes of object characteristics are random;
H_1: changes of object characteristics are not random;
α is a **significance level.**

Let
X_i – Value of an investigated characteristic of ***i***-th object before factor action;
Y_i – Value of a characteristic of the same object after factor action.
Direction of change of a characteristic value is defined by a sign of **$D_i=Y_i – X_i$**.
Laws of distribution of variables **X** and **Y** are considered to be identical.
If variables **X** and **Y** were independent the probability of positive and negative values of **D** would be identical and equal to 0.5.

Let's consider that for the correlated variables **X** and **Y** the nunbers of positive n^+ and negative n^- values of **D** in the sample are different ($n^+ \neq n^-$). Objects for which **D=0** are not included into volume of sample **n**, that is sample volume $n = n^+ + n^-$.

Smaller number of n^+ and n^- is denoted as **k** and is considered to be a criterion of hypotheses testing. If ***k*> *k**** the null hypothesis isn't rejected. If ***k* ≤*k**** the null hypothesis has to be rejected and influance of factor on an investigated object characteristic is considered to be significant.
Critical value of criterion ***k* = k(•; n)*** is defined from special tables.

The Comparison of Action of Two Medicines

Let:

n_1 –volume of sample for studying of action of the first medicine, and $n_1 = n_1^+ + n_1^-$, where n_1^+ and n_1^- – number of positive and negative effects of action of the first medicine;

n_2 – volume of sample for studying of action of the second medicine, and $n_2 = n_2^+ + n_2^-$, where n_2^+ and n_2^- – number of positive and negative effects of action of the second medicine.

We make up the contingency table:

n_1^+	n_1^-	n_1
n_2^+	n_2^-	n_2
$n_1^+ + n_2^+$	$n_1^- + n_2^-$	n_1+n_2

For comparison of action of two drugs **χ^2-score** is calculated:

$$\chi^2 = \frac{(n_1+n_2)\left(\left|n_1^+ n_2^- - n_1^- n_2^+\right| - \frac{1}{2}(n_1+n_2)\right)^2}{(n_1^+ + n_2^+)(n_1^- + n_2^-)\cdot n_1 \cdot n_2}$$

If **$\chi^2 > \chi^{2*}$** difference of action of two medicines is considered to be significant with probability of conclusion error **$p<\alpha$**.

Critical value **$\chi^2=\chi^{2*}(p=1-\alpha;\ \nu=1)$** is defined from the **χ^2**-distribution table.

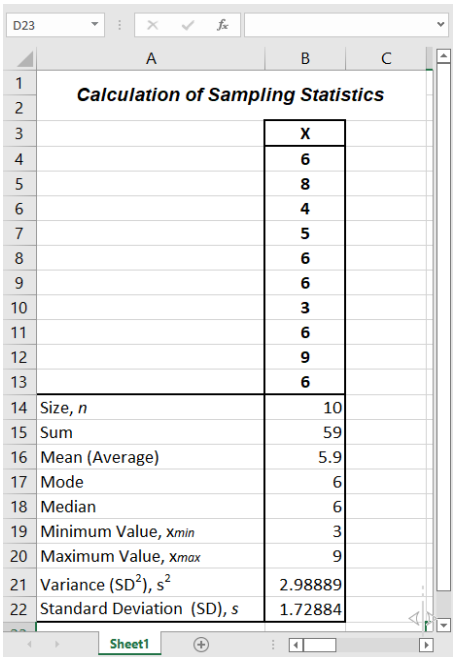
Some of MS Excel Statistical functions:

Statistical functions (reference). https://support.microsoft.com/en-us/office/statistical-functions-reference-624dac86-a375-4435-bc25-76d659719ffdm

Statistical			
AVERAGE	Returns the average of its arguments	**F.DIST.RT**	Returns the right-tailed F probability distribution for two data sets
COUNT	Counts how many numbers are in the list of arguments	**F.TEST**	Returns the result of an F-test
MAX	Returns the maximum value in a list of arguments	**MEDIAN**	Returns the median of the given numbers
MIN	Returns the minimum value in a list of arguments	**MODE**	Returns the most common value in a data set
CORREL	Returns the correlation coefficient between two data sets	**NORM.DIST**	Returns the normal cumulative distribution
CHISQ.DIST.RT	Returns the right-tailed probability of the chi-squared distribution	**PEARSON**	Returns the Pearson product moment correlation coefficient
CONFIDENCE.NORM	Returns the confidence interval for a population mean, using a normal distribution	**STDEV.S**	Estimates standard deviation based on a sample
CHISQ.TEST	Returns the chi-squared statistical test for independence	**T.DIST.2T**	Returns the two-tailed Student's t-distribution
FISHER	Returns the Fisher transformation	**DEVSQ**	Returns the sum of squares of deviations

EXAMPLE №1. *Given a sample X {6, 8, 4, 5, 6, 6, 3, 6, 9, 6}. Calculate* ***size (n)***, ***sum***, ***mean (average value)*** $\overline{x}$, ***mode***, ***median, minimum value*** x_{min} , ***maximum value*** x_{max} , ***variance (s^2)***, ***standard deviation (SD)*** S ***(square root of variance)*** *using* **MS Excel** *mathematical and statistical functions.*

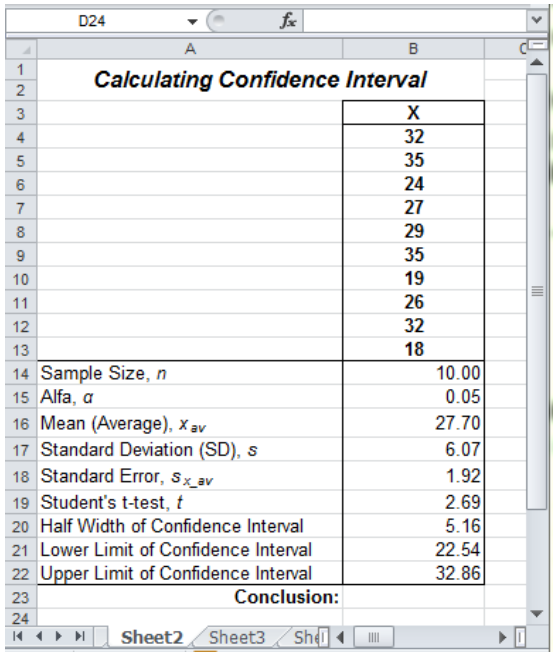
Create a new table as shown on the ***Fig. 1***:



	A	B	C
1	Calculation of Sampling Statistics		
2			
3		X	
4		6	
5		8	
6		4	
7		5	
8		6	
9		6	
10		3	
11		6	
12		9	
13		6	
14	Size, *n*	10	
15	Sum	59	
16	Mean (Average)	5.9	
17	Mode	6	
18	Median	6	
19	Minimum Value, x_{min}	3	
20	Maximum Value, x_{max}	9	
21	Variance (SD^2), s^2	2.98889	
22	Standard Deviation (SD), *s*	1.72884	

Sheet1

Fig. 1



	A	B
1	Calculating Confidence Interval	
2		
3		X
4		32
5		35
6		24
7		27
8		29
9		35
10		19
11		26
12		32
13		18
14	Sample Size, *n*	10.00
15	Alfa, α	0.05
16	Mean (Average), x_{av}	27.70
17	Standard Deviation (SD), *s*	6.07
18	Standard Error, s_{x_av}	1.92
19	Student's t-test, *t*	2.69
20	Half Width of Confidence Interval	5.16
21	Lower Limit of Confidence Interval	22.54
22	Upper Limit of Confidence Interval	32.86
23	Conclusion:	

Sheet2 Sheet3

Fig. 2

• select cells **A1:C2** on the **Sheet1**, on the **Home** tab, in the **Alignment** group, click **Merge and Center** ;

• type text into cells **A1:C2**, **B3:B13** and **A14:A22** according to **Fig. 1**;

Calculate the values of the corresponding quantities:

• click the cell **B14** and type the formula **=COUNT(B4:B13)** (click the cell **B14**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNT** → **OK** → type **B4:B13** → **OK)**;

• click the cell **B15** and type the formula **=SUM(B4:B13)** (click the cell **B15**, click **Insert Function** button on the **Formula bar** → select **Math and Trig** from **select a category** box → select **SUM** → **OK** → type **B4:B13** → **OK)**;

• click the cell **B16** and type the formula **=AVERAGE(B4:B13)** (click the cell **B16**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → type **B4:B13** → **OK)**;

• click the cell **B17** and type the formula **=MODE.SNGL(B4:B13)** (click the cell **B17**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **MODE.SNGL** → **OK** → type **B4:B13** → **OK)**;

• click the cell **B18** and type the formula **=MEDIAN(B4:B13)** (click the cell **B18**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **MEDIAN** → **OK** → type **B4:B13** → **OK)**;

• click the cell **B19** and type the formula **=MAX(B4:B13)** (click the cell **B19**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **MAX** → **OK** → type **B4:B13** → **OK)**;

• click the cell **B20** and type the formula **=MIN(B4:B13)** (click the cell **B20**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **MIN** → **OK** → type **B4:B13** → **OK)**;

• click the cell **B21** and type the formula **=STDEV.S(B4:B13)** (click the cell **B21**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **STDEV.S** → **OK** → type **B4:B13** → **OK)**;

• click the cell **B22** and type the formula **=VAR.S(B4:B13)** (click the cell **B22**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **VAR.S** → **OK** → type **B4:B13** → **OK)**;

*Format the table according to **Fig. 1**.*

Formatting instructions:
Font: **Arial**;
Size: cells **A1:C2** – **12**, other cells – **10**;
Style: cells **A1:C2 – Bold Italic**, **B3:B13** – **Bold**, other cells – **Regular**;
Horizontal alignment: **A1:C2, B3:B13** – **Center,** other cells – **by default** (don't change);
Vertical alignment: cells **A1:C2** – **Center.**

*Apply cell borders to the table according to the **Fig. 1**.*
*Click **Save** .*

****

EXAMPLE №2. *Calculate **confidence interval** for the mean of the sample: **32, 35, 24, 27, 29, 35, 19, 26, 32, 18 (α=0.05)**.*

*Create a new table as shown on the **Fig. 2**:*
• select cells **A1:B2** on the **Sheet2**, on the **Home** tab, in the **Alignment** group, click **Merge and Center** ;
• type text into cells **A1:B2**, **B3:B13** and **A14:A23** according to **Fig. 2**;

Calculate the values of the corresponding quantities:
• click the cell **B14** and type the formula **=COUNT(B4:B13)** (click the cell **B14**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNT** → **OK** → type **B4:B13** → **OK)**;
• click the cell **B15** and type **0.05**, press **Enter**;
• click the cell **B16** and type the formula **=AVERAGE(B4:B13)** (click the cell **B16**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → type **B4:B13** → **OK)**;
• click the cell **B17** and type the formula **=STDEV.S(B4:B13)** (click the cell **B17**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **STDEV.S** → **OK** → type **B4:B13** → **OK)**;
• click the cell **B18** and type the formula **=B17/SQRT(B14)** (click the cell **B18**, press **=**, click **B17**, press **/**, click **Insert Function** button on the **Formula bar** → select **Math and Trig** from **select a category** box → select **SQRT** → **OK** → type **B14** → **OK)**;
• click the cell **B19** and type the formula **=T.INV.2T(1-(1+(1-B15))/2,B14-1)** (click the cell **B19**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **T.INV.2T** → **OK** → type **1-(1+(1-B15))/2** in **Probability** box → type **B14-1** in **Deg_freedom** box → **OK)**;
• click the cell **B20** and type **=B19*B18**, press **Enter**;
• click the cell **B21** and type **=B16-B20**, press **Enter**;
• click the cell **B22** and type **=B16+B20**, press **Enter**;

*Make a conclusion and type it into the cell **B23.***
***Note**: For making conclusion use the formula **lower limit ≤ μ ≤ upper limit**.*
*Format the table according to **Fig. 2**.*

Formatting instructions:
Font: **Arial**;
Size: cells **A1:B2** – **12**, other cells – **10**;
Style: cells **A1:B2 – Bold Italic**, **B3:B13, A23** – **Bold**, other cells – **Regular**;
Horizontal alignment: **A1:B2, B3:B13** – **Center, A23** – **Right,** other cells – **by default** (don't change);
Vertical alignment: cells **A1:B2** – **Center.**

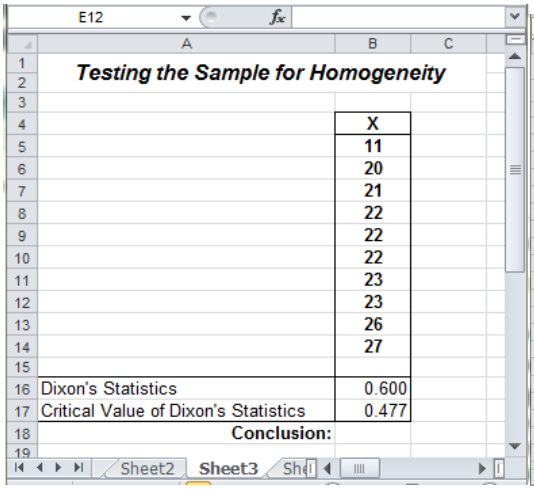
*Apply cell borders to the table according to the **Fig. 2**.*
*Click **Save** .*

****

EXAMPLE №3. *Using* **MS Excel** *test the sample for homogeneity applying the Dixon's test, if* **α = 0,05**, *and experimental data are:* **22**, **26**, **20**, **23**, **11**, **22**, **23**, **27**, **21**, **22**.

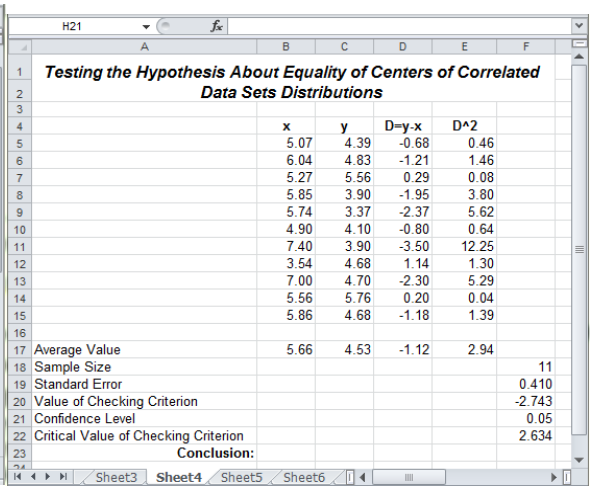
*Create a new table as shown on the **Fig. 3**:*
• select cells **A1:C2** on the **Sheet3**, on the **Home** tab, in the **Alignment** group, click **Merge and Center** ;
• type text into cells **A1:C2**, **B4** and **A16:A18** according to **Fig. 3**;
• type into cells **B5:B14** following data: **22**, **26**, **20**, **23**, **11**, **22**, **23**, **27**, **21**, **22**;

Calculate the values of the corresponding quantities:
• select cells **B5:B14**, on the **Data** tab, in the **Sort & Filter** group, click **Sort A to Z** ;
• click the cell **B16** and type the formula **=(B6-B5)/(B13-B5)** and press **Enter**;
• click the cell **B17** and type **0,477** (critical value of Dixon's statistics), press **Enter**;



	A	B	C
1	***Testing the Sample for Homogeneity***		
2			
3			
4		X	
5		11	
6		20	
7		21	
8		22	
9		22	
10		22	
11		23	
12		23	
13		26	
14		27	
15			
16	Dixon's Statistics	0.600	
17	Critical Value of Dixon's Statistics	0.477	
18	**Conclusion:**		

Fig. 3



	A	B	C	D	E	F
1	***Testing the Hypothesis About Equality of Centers of Correlated Data Sets Distributions***					
2						
3						
4		x	y	D=y-x	D^2	
5		5.07	4.39	-0.68	0.46	
6		6.04	4.83	-1.21	1.46	
7		5.27	5.56	0.29	0.08	
8		5.85	3.90	-1.95	3.80	
9		5.74	3.37	-2.37	5.62	
10		4.90	4.10	-0.80	0.64	
11		7.40	3.90	-3.50	12.25	
12		3.54	4.68	1.14	1.30	
13		7.00	4.70	-2.30	5.29	
14		5.56	5.76	0.20	0.04	
15		5.86	4.68	-1.18	1.39	
16						
17	Average Value	5.66	4.53	-1.12	2.94	
18	Sample Size					11
19	Standard Error					0.410
20	Value of Checking Criterion					-2.743
21	Confidence Level					0.05
22	Critical Value of Checking Criterion					2.634
23	**Conclusion:**					

Fig. 4

*Make a conclusion about sample homogeneity and type it into the cell **B18.***
*Format the table according to **Fig. 3**.*

Formatting instructions:
Font: **Arial**;
Size: cells **A1:C2** – **12**, other cells – **10**;
Style: cells **A1:C2 – Bold Italic**, **B4:B14, A18** – **Bold**, other cells – **Regular**;
Horizontal alignment: **A1:C2, B4:B14** – **Center, A18** – **Right,** other cells – **by default** (don't change);
Vertical alignment: cells **A1:C2** – **Center.**

*Apply cell borders to the table according to the **Fig. 3**.*
*Click **Save** .*

****

EXAMPLE №4. *Using* **MS Excel** *test the hypothesis about equality of centers of correlated data sets distributions, if it is known that* **α=0,05** *and that investigating the cholesterol changes in blood plasma in patients that have had gastric resection before (**X**) and after (**Y**) rehabilitation treatment following data were obtained:*
X: 5,07; **6,04**; **5,27**; **5,85**; **5,74**; **4,90**; **7,40**; **3,54**; **7,00**; **5,56**; **5,86**
Y: 4,39; **4,83**; **5,56**; **3,90**; **3,37**; **4,10**; **3,90**; **4,68**; **4,70**; **5,76**; **4,68**.

*Create a new table as shown on the **Fig. 4***:
• select cells **A1:F2** on the **Sheet4**, on the **Home** tab, in the **Alignment** group, click **Merge and Center** ;
• type text into cells **A1:F2**, **B4:E4, B5:C15** and **A17:A23** according to **Fig. 4**;

Calculate the values of the corresponding quantities:
• select cell **D5** · type formula **=C5-B5** ·· press **Enter**;
• select cell **E5** · type formula **=D5^2** · press **Enter**;
• select cells **D5:E5** and copy their content into cells **D6:E15** using drag and drop method;
• click the cell **B17** and type the formula **=AVERAGE(B5:B15)** (click the cell **B17**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → type **B5:B15** → **OK)**;
• copy content of **B17** into cells **C17:E17** using drag and drop method;
• click the cell **F18** and type the formula **=COUNT(B5:B15)** (click the cell **F18**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNT** → **OK** → type **B5:B15** → **OK)**;
• click the cell **F19** and type the formula **=SQRT((E17-D17^2)/(F18-1))** (click the cell **F18**, click **Insert Function** button on the **Formula bar** → select **Math & Trig** from **select a category** box → select **SQRT** → **OK** → type **(E17-D17^2)/(F18-1)** → **OK)**;
• click cell **F20** · type formula **=D17/F19** · press **Enter**;
• click cell **F21** · type **0.05** · press **Enter**;
• click the cell **F22** and type the formula **=T.INV.2T(F21/2;F18-1)** (click the cell **F22**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **T.INV.2T** → **OK** → type **F21/2** in **Probability** box → type **F18-1** in **Deg_freedom** box → **OK)**;

*Make a conclusion and type it into the cell **B23.***
*Format the table according to **Fig. 4***.

Formatting instructions:
Font: **Arial**;
Size: cells **A1:F2** – **12**, other cells – **10**;
Style: cells **A1:F2 – Bold Italic**, **B4:E4, A23** – **Bold**, other cells – **Regular**;
Horizontal alignment: **A1:F2, B4:E4** – **Center, A23** – **Right,** other cells – **by default** (don't change);
Vertical alignment: cells **A1:F2** – **Center.**
*Click **Save*** .

****

EXAMPLE №5. *Using* **MS Excel** *test the hypothesis about influence of thermal treatment of nuts on change in mass of rats applying the sign test if* **α=0,05**, *and 1st group of rats ate raw nuts, and 2nd group ate fried nuts. Following data were obtained (in g):*
X: 59; **61**; **60**; **60**; **56**; **63**; **59**; **59**; **56**; **44**; **61**; **63**; **58**; **59**; **62**
Y: 56; **55**; **57**; **54**; **56**; **61**; **60**; **57**; **56**; **42**; **58**; **54**; **55**; **57**; **59,**
where **X** *– mass of rats which ate raw nuts,* **Y** *– mass of rats which ate fry nuts*.

*Create a new table as shown on the **Fig. 5***:
• select cells **A1:D2** on the **Sheet5**, on the **Home** tab, in the **Alignment** group, click **Merge and Center** ;
• in the same way merge cells **A24:C24**, **A25:C25**, **A26:C26** and **A27:C27**;
• type text into cells **A1:D2**, **A4:D4, A5:C19**, **C21:C23** and **A24:A27** according to **Fig. 5**;

Calculate the values of the corresponding quantities:

• click the cell **D5** ▪ type formula **=C5-B5** ▪▪ press **Enter**;
• copy content of **D5** into cells **D6:D19**;
• click the cell **D21** and type the formula **=COUNTIF(D5:D19;">0")** (click the cell **D21**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNTIF** → **OK** → type **D5:D19** in **Range** box → type **>0** in **Criteria** box → **OK)**;
• click the cell **D22** and type the formula **=COUNTIF(D5:D19;"<0")** (click the cell **D22**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNTIF** → **OK** → type **D5:D19** in **Range** box → type **<0** in **Criteria** box → **OK)**;
• click the cell **D23** ▪ type formula **=D21+D22** ▪▪ press **Enter**;
• click the cell **D24** and type the formula **=MIN(D21:D22)** (click the cell **D24**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **MIN** → **OK** → type **D21:D22** → **OK)**;
• click cell **D25** ▪ type **0.05** ▪ press **Enter**;
• click cell **D25** ▪ type **3** (critical value of sign criterion) ▪ press **Enter**;

*Make a conclusion and type it into the cell **D27.***
*Format the table according to **Fig. 5**.*

Formatting instructions:
Font: **Arial**;
Size: cells **A1:D2** – **12**, other cells – **10**;
Style: cells **A1:D2 – Bold Italic**, **A4:D4, C21:C23, A24:A27** – **Bold**, other cells – **Regular**;
Horizontal alignment: **A1:D2, A4:D4, A24:A26** – **Center, A27** – **Right,** other cells – **by default** (don't change);
Vertical alignment: cells **A1:D2** – **Center.**

*Click **Save** .*

E28

	A	B	C	D
1	***Testing the Hypothesis About Influence of***			
2	***Factor on Result Applying the Sign Test***			
3				
4	№	X	Y	D=Y-X
5	1	59	56	-3
6	2	61	55	-6
7	3	60	57	-3
8	4	60	54	-6
9	5	56	56	0
10	6	63	61	-2
11	7	59	60	1
12	8	59	57	-2
13	9	56	56	0
14	10	44	42	-2
15	11	61	58	-3
16	12	63	54	-9
17	13	58	55	-3
18	14	59	57	-2
19	15	62	59	-3
20				
21			n^+	1
22			n^-	11
23			$n=n^++n^-$	12
24	Checking Criterion, *k*			1
25	Confidence Level, *α*			0.05
26	Critical Value, *k**			3
27			Conclusion:	

Sheet3 Sheet4 She

Fig. 5

E13

	A	B	C	D
1	***Comparison of Two Medicines Action***			
2				
3				
4		Number of Positive Observations	Number of Negative Observations	Totals
5	1-st Medicine (A)	35	15	50
6	2-nd Medicine (B)	30	20	50
7	Totals for Observations	65	35	100
8				
9	Confidence Level			0.05
10	Checking Criterion			0.703
11	Critical Value of Checking Criterion			3.841
12			Conclusion:	
13				

Sheet5 Sheet6

Fig. 6

****

EXAMPLE №6. *Using* **MS Excel** *compare the action of two medicines* **A** *and* **B**, *if* **α = 0,05**, *when after application of medicine* **A** *to the first studied group 15 of 50 mice died and after application of medicine* **B** *to the second studied group 20 of 50 mice died.*

*Create a new table as shown on the **Fig. 6**:*
• select cells **A1:D2** on the **Sheet5**, on the **Home** tab, in the **Alignment** group, click **Merge and Center** ;

• in the same way merge cells **A9:C9**, **A10:C10**, **A11:C11** and **A12:C12**;
• type text into cells **A1:D2**, **B4:D4, A5:A7**, **B5:C6** and **A9:A12** according to **Fig. 6**;

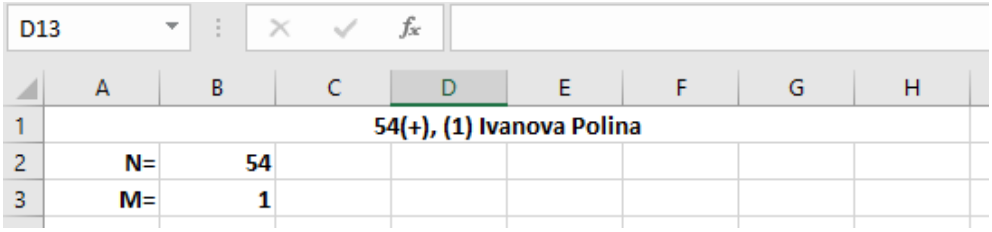
Calculate the values of the corresponding quantities:
• click the cell **D5** and type the formula **=SUM(B5:C5)** (click the cell **D5**, click **Insert Function** button on the **Formula bar** → select **Math and Trig** from **select a category** box → select **SUM** → **OK** → type **B5:C5**→ **OK)**;
• copy the content of cell **D5** into the cell **D6**;
• click the cell **B7** and type the formula **=SUM(B5:B6)** (click the cell **B7**, click **Insert Function** button on the **Formula bar** → select **Math and Trig** from **select a category** box → select **SUM** → **OK** → type **B5:B6**→ **OK)**;
• copy the content of cell **B7** into the cells **C7:D7;**
• click cell **D9** · type **0.05** · press **Enter**;
• click the cell **D10** · type formula **=D7*(ABS(B5*C6-C5*B6)-D7/2)^2/(B7*C7*D5*D6)** · press **Enter**;
• click the cell **D11** and type the formula **=CHISQ.INV.RT(D9;1)** (click the cell **D11**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **CHISQ.INV.RT** → **OK** → type **D9** in **Probability** box → type **1** in **Deg_freedom** box → **OK)**;

*Make a conclusion and type it into the cell **D12.***
*Format the table according to **Fig. 6**.*

Formatting instructions:
Font: **Arial**;
Size: cells **A1:D2** – **12**, other cells – **10**;
Style: cells **A1:D2 – Bold Italic**, **B4:D4, A5:A7, A9:A12** – **Bold**, other cells – **Regular**;
Horizontal alignment: **A1:D2, B4:D4, A5:A7, A9:A11** – **Center, A12** – **Right,** other cells – **by default** (don't change);
Vertical alignment: cells **A1:D2, B4:D4, A5:A7** – **Center.**

Practical tasks for students.
Instructions for the execution of practical work

1. Start a computer and wait for the loading **Windows OS.**
2. Start **Microsoft Excel** program.
3. *Save the document on Desktop*.
4. Merge cells **A1-H1**. In this field specify
Group Number, (Your sequential number in the group) Name, Surname
For example:



5. Perform the following tasks:

N – your group number **M** – your sequential number in the group

Task №1. *Given a sample X {***N, N-M, (N+M)/2, 53, 61, 62, 53, 56, 59, 61***}. Calculate* ***size (n)***, ***sum***, ***mean (average value)*** $\overline{x}$, ***mode***, ***median, minimum value*** x_{min} , ***maximum value*** x_{max} , ***variance (*** s^2 ***)***,

standard deviation (SD) S *(square root of variance)* using **MS Excel** mathematical and statistical functions.
Create the table according to *Fig.1*.

Task №2. Calculate *confidence interval* for the mean of the sample.
*N/2, N-2*M, (N+M)/2, 29, 28, 33, 21, 21, 33, 15 (α=0,05).*
Create a new table as shown on the *Fig. 2*.

Task №3. Using **MS Excel** test the sample for homogeneity by applying the Dixon's test, if α = **0,05** and experimental data are: *N/2, N-2*M, (N+M)/2*, 23, 11, 22, 23, 27, 21, 22.
Create a new table as shown on the *Fig. 3*.

Task №4. Using **MS Excel** test the hypothesis about equality of centers of correlated data sets distributions, if it is known that **α=0,05** and then investigating the cholesterol changes in blood plasma in patients that have had gastric resection before (*X*) and after (*Y*, rehabilitation treatment following data were obtained:
X: 4,07; 5,02; 6,17; 4,75; 5,72; 4,98; 6,40; 3,58; 6,00; 6,26; 5,86
Y: 4,41; 3,73; 4,56; 3,90; 3,57; 4,10; 3,90; 4,68; 4,70; 5,76; 4,68
Create a new table as shown on the *Fig. 4*.

Task №5. Using **MS Excel** test the hypothesis about influence of thermal treatment of nuts on change in mass of rats applying the sign test if α=0,05, and 1st group of rats are raw nuts, and 2nd group are fried nuts. Following data were obtained (in g):
X: N; N-M; 60; 60; 56; 63; N; N; 56; N-M; 61; 63; 58; 59; N
Y: N; 55; 57; 54; 56; 61; N-M; 57; 56; 42; 58; 54; 55; 57; N;
where X – mass of rats which ate raw nuts, Y – mass of rats which ate fry nuts.

Create a new table as shown on the Fig. 5:

Task №6. Using **MS Excel** compare the action of two medications **A** and **B**, if α = 0,05. After application of medication **A** to the first studied group *12* of **N** mice died. After application of medication **B** to the second studied group *20* of **N** mice died. **N** – your group number.

Create a new table as shown on the Fig. 6:

Attention: *After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:
Excel help & learning. Microsoft.com. from https://support.microsoft.com/en-us/excel
1) Rosner, B. A., & Kras, J. F. (2023). *Statistics for health care management and administration: Working with excel* (4th ed.). Jossey-Bass.
2) Quirk, T. J., & Cummings, S. V. (2019). *Excel 2016 for health services management statistics: A guide to solving practical problems*. Springer International Publishing.
3) Hoffman, J. I. E. (2019). *Biostatistics for medical and biomedical practitioners* (2nd ed.). Academic Press.
Additional:
1) Forister, J. G., & Blessing, J. D. (2019). *Introduction to research and medical literature for health professionals* (4th ed.). Jones & Bartlett.
2) Cleophas, T. J., & Zwinderman, A. H. (2020). *Clinical data analysis on a pocket calculator*. Springer International Publishing.
3) Rothman, K. J., Lash, T. L., & Greenland, S. (2021). *Modern Epidemiology* (3rd ed.). Lippincott Williams and Wilkins.

Topic 6: ONE-WAY ANALYSIS OF VARIANCE (ANOVA).

Actuality: Medical workers need to know how to test the hypothesis about the equality of means of a continuous variable in two or more independent comparison groups. In a clinical trial to evaluate a new medication, investigators might compare an experimental medication to a placebo and a standard treatment (i.e., a medication currently being used). For comparing the means of the comparison groups, the Analysis of Variance technique is used. For statistical calculations, the most expedient is the application of personal computers. A program that provides good capabilities for doing certain basic statistical analyses is MS Excel. That is why the ability to perform analysis of variance using MS Excel is important for future medical workers.

Educational aims of the lesson:

To know:

1. theoretical bases of analysis of variance;
2. syntax of MS Excel functions that are used in the analysis of variance.

To be able to:

1. apply possibilities of MS Excel for analyzing variance in clinical practice and scientific medical-biological investigations;
2. calculate F-statistic using MS Excel statistical functions.

The list of questions for the survey:

1. What the ANOVA technique is used for?
2. One-way (one-factor) ANOVA step by step.
3. Calculating the Between-Group, Within-Group, and Total Sum of Squares, Between-Group, Within-Group, and Total Mean Squared Deviations, F-score.
4. ANOVA Summary Table.
5. Evaluation of differences between factor levels for their impact on the final characteristic of X.

The list of required practical skills:

1. applying possibilities of MS Excel for analyzing variance in clinical practice and scientific medical-biological investigations;
2. calculating F-statistic using MS Excel statistical functions.

Brief theoretical information

Analysis of Variance (**ANOVA**) is a statistical method for detecting the effect of individual factors on the results of an experiment, and for the subsequent planning of similar experiments. Modern applications of **ANOVA** embrace a wide scope of problems in economics, sociology, biology, and technology. Analysis of Variance is a statistical method used to test differences between two or more means.

The null hypothesis (H_0) of the **ANOVA** is always that the group means are equal (factor is insignificant) and the alternative hypothesis (H_a) is always that the group means are not equal (factor is significant).

In describing an **ANOVA** design, the term factor is a synonym for the independent variable. An **ANOVA** conducted on a design in which there is only one factor is called a one-way (one-factor) **ANOVA**. If an experiment has two factors, then the **ANOVA** is called a two-way (two-factor) **ANOVA**. In general, if an experiment has more than one factor, then the **ANOVA** is called multi-factor.

Factors can only assume a limited number of possible values, known as factor levels.

In **ANOVA**, factors are either fixed or random. Usually, if the investigator controls the levels of a factor, then the factor is fixed. Conversely, if the investigator randomly sampled the levels of a factor from a population, then the factor is random.

ANOVA Step by Step

In the simplest case of Analysis of Variance, it is considered the impact of one (main) factor *A* on the final sign of *X*.

Let this factor has *m* quantitative or qualitative levels according to which the whole set of scores can be divided into *m* groups. It can be conveniently presented in tabular form:

Levels of factor A	**A_1**	**A_2**	**…**	**A_m**
Value of X	X_{11}, X_{12}, …, X_{1n1}	X_{21}, X_{22}, …, X_{2n2}	…	X_{m1}, X_{m2}, …, X_{mnm}
Number of trials at the i-th factor level	n_1	n_2	…	n_m

where x_{ik} is the response value at the *i-th* factor level and the *k-th* trial, n_i is the number of trials at the *i-th* factor level $\sum_{i=1}^{m} n_i = n$, and is the total number of trials at all factor levels.

Steps for One-Way ANOVA

Step 1. Calculate the **Grand Mean** (the mean of all scores in all groups in the sample):

$$\bar{x} = \frac{\sum_{i=1}^{m}\sum_{k=1}^{n_i} x_{ik}}{\sum_{i=1}^{m} n_i}.$$

Step 2. Calculate **Means of a Particular Group**, (the means at *i-th* factor levels):

$$\bar{x}_i = \frac{\sum_{k=1}^{n_i} x_{ik}}{n_i}.$$

Step 3. Calculate **Between-Group Sum of Squares (Squared Deviations)**:

$$SS_{\text{Between}} = C_x = \sum_{i=1}^{m} n_i \left(\bar{x}_i - \bar{x}\right)^2.$$

Step 4. Calculate **Within-Group Sum of Squares** (or **Error Sum of Squares**):

$$SS_{\text{Within}} = C_z = \sum_{i=1}^{m}\sum_{k=1}^{n_i} \left(x_{ik} - \bar{x}_i\right)^2.$$

Step 5. Calculate **Total Sum of Squares**: $SS_{Total} = C_y = SS_{Between} + SS_{Within}$.

Step 6. Calculate the ratio $\eta_x^2 = SS_{\text{Between}} / SS_{Total}$ that represents the influence of factor *A* on *X*.

Step 7. Calculate the ratio $\eta_z^2 = SS_{\text{Within}} / SS_{Total}$ that represents the influence of random factors on *X*.

Step 8. Calculate **Total Mean Squared Deviation:** $MS_{Total} = \sigma_y^{*2} = \frac{SS_{Total}}{n-1}$.

Step 9. Calculate **Between-Group Mean Squared Deviation**: $MS_{Between} = \sigma_x^{*2} = \frac{SS_{Between}}{m-1}$.

Step 10. Calculate **Within-Group Mean Squared Deviation:** $MS_{Within} = \sigma_z^{*2} = \frac{SS_{Within}}{n-m}$.

Step 11. Calculate the **F statistic ratio** $F = \frac{MS_{Between}}{MS_{Within}}$

This **F-statistic** follows the **F-distribution** with *m-1*, and *n-m* degrees of freedom provided that *X* follows the normal distribution with equal variance in each group.

If **F>F***, then it could be said about the reliable influence of factor *A* on *X* (P=1-$\alpha \geq 0.95$). Critical value $F^*=F(P=1-\alpha;\ v_1=m-1;\ v_2=n-m)$ is taken from the Fisher's distribution table for given probability P=1-$\alpha \geq 0.95$ or significance level $\alpha \leq 0.05$.

Finally, you should always present what is called an ANOVA Summary Table that contains the results of all of these calculations. It should look like this:

Source of Variation	SS	MS	F
Between groups	$SS_{\text{Between}} = C_x = \sum_{i=1}^{m} n_i \left(\overline{x_i} - \overline{x}\right)^2$	$MS_{Between} = \sigma_x^{*2} = \frac{SS_{Between}}{m-1}$	$F = \frac{MS_{Between}}{MS_{Within}}$
Within groups	$SS_{\text{Within}} = C_z = \sum_{i=1}^{m} \sum_{k=1}^{n_i} \left(x_{ik} - \overline{x_i}\right)^2$	$MS_{Within} = \sigma_z^{*2} = \frac{SS_{Within}}{n-m}$	
Total	$SS_{Total} = C_y = SS_{Between} + SS_{Within}$		

Evaluation of differences between factor levels for their impact on the final sign of X

For evaluating the reliability of pairwise differences of group means $\bar{x}_i$ (i=1, 2, …, m) used the following criterion:

$$F_{12} = \frac{n_1 \cdot n_2}{n_1 + n_2} \frac{\left(\bar{x}_1 - \bar{x}_2\right)}{MS_{Within}^2},$$

Random variable F follows the F-distribution with v_1=1 and v_{12}=*n-m* degrees of freedom.
If F_{12}>F*, then it could be said about the reliable difference of group means $\bar{x}_1$ and $\bar{x}_2$ (*P*=1-α), that is, the difference between factor levels for their impact on the final sign of *X* is significant.
Critical value ***F****=***F*** (*P*=1-α; v_1=1; v_2=*n-m*) is taken from Fisher's distribution table.

Practical tasks for students. Instructions for execution of practical work

1. Start a computer and wait for the loading of Windows OS**.**
2. Start **Microsoft Excel** program.
3. *Save the document on Desktop*.

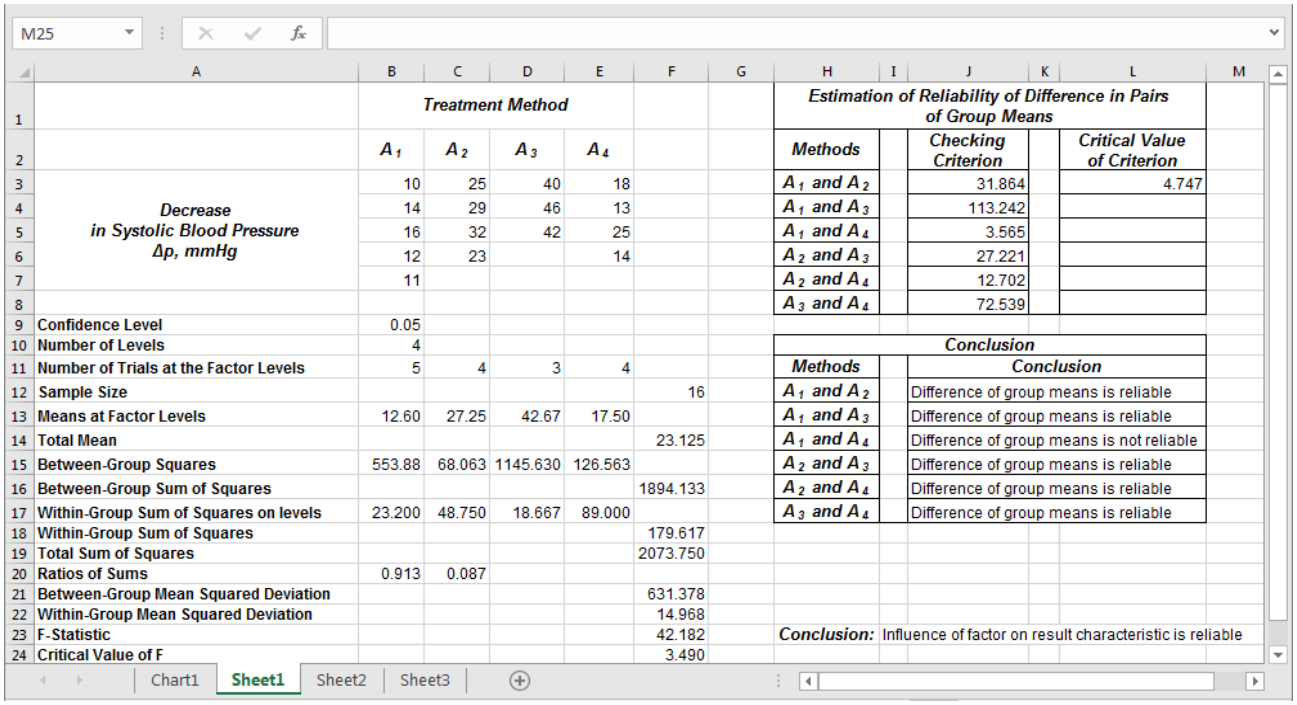
Attention: *Don't forget to click the icon* ***Save***  *on the* ***Quick Access toolbar*** *every few minutes during the lesson to avoid losing your work.*

4. Perform the following tasks:

Task №1. *Using* ***MS Excel*** *investigate with the help of analysis of variance influence of treatment method on the decrease in systolic blood pressure of hypertension patients if* ***α=0,05****, conclude. The following data were received:*

Treatment Method	Decrease in Systolic Blood Pressure Δp, mmHg				
A_1	10	14	16	12	11
A_2	25	29	32	23	-
A_3	40	46	42	-	-
A_4	18	13	25	14	-

Create a new table as shown in ***Fig. 1***:
select cells **B1:E1** on the **Sheet1**, on the **Home** tab, in the **Alignment** group, click **Merge and Center**  ;



		Treatment Method						Estimation of Reliability of Difference in Pairs of Group Means					
		A_1	A_2	A_3	A_4			Methods		Checking Criterion		Critical Value of Criterion	
	Decrease in Systolic Blood Pressure Δp, mmHg	10	25	40	18			A_1 and A_2		31.864		4.747	
		14	29	46	13			A_1 and A_3		113.242			
		16	32	42	25			A_1 and A_4		3.565			
		12	23		14			A_2 and A_3		27.221			
		11						A_2 and A_4		12.702			
								A_3 and A_4		72.539			
Confidence Level		0.05											
Number of Levels		4						Conclusion					
Number of Trials at the Factor Levels		5	4	3	4			Methods		Conclusion			
Sample Size						16		A_1 and A_2		Difference of group means is reliable			
Means at Factor Levels		12.60	27.25	42.67	17.50			A_1 and A_3		Difference of group means is reliable			
Total Mean						23.125		A_1 and A_4		Difference of group means is not reliable			
Between-Group Squares		553.88	68.063	1145.630	126.563			A_2 and A_3		Difference of group means is reliable			
Between-Group Sum of Squares						1894.133		A_2 and A_4		Difference of group means is reliable			
Within-Group Sum of Squares on levels		23.200	48.750	18.667	89.000			A_3 and A_4		Difference of group means is reliable			
Within-Group Sum of Squares						179.617							
Total Sum of Squares						2073.750							
Ratios of Sums		0.913	0.087										
Between-Group Mean Squared Deviation						631.378							
Within-Group Mean Squared Deviation						14.968							
F-Statistic						42.182		Conclusion:		Influence of factor on result characteristic is reliable			
Critical Value of F						3.490							

Fig. 1

in the same way merge cells **A3:A7**, **H1:L1**, **H10:L10, J11:L11, J12:L12, J13:L13, J14:L14, J15:L15, J16:L16, J17:L17** and **I23:L23**;
type text into cells **A3:A7**, **A9:A24, B1:E7**, **H1:L2, H3:H8, H10:L11, H12:H17** and **H23** according to **Fig. 1**;
click the cell **B9** and type **0.05;**

Perform the calculations:
click the cell **B10** and enter the formula **=COUNT(B3:E3)** (click the cell **B10**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNT** → **OK** → enter **B3:E3** → **OK)**;
click the cell **B11** and enter the formula **=COUNT(B3:B7)** (click the cell **B11**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNT** → **OK** → enter **B3:B7** → **OK)**;
copy the formula from the cell **B11** into the cells **C11:E11** using drag and drop method;
click the cell **F12** and enter the formula **=COUNT(B3:E7)** (click the cell **F12**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNT** → **OK** → enter **B3:E7** → **OK)**;
click the cell **B13** and enter the formula **=AVERAGE(B3:B7)** (click the cell **B13**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → enter **B3:B7** → **OK)**;
copy the formula from the cell **B13** into the cells **C13:E13** using drag and drop method;
click the cell **F14** and enter the formula **=AVERAGE(B3:E7)** (click the cell **F14**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → enter **B3:E7** → **OK)**;
click the cell **B15** and enter the formula **=B11*(B13-$F$14)^2** ‥press **Enter;**
copy the formula from the cell **B15** into the cells **C15:E15** using drag and drop method;
click the cell **F16** and enter the formula **=SUM(B15:E15)** (click the cell **F16**, click **Insert Function** button f_x on the **Formula bar** → select **Math & Trig** from **select a category** box → select **SUM** → **OK** → enter **B15:E15** → **OK)**;
click the cell **B17** and enter the formula **=DEVSQ(B3:B7)** (click the cell **B17**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **DEVSQ** → **OK** → enter **B3:B7** → **OK)**;
copy the formula from the cell **B17** into the cells **C17:E17** using drag and drop method;

click the cell **F18** and enter the formula **=SUM(B17:E17)** (click the cell **F18**, click **Insert Function** button on the **Formula bar** → select **Math & Trig** from **select a category** box → select **SUM** → **OK** → enter **B17:E17** → **OK)**;
click the cell **F19** and enter the formula **=F16+F18** ‥press **Enter**;
click the cell **B20** and enter the formula **=F16/F19** ‥press **Enter**;
click the cell **C20** and enter the formula **=F18/F19** ‥press **Enter**;
click the cell **F21** and enter the formula **=F16/(B10-1)** ‥press **Enter**;
click the cell **F22** and enter the formula **=F18/(F12-B10)** ‥press **Enter**;
click the cell **F23** and enter the formula **=F21/F22** ‥press **Enter**;
click the cell **F24** and enter the formula **=F.INV.RT(B9,B10-1,F12-B10)** (click the cell **F24**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **F.INV.RT** → **OK** → enter **B9** in **Probability** box → enter **B10-1** in **Deg_freedom1** box → enter **F12-B10** in **Deg_freedom2** box → **OK)**;
click the merged cell **I23** and enter the formula **=IF(F23>F24,"Influence of factor on result characteristic is reliable","Influence of factor on result characteristic is not reliable")** (click the cell **I23,** click **Insert** → **Function…** → select **Logical** from **select a category** box → select **IF** → **OK** → enter **F23>F24** in **Logical_test** box → enter **Influence of factor on result characteristic is reliable** in **Value_if_true** box → enter **Influence of factor on result characteristic is not reliable** in **Value_if_false** box → **OK**);
click the cell **J3** and enter the formula **=B11*C11*(B13-C13)^2/(F22*(B11+C11))** ‥press **Enter**;
click the cell **J4** and enter the formula **=B11*D11*(B13-D13)^2/(F22*(B11+D11))** ‧ press **Enter**;
click the cell **J5** and enter the formula **=B11*E11*(B13-E13)^2/(F22*(B11+E11))** ‧ press **Enter**;
click the cell **J6** and enter the formula **=C11*D11*(C13-D13)^2/(F22*(C11+D11))** ‧ press **Enter**;
click the cell **J7** and enter the formula **=C11*E11*(C13-E13)^2/(F22*(C11+E11))** ‧ press **Enter**;
click the cell **J8** and enter the formula **=D11*E11*(D13-E13)^2/(F22*(D11+E11))** ‧ press **Enter**;
click the cell **L3** and enter the formula **=F.INV.RT(B9,1,F12-B10)** (click the cell **L3**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **F.INV.RT** → **OK** → enter **B9** in **Probability** box → enter **1** in **Deg_freedom1** box → enter **F12-B10** in **Deg_freedom2** box → **OK)**;
click the cell **J12** and enter the formula **=IF(J3>$L$3,"Difference of group means is reliable","Difference of group means is not reliable")** (click the cell **J12,** click **Insert** → **Function…** → select **Logical** from **select a category** box → select **IF** → **OK** → enter **J3>$L$3** in **Logical_test** box → enter **Difference of group means is reliable** in **Value_if_true** box → enter **Difference of group means is not reliable** in **Value_if_false** box → **OK**);
copy the formula from cell **J12** into the cells **J13:J17** using drag and drop method;

Conclude the influence of factor A on the resulting characteristic of X and about differences between levels of factor A versus their influence on the resulting characteristic of X.

*Format the table according to **Fig. 1**.*

Formatting instructions:
Font: **Arial**;
Size: cells **B1:E2, A3:A7, H1:L2, H3:H8, H10:L11, H12:H17** and **H23 – 12;** other cells – **11**;
Style: cells **B1:E2, A3:A7, H1:L2, H3:H8, H10:L11, H12:H17** and **H23 – Bold Italic**; **A9:A24** – **Bold**; other cells – **Regular**;
Horizontal alignment: cells **B1:E2, A3:A7, H1:L2, H3:H8, H10:L11, H12:H17,** and **H23** – **Center,** other cells – **by default** (don't change);
Vertical alignment: cells **B1:E2, A3:A7, H1:L2, H3:H8, H10:L11, H12:H17,** and **H23** – **Center,** other cells – **by default** (don't change);
*Apply cell borders to the table according to **Fig. 1**.*
*Click **Save** .*

Task №2. *Using the program **MS Excel** based on **Task 1** construct the histogram of group means of decrease in systolic blood pressure versus treatment method.*

select cells **B2:E2**, press and hold down the **Ctrl** button while you select cells **B13:E13** · click the **Insert** tab, click the **Arrow** button next to the **Charts** group · click **All Charts** · click **Column** · select **Clustered Column** · click **OK**;

click on the chart · click the **Chart Elements** button · put a tick against the **Axis Titles** and **Data Labels**;

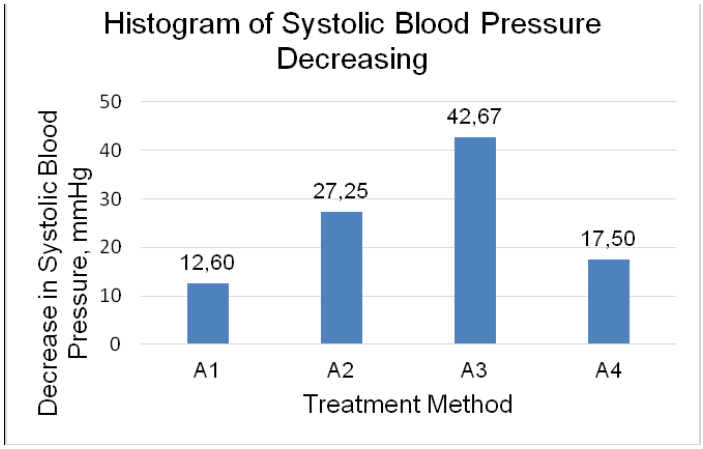


Fig. 2

type the chart title and axis titles according to the **Fig. 2**;

on the **Chart Tools Design** tab click **Move Chart** · click **New sheet** · **OK**;

format the chart according to **Fig.2**;

click **Save**.

Task №3. *Using* **MS Excel** *investigate with the help of analysis of variance influence of method of treatment of pharmaceutical raw materials on value of product yield, if* ***α=0.05****, and make a conclusion. The following data were received:*

Process Method of Pharmacy Raw Material	**Product Yield, Unit.**					
A_1	72	75	76	72	73	74
A_2	74	70	72	73	-	-
A_3	70	72	71	68	72	-

Perform the calculations:

click **Sheet1** → select cells **A1:L24** → on the **Home** tab click **Copy** → click **Sheet2** → select cell **A1** → on the **Home** tab click **Paste**;

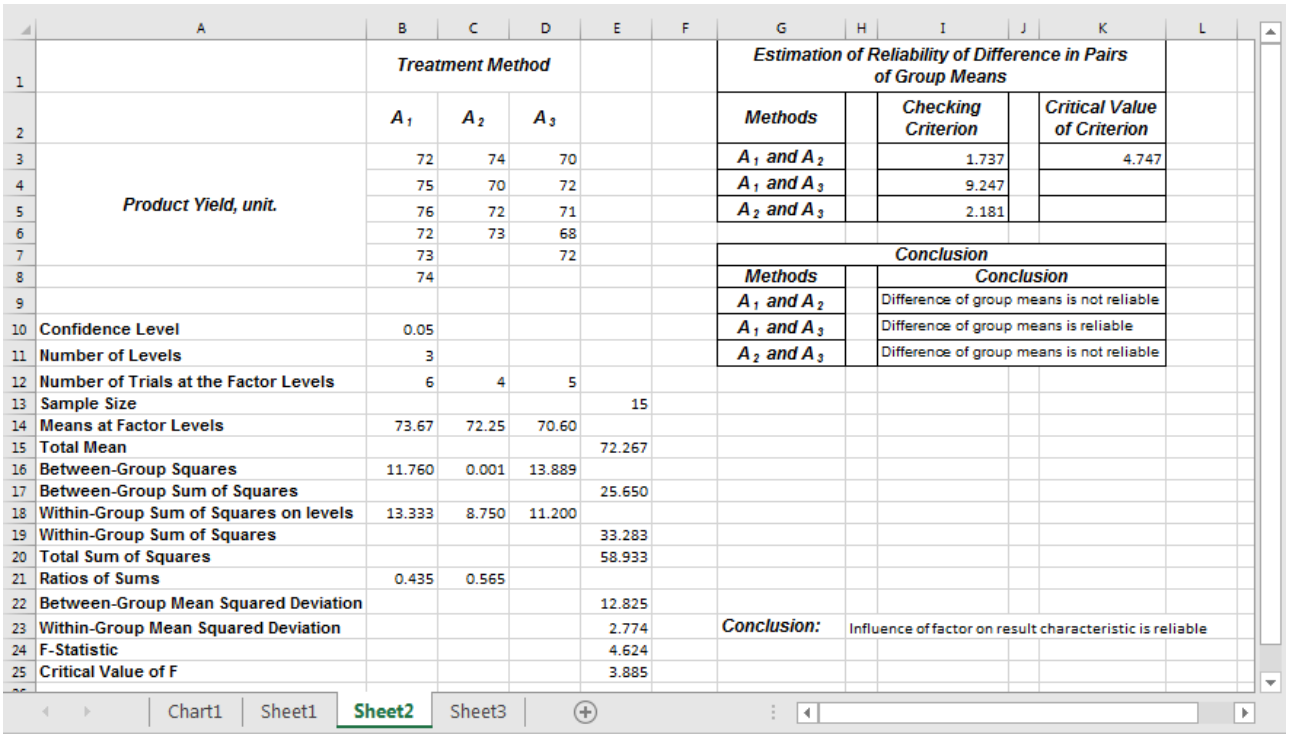
solve the problem by corrections of data according to **Task 3** (see. **Fig.3**) and using instructions in **Fig.4** and **Fig.5**;

Conclude the influence of factor A on the resulting characteristic of X and differences between levels of factor A versus their influence on the resulting characteristic of X.

*Format the table according to **Fig. 3**.*

*Apply cell borders to the table according to **Fig. 3**.*

*Click **Save**.*



	A	B	C	D	E	F	G	H	I	J	K	L
1		Treatment Method					Estimation of Reliability of Difference in Pairs of Group Means					
2		A_1	A_2	A_3			Methods		Checking Criterion		Critical Value of Criterion	
3		72	74	70			A_1 and A_2		1.737		4.747	
4		75	70	72			A_1 and A_3		9.247			
5	Product Yield, unit.	76	72	71			A_2 and A_3		2.181			
6		72	73	68								
7		73		72			Conclusion					
8		74					Methods		Conclusion			
9							A_1 and A_2		Difference of group means is not reliable			
10	Confidence Level	0.05					A_1 and A_3		Difference of group means is reliable			
11	Number of Levels	3					A_2 and A_3		Difference of group means is not reliable			
12	Number of Trials at the Factor Levels	6	4	5								
13	Sample Size				15							
14	Means at Factor Levels	73.67	72.25	70.60								
15	Total Mean				72.267							
16	Between-Group Squares	11.760	0.001	13.889								
17	Between-Group Sum of Squares				25.650							
18	Within-Group Sum of Squares on levels	13.333	8.750	11.200								
19	Within-Group Sum of Squares				33.283							
20	Total Sum of Squares				58.933							
21	Ratios of Sums	0.435	0.565									
22	Between-Group Mean Squared Deviation				12.825							
23	Within-Group Mean Squared Deviation				2.774		Conclusion:		Influence of factor on result characteristic is reliable			
24	F-Statistic				4.624							
25	Critical Value of F				3.885							

Chart1 | Sheet1 | Sheet2 | Sheet3

Fig. 3

	A	B	C	D	E
1		Treatment Method			
2		A_1	A_2	A_3	
3		72	74	70	
4		75	70	72	
5	Product Yield, unit.	76	72	71	
6		72	73	68	
7		73		72	
8		74			
9					
10	Confidence Level	0.05			
11	Number of Levels	=COUNT(B3:D3)			
12	Number of Trials at the Factor Levels	=COUNT(B3:B8)	=COUNT(C3:C7)	=COUNT(D3:D7)	
13	Sample Size				=COUNT(B3:D8)
14	Means at Factor Levels	=AVERAGE(B3:B8)	=AVERAGE(C3:C8)	=AVERAGE(D3:D8)	
15	Total Mean				=AVERAGE(B3:D8)
16	Between-Group Squares	=B12*(B14-$E$15)^2	=C12*(C14-$E$15)^2	=D12*(D14-$E$15)^2	
17	Between-Group Sum of Squares				=SUM(B16:D16)
18	Within-Group Sum of Squares on levels	=DEVSQ(B3:B8)	=DEVSQ(C3:C8)	=DEVSQ(D3:D8)	
19	Within-Group Sum of Squares				=SUM(B18:D18)
20	Total Sum of Squares				=E17+E19
21	Ratios of Sums	=E17/E20	=E19/E20		
22	Between-Group Mean Squared Deviation				=E17/(B11-1)
23	Within-Group Mean Squared Deviation				=E19/(E13-B11)
24	F-Statistic				=E22/E23
25	Critical Value of F				=F.INV.RT(B10,B11-1,E13-B11)

Chart1 | Sheet1 | Sheet2 | Sheet3

Fig. 4

	G	H	I	J	K
1	***Estimation of Reliability of Difference in Pairs***				
2	***Methods***		***Checking Criterion***		***Critical Value of Criterion***
3	A_1 and A_2		=B12*C12*(B14-C14)^2/(E23*(B12+C12))		=F.INV.RT(B10,1,E13-B11)
4	A_1 and A_3		=B12*D12*(B14-D14)^2/(E23*(B12+D12))		
5	A_2 and A_3		=C12*D12*(C14-D14)^2/(E23*(C12+D12))		
6					
7	***Conclusion***				
8	***Methods***		***Conclusion***		
9	A_1 and A_2		=IF(I3>$K$3,"Difference of group means is reliable","Difference of group means is not reliable")		
10	A_1 and A_3		=IF(I4>$K$3,"Difference of group means is reliable","Difference of group means is not reliable")		
11	A_2 and A_3		=IF(I5>$K$3,"Difference of group means is reliable","Difference of group means is not reliable")		
12					
13					
14					
15					
16					
17					
18					
19					
20					
21					
22					
23	***Conclusion:***	=IF(E24>E25,"Influence of factor on result characteristic is reliable","Influence of factor on result characteristic is not reliable")			
24					

Chart1 | Sheet1 | Sheet2 | **Sheet3**

Fig.5

5. Show the teacher the results of your work.

6. Close the **MS Excel** document.

Attention: *After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:

Excel help & learning. Microsoft.com. from https://support.microsoft.com/en-us/excel

1) Rosenthal, D. A., & Kros, J. F. (2023). *Statistics for health care management and administration: Working with excel (4th ed.).* Jossey-Bass.

2) Quirk, T. J., & Cummings, S. M. (2020). *Excel 2019 for health services management statistics: A guide to solving practical problems.* Springer International Publishing.

3) Hoffman, J. I. E. (2019). *Biostatistics for medical and biomedical practitioners* (2nd ed.). Academic Press.

Additional

1) Forister, J. G., & Blessing, J. D. (2019). *Introduction to research and medical literature for health professionals (5th ed.).* Jones & Bartlett.

2) Cleophas, T. J., & Zwinderman, A. H. (2020). *Clinical data analysis on a pocket calculator*. Springer International Publishing.

3) Rothman, K. J., Lash, T. L., & Greenland, S. (2012). *Modern Epidemiology* (3rd ed.). Lippincott Williams and Wilkins.

Topic 7: CORRELATION AND REGRESSION ANALYSES.

Actuality: Correlation and regression analysis is an important statistical method for the analysis of medical data. It enables the identification and characterization of relationships among multiple factors. It also enables the identification of prognostically relevant risk factors and the calculation of risk scores for individual prognostication. As carrying out correlation and regression analysis requires processing plenty of numbers, a researcher needs skills in working with computer programs, that make it possible. One such program is MS Excel. Thus, the ability to work with this spreadsheet application is very important for every future medical worker.

Educational aims of the lesson:

To know:

1. theoretical bases of correlation and regression analysis.

To be able to:

1. carrying out correlation and regression analysis using MS Excel.

The list of questions for the survey:

2. Functional and statistical dependencies between random variables.
3. Correlation dependence between random variables.
4. Correlation field. Regression line. Regression equation.
5. Correlation coefficient as a measure of linear correlation.
6. Correlation coefficient properties.
7. Nonlinear correlation.
8. Multiple correlations.
9. Linear regression equation.

The list of required practical skills:

1. To calculate the correlation between random variables using MS Excel.

Brief theoretical information

Statistical analysis in medical data is often used to understand the relationship between two or more variables. For example, instead of just knowing if patients have high blood pressure, we may want to know if factors like age and weight affect the likelihood of having high blood pressure.

The variable being studied (blood pressure) is called the **dependent variable** or **response variable**, while the factors that might influence it (age, weight) are called **independent variables** or **predictor variables**. To get an idea of how strongly the variables are related, measures of association are used. When both the dependent and independent variables are continuous, like blood pressure and weight, a **correlation coefficient** can be calculated to measure the strength of their relationship.

Correlation is a statistical method used to determine if two variables are related and how strong their relationship is.

The **correlation coefficient** measures the strength of this relationship. For linear relationships, the **correlation coefficient (r)** shows both the strength and direction of the connection between two variables. This coefficient is also known as the **Pearson correlation coefficient**, named after Karl Pearson, who developed it.

Let ***X*** and ***Y*** be any two random variables. Let ***x1***, ***x2***, ... ***xn*** and ***y***1, ***y2***, ... ***yn*** are the values of ***X*** and ***Y*** respectively. The mathematical formula for ***linear correlation coefficient r***:

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

where ***n*** is the number of pairs of data. The sample average of each set: $\bar{x} = \frac{1}{n}\sum x_i$; $\bar{y} = \frac{1}{n}\sum y_i$.

Properties of the correlation coefficient:

The value of **r** is such that **-1 < r < +1**. The + and - signs indicate positive linear correlations and

negative linear correlations, respectively.
r > 0. Positive values indicate that as values for ***x*** increase, values for ***y*** also increase.
r<0. Negative values indicate that as values for ***x*** increase, values for ***y*** decrease.
r→0. A value near zero means that there is a random, nonlinear relationship between the two variables. **r = 0** indicates no relationship (or that the variables are independent and not related).
r→1 Positive correlation: If ***x*** and ***y*** have a strong positive linear correlation, ***r*** is close to +1.
r→-1 Negative correlation: If ***x*** and ***y*** have a strong negative linear correlation, ***r*** is close to -1.
If 0.7<|r|<1.00, correlation dependence is **strong**.
If 0.3<|r|<0.7, correlation dependence of **moderate** force.
If 0.0<|r|<0.3, correlation dependence is **weak**.

Nonlinear Correlation

Correlation is said to be ***nonlinear*** if the ratio of change is not constant. In other words, it can be defined as if all the points on the scatter diagram tend to lie near a smooth curve, the correlation is said to be nonlinear (curvilinear). As a measure of the nonlinear correlation, the ***correlation ratios*** of systematic and total variances of random variables are used.

Formulas for calculating the correlation ratios.

Correlation ratio of Y to X	Correlation ratio of X to Y
$\eta_{yx} = \sqrt{\frac{\Sigma\left(y_{x_i} - \overline{y}\right)^2}{\Sigma\left(y_i - \overline{y}\right)^2}}$	$\eta_{yx} = \sqrt{\frac{\Sigma\left(x_{y_i} - \overline{x}\right)^2}{\Sigma\left(x_i - \overline{x}\right)^2}}$

Algorithm for calculating the correlation ratio Y to X:

Step 1. Sort the given data pairs (x, y) in descending order by X.
Step 2. Find the value of y_x:
if the value of x_i is found once, then $y_{xi} = y_i$;
if the value of x_i is repeated *k* times, we need to find the average value: $y_{x_i} = \frac{\sum y_i}{k}$
Step 3. Find the average value of *Y*: $\overline{y} = \frac{\sum y_i}{n}$
Step 4. Calculate the squared differences: $\left(y_{x_i} - \overline{y}\right)^2, \left(y_i - \overline{y}\right)^2$, and their sums $\Sigma\left(y_{x_i} - \overline{y}\right)^2$, $\Sigma\left(y_i - \overline{y}\right)^2$
Step 5. Find the correlation ratio of Y to X: $\eta_{yx} = \sqrt{\frac{\Sigma\left(y_{x_i} - \overline{y}\right)^2}{\Sigma\left(y_i - \overline{y}\right)^2}}$
Step 6. Test the hypothesis about correlational dependence using a t-test.
Perform similar actions to calculate the correlation ratio of X to Y.

Basic properties of correlation ratio:

1. $0 \le \eta \le 1$, which follows from the definition of the correlation relationship.
2. $|r| \le \eta_{yx}$, and $|r| \le \eta_{xy}$
3. $\eta_{yx} \ne \eta_{xy}$ (unlike the linear correlation coefficient) and it is significant, which variable is assumed to be independent, and which is dependent.
4. If $\eta_{yx} = \eta_{xy}$, then there is linear correlation dependence between variables.
5. If η = 0, then there is no correlation.
6. If η = 1, then there is functional dependence between variables.

Multiple Correlation

We can also calculate the correlation between more than two variables. In the case of three variables: ***X***, ***Y***, and ***Z***, where ***Z*** and ***Y*** are independent variables and ***X*** is the dependent variable, the ***multiple correlation coefficient*** is calculated using a formula:

$$R_{x.yz} = \sqrt{\frac{r_{xy}^2 - 2r_{xy}r_{xz}r_{yz} + r_{xz}^2}{1 - r_{yz}^2}}$$

where ***rxy***, ***rxz***, ***ryz*** – correlation coefficients between ***x*** and ***y***, ***x*** and ***z***, ***y*** and ***z*** respectively.
The ***partial correlation*** of *X* and *Y* holding *Z* constant is defined as follows:

$$r_{xy.z} = \frac{r_{xy} - r_{xz}r_{yz}}{\sqrt{1 - r_{xz}^2}\sqrt{1 - r_{yz}^2}}$$

Regression Analysis

Regression analysis is a technique for measuring the relationship between two interval- or ratio-level variables. The regression framework is at the heart of empirical social and political science research.
The linear equation is specified as follows:
$Y = a + bX,$
where ***Y is the*** dependent variable and ***X*** is the independent variable.
The intercept (*a*) and slope (*b*) of the regression line are referred to as the *parameters or coefficients of the regression equation*. Parameters of the regression equation: *a* – constant (value of *Y* when *X* = 0), *b* – is the slope of the regression line.
The goal of regression analysis is to find an equation that "best fits" the data. Use the following equations to find *a* and *b*:

$$a = \frac{\Sigma y_i \Sigma x_i^2 - \Sigma x_i \Sigma x_i y_i}{n\Sigma x_i^2 - \left(\Sigma x_i\right)^2}; \qquad b = \frac{n\Sigma y_i x_i - \Sigma x_i \Sigma y_i}{n\Sigma x_i^2 - \left(\Sigma x_i\right)^2};$$

In regression, an equation is found in such a way that its graph is a line that minimizes the squared vertical distances between the data points and the lines drawn – the ***line of regression.***
The exponential regression equation has the form:

$$Y = Ar^X,$$

where $r = 10^a; A = 10^b$, *a* and *b* are the slope and intercept of the regression line.

Coefficient of determination (R^2). A measure indicating the percentage of the variation in the dependent variable accounted for by variations in the independent variables. R^2 is a measure of the goodness of fit of the regression model.

	Correlation	**Regression**
Implication	Quantify the relationship between two or more variables.	Investigate the dependency relationship between the independent and dependent variables.
Prerequisite	Bivariate normal distribution	An Independent variable is a normally distributed random variable.
Application	investigate the quantitative association	investigate the quantitative dependency relationship between variables prediction variable selection
Connection	1. The correlation coefficient has the same sign as the regression coefficient.	
	2. The hypothesis testing for the correlation coefficient and regression coefficient is equivalent.	
	3. For bivariate normal distributed variables, a regression could be used to interpret correlation: The high determine coefficient indicates that X is closely correlated to Y.	

Practical tasks for students. Instructions for execution of practical work

1. Start a computer and wait for the loading of Windows OS**.**
2. Start **Microsoft Excel** program.
3. *Save the document on Desktop.*

> ***Attention***: *Don't forget to click the icon* ***Save*** *on the* ***Quick Access toolbar*** *every few minutes during the lesson to avoid losing your work.*

Perform the following tasks:

Task №1. *Using* ***MS Excel*** *carry out* ***correlation analysis****, considering that* ***α = 0.05*** *and the following data were obtained after performing the investigation:*

Table 1

X	154	165	180	175	170	185	165	190	182	184	166	173	182	169	180	176	180	177	178	170
Y	72	69	80	76	82	92	70	85	90	90	74	70	85	74	85	74	82	72	80	72

o *Create a new table as shown in the* ***Fig. 1***:

A22 — Confidence level

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1		N	x_i	y_i	y_x	$(y_x-y_{av})^2$	$(y_i-y_{av})^2$	y_i	x_i	x_y	$(x_y-x_{av})^2$	$(x_i-x_{av})^2$	$(y_i-y_{av})(x_i-x_{av})$		
2		1	154	72	72	44.89	44.89	69	165	165	101.00	101.00	141.04	Correlation Ratio y/x	0.963
3		2	165	69	69.5	84.64	94.09	70	165	169	36.60	101.00	97.49	t test	15.069
4		3	165	70	69.5	84.64	75.69	70	173	169	36.60	4.20	87.44	Critical Value of t test	2.101
5		4	166	74	74	22.09	22.09	72	154	167	64.80	443.10	42.54		
6		5	169	74	74	22.09	22.09	72	170	167	64.80	25.50	28.44	Correlation Ratio x/y	0.815
7		6	170	82	77	2.89	10.89	72	177	167	64.80	3.80	-16.67	t test	5.958
8		7	170	72	77	2.89	44.89	74	166	170.3	22.25	81.90	33.84	Critical Value of t test	2.101
9		8	173	70	70	75.69	75.69	74	169	170.3	22.25	36.60	17.84		
10		9	175	76	76	7.29	7.29	74	176	170.3	22.25	0.90	0.14		
11		10	176	74	74	22.09	22.09	76	175	175	0.00	0.00	-4.46		
12		11	177	72	72	44.89	44.89	80	178	179	15.60	8.70	-13.06		
13		12	178	80	80	1.69	1.69	80	180	179	15.60	24.50	3.83		
14		13	180	80	82.3	13.20	1.69	82	170	175	0.00	25.50	6.43		
15		14	180	85	82.3	13.20	39.69	82	180	175	0.00	24.50	31.18		
16		15	180	82	82.3	13.20	10.89	85	180	184	80.10	24.50	16.33		
17		16	182	90	87.5	77.44	127.69	85	182	184	80.10	48.30	78.53		
18		17	182	85	87.5	77.44	39.69	85	190	184	80.10	223.50	43.78		
19		18	184	90	90	127.69	127.69	90	182	183	63.20	48.30	101.14		
20		19	185	92	92	176.89	176.89	90	184	183	63.20	80.10	132.34		
21		20	190	85	85	39.69	39.69	92	185	185	99.00	99.00	94.18		
22	Confidence level	0.05													
23	Sample size	20													
24	Sum					954.533	1030.200				932.283	1404.950	922.300		
25	Average		175.050	78.700											
26	Correlation Coefficient		0.767			0.767									
27	t test		5.065												
28	Critical Value of t test		2.101												

Sheet1 Sheet2 Sheet3 Sheet4

Fig.1

select cells **A24:B24** on **Sheet1**, on the **Home** tab, in the **Alignment** group, click **Merge and Center**;

in the same way merge cells **A25:B25, A26:B26, A27:B27** and **A28:B28;**

type text into cells **B1:M1**, **B2:B21, A22:A28**, **N2:N4** and **N6:N8** according to **Fig. 1**;

into cells **C2:C21** type the following data: **154**, **165**, **180**, **175**, **170**, **185**, **165**, **190**, **182**, **184**, **166**, **173**, **182**,
169, **180**, **176**, **180**, **177**, **178**, **170**;

into cells **D2:D21** type the following data: **72**, **69**, **80**, **76**, **82**, **92**, **70**, **85**, **90**, **90**, **74**, **70**, **85**, **74**, **85**, **74**, **82**, **72**,
80, **72**;

click the cell **B22** and type **0.05;**

o Perform the calculations:

copy data from cells **C2:C21** to cells **I2:I21**;

copy data from cells **D2:D21** to cells **H2:H21;**

select cells **C1:D21**, on the **Data** tab, in the **Sort & Filter** group, click **Sort**, in the **Sort** dialog box select ***Sort by*** **xi**, ***Sort On*** **Values**, ***Order*** **Smallest to Largest** → **OK**;

click the cell **E2** and type the formula **=D2** ▪ press **Enter;**
copy the content of cell **E2** into the cells **E5, E6, E9, E10, E11, E12, E13 E19, E20, E21**;
click the cell **E3** and enter the formula **=AVERAGE($D$3:$D$4)** (click the cell **E3**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → enter **$D$3:$D$4** → **OK)**;
Note**: To create an absolute cell reference, for example, **$D$3**, type **D3** and then press **F4.
copy the content of cell **E3** into the cell **E4**;
click the cell **E7** and enter the formula **=AVERAGE($D$7:$D$8)** (click the cell **E7**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → enter **$D$7:$D$8** → **OK)**;
copy the content of cell **E7** into the cell **E8**;
click the cell **E14** and enter the formula **=AVERAGE($D$14:$D$16)** (click the cell **E14**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → enter **$D$14:$D$16** → **OK)**;
copy the content of cell **E14** into the cells **E15:E16**;
click the cell **E17** and enter the formula **=AVERAGE($D$17:$D$18)** (click the cell **E17**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → enter **$D$17:$D$18** → **OK)**;
copy the content of cell **E17** into the cell **E18**;

- to find sample averages: $\bar{x} = \frac{1}{n}\sum x_i \quad \bar{y} = \frac{1}{n}\sum y_i$ click the cell **C25** and enter the formula **AVERAGE(C2:C21);**

copy the content of cell **C25** into the cell **D25;**

- to find squares of all deviations $\left(y_{x_i} - \bar{y}\right)^2$ click the cell **F2** and enter the formula **=(E2-$D$25)^2** → press **Enter**;
- to find squares of all deviations $a_{y_i}^2 = \left(y_{x_i} - \bar{y}\right)^2$ click the cell **G2** and enter the formula **=(D2-$D$25)^2** → press **Enter**;
- select cells **F2:G2** → copy formulas into cells **F3:G21** using drag and drop method;

select cells **H1:I21**▪ on the **Data** tab, in the **Sort & Filter** group, click **Sort** , in the **Sort** dialog box select ***Sort by* yi, *Sort On* Values, *Order* Smallest to Largest** → **OK**;
click the cell **J2** and enter the formula **=I2** ▪ press **Enter**;
copy the content of the cell **J2** into the cells **J11** and **J21**;
click the cell **J3** and enter the formula **=AVERAGE($I$3:$I$4)**;
copy the content of the cell **J3** into the cell **J4**;
click the cell **J5** and enter the formula **=AVERAGE($I$5:$I$7)**;
copy the content of the cell **J5** into the cells **J6:J7**;
click the cell **J8** and enter the formula **=AVERAGE($I$8:$I$10)**;
copy the content of the cell **J8** into the cells **J9:J10**;
click the cell **J12** and enter the formula **=AVERAGE($I$12:$I$13)**;
copy the content of the cell **J12** into the cell **J13**;
click the cell **J14** and enter the formula **=AVERAGE($I$14:$I$15)**;
copy the content of the cell **J14** into the cell **J15**;
click the cell **J16** and enter the formula **=AVERAGE($I$16:$I$18)**;
copy the content of the cell **J16** into the cells **J17:J18;**
click the cell **J19** and enter the formula **=AVERAGE($I$19:$I$20)**;
copy the content of the cell **J19** into the cell **J20;**

- to find squares of all deviations $\left(x_{y_i}-\bar{x}\right)^2$ click the cell **K2** and enter the formula **=(J2-$C$25)^2** → press **Enter;**
- to find squares of all deviations $a_{x_i}^2=\left(x_i-\bar{x}\right)^2$ click the cell **L2** and enter the formula **=(I2-$C$25)^2** → press **Enter**;
- to find $a_{x_i}a_{y_i}$ click the cell **M2** and enter the formula **=(C2-$C$25)*(D2-$D$25)** → press **Enter**;
- select cells **K2:M2** → copy formulas into cells **K3:M21** using drag and drop method;
- to find $\sum\left(y_{x_i}-\bar{y}\right)^2$ click the cell **F24** and enter the formula **=SUM(F2:F21)** (click the cell **F24**, click **Insert Function** button f_x on the **Formula bar** → select **Math & Trig** from **select a category** box → select **SUM** → **OK** → enter **F2:F21** in **Number1** box → **OK**);
- to find $\sum a_{y_i}^2$ copy the content of the cell **F24** into the cell **G24**;
- to find $\sum\left(x_{y_i}-\bar{x}\right)^2$ click the cell **K24** and type the formula **=SUM(K2:K21)** → press **Enter**;
- to find $\sum a_{x_i}^2$ and $\sum a_{x_i}a_{y_i}$ copy the content of the cell **K24** into the cells **L24:M24**;
- to calculate the correlation coefficient $r=\frac{\sum a_{x_i}a_{y_i}}{\sqrt{\sum a_{x_i}^2\sum a_{y_i}^2}}$ click the cell **C26** and enter the formula **=M24/SQRT(L24*G24);**
- to calculate the correlation coefficient using **MS Excel** built-in functions click the cell **F26** and enter the formula **=CORREL(C2:C21,D2:D21)** (click the cell **F26**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **CORREL** → **OK** → enter **C2:C21** in **Array1** box → enter **D2:D21** in **Array2** box → **OK**);
- to find sample size click the cell **B23** and enter the formula **=COUNT(B2:B21)** (click the cell **B23**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNT** → **OK** → enter **B2:B21** → **OK);**
- click the cell **C27** and enter the formula **=C26*SQRT((B23-2)/(1-C26^2));**
- click the cell **C28** and enter the formula **=T.INV.2T(B22,B23-2)** (click the cell **C28**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **T.INV.2T** → **OK** → enter **B22** in **Probability** box → enter **B23-2** in **Deg_freedom** box → **OK);**
- to find the correlation ratio η_{yx} click the cell **O2** and enter the formula **=SQRT(F24/G24)** (click the cell **O2**, click **Insert Function** button f_x on the **Formula bar** → select **Math & Trig** from **select a category** box → select **SQRT** → **OK** → enter **F24/G24** → **OK);**
- click the cell **O3** and enter the formula **=O2*SQRT((B23-2)/(1-O2^2));**
- click the cell **O4** and enter the formula **=T.INV.2T(B22,B23-2);**
- to find the correlation ratio η_{xy} click the cell **O6** and enter the formula **=SQRT(K24/L24);**
- click the cell **O7** and enter the formula **=O6*SQRT((B23-2)/(1-O6^2));**
- click the cell **O8** and enter the formula **=T.INV.2T(B22,B23-2);**
  - *Make a conclusion about correlation between X and Y.*
  - *Format the table according to* ***Fig. 1****.*

Formatting instructions:

Font: **Arial**;
Size: cells **B1:M1 – 10**;
Style: cells **B1:M1 – Bold Italic**, **N2, N6, A22:A23, A24:A28 – Bold**, other cells – **Regular**;
Horizontal alignment: **B1:M21, – Center, A24:A28 – Left,** other cells – **by default** (don't change);

Apply cell borders to the table according to the ***Fig. 1****.*

- *Click* ***Save*** .

* * * * * * * * * * * *

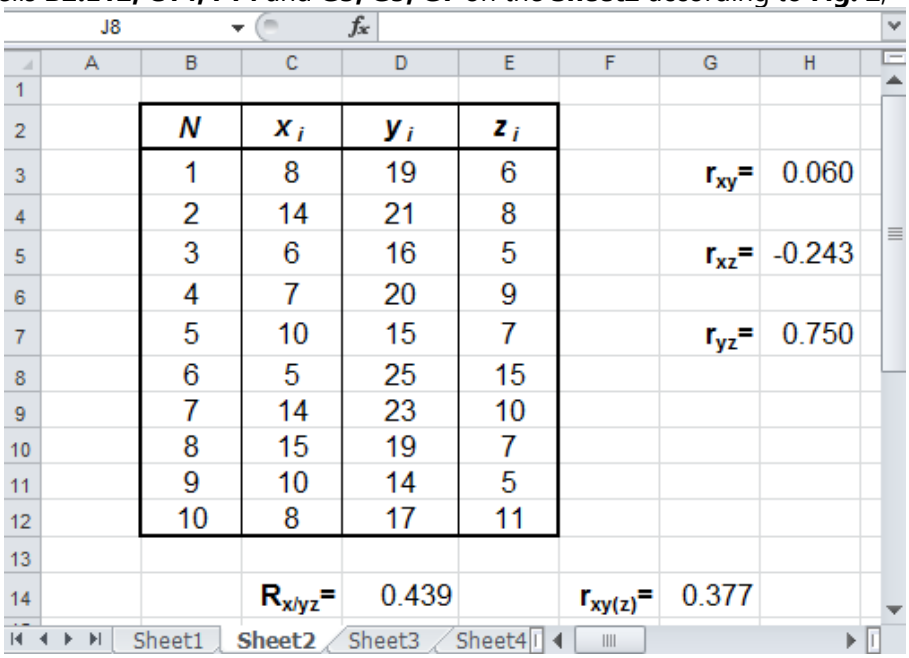
Task №2. *Using program **MS Excel** calculate **multiple correlation coefficient** if after performing the investigation following data were obtained:*

Table 2

X	8	14	6	7	10	5	14	15	10	8
Y	19	21	16	20	15	25	23	19	14	17
Z	6	8	5	9	7	15	10	7	5	11

*Create a new table as shown on the **Fig. 2**:*

type text into cells **B2:E12, C14, F14** and **G3, G5, G7** on the **Sheet2** according to **Fig. 2**;



	N	x_i	y_i	z_i		
1	1	8	19	6	r_{xy}=	0.060
2	2	14	21	8		
3	3	6	16	5	r_{xz}=	-0.243
4	4	7	20	9		
5	5	10	15	7	r_{yz}=	0.750
6	6	5	25	15		
7	7	14	23	10		
8	8	15	19	7		
9	9	10	14	5		
10	10	8	17	11		
11						
12		$R_{x/yz}$=	0.439		$r_{xy(z)}$=	0.377

Fig. 2

Calculate correlation coefficients:

- to find the correlation coefficient between x and y r_{xy} click the cell **H3** and enter the formula **=CORREL(C3:C12,D3:D12)** (click the cell **H3**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **CORREL** → **OK** → enter **C3:C12** in **Array1** box → enter **D3:D12** in **Array2** box → **OK**);
- to find the correlation coefficient between x and z r_{xz} click the cell **H5** and enter the formula **=CORREL(C3:C12,E3:E12);**
- to find r_{yz} click the cell **H7** and enter the formula **=CORREL(D3:D12,E3:E12);**
- to find the multiple correlation coefficient $R_{x.yz}=\sqrt{\frac{r_{xy}^2-2r_{xy}r_{xz}r_{yz}+r_{xz}^2}{1-r_{yz}^2}}$. click the cell **D14** and enter the formula **=SQRT((H3^2-2*H3*H5*H7+H5^2)/(1-H7^2));**
- to find the partial correlation coefficient between x and y holding z constant $r_{xy.z}=\frac{r_{xy}-r_{xz}r_{yz}}{\sqrt{1-r_{xz}^2}\sqrt{1-r_{yz}^2}}$ click the cell **F14** and enter the formula **=(H3-H5*H7)/SQRT((1–H5^2)*(1–H7^2));**
  - *Format the table according to **Fig. 2**.*

Formatting instructions:

Font: **Arial**;
Size: **12**;
Style: cells **B2:E2** – **Bold Italic**, **C14, F14, G3, G5, G7** – **Bold**, other cells – **Regular**;
Horizontal alignment: **B2:E12** – **Center**, **C14, F14, G3, G5, G7** – **Right**, other cells – **by default** (don't change);

*Apply cell borders to the table according to the **Fig. 2**.*

- *Click **Save** .*

* * * * * * * * * * * *

Task №3. *Using **MS Excel** calculate **the parameters of linear and exponential regression equations**,*

*construct **correlation field**, **linear and exponential regression lines** and compare their quality if after performing the investigation following data were obtained:*
Table 3

X	4	5	6	6	8	9	10	11	11	14
Y	12	12	11	14	15	11	16	13	15	21

*Create a new table as shown on the **Fig. 3***:
select cells **A14:B14** on the **Sheet3**, on the **Home** tab, in the **Alignment** group, click **Merge and Center** ;
in the same way merge cells **A18:B18**;
type text into cells **B2:D12**, **A14:A16** and **A18:A20** according to **Fig. 3**;

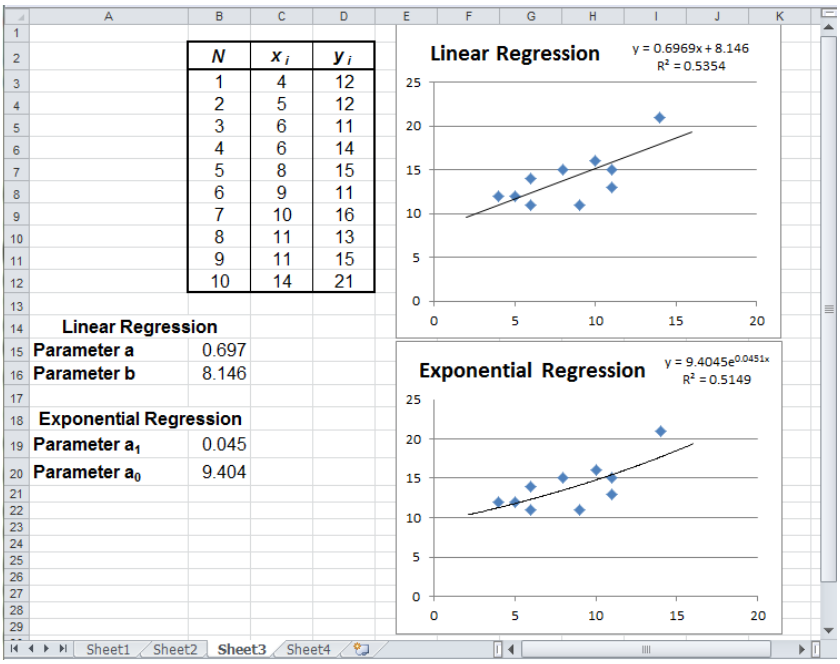


Fig. 3

Calculate the linear regression parameters:

- click the cell **B15** and enter the formula **=INDEX(LINEST(D3:D12,C3:C12),1)**;

Note. To create the above formula:

- click the cell **B15**, click **Insert Function** button on the **Formula bar** → select **Lookup & Reference** from **select a category** box → select **INDEX** → **OK**;
- in the **Select Arguments** dialog box select **array;row_num;column_num** → **OK;**
- in the **INDEX** dialog box click **Row_num** to type **1,** click in **Array** box → click in the left part of **MS Excel** window next to the **Formula Bar** → click **More Functions…;**
- select **Statistical** from **select a category** box → select **LINEST** → **OK**;
- in **LINEST** dialog box click **Known_y's** → enter **D3:D12** → click **Known_x's** → enter **C3:C12** → click **OK;**

- click the cell **B16** and enter the formula **=INDEX(LINEST(D3:D12,C3:C12),2)**.
  - Calculate the exponential regression parameters:
- click the cell **B19** and enter the formula **=LN(INDEX(LOGEST(D3:D12,C3:C12),1));**

Note. To create the above formula:

click the cell **B19**, click **Insert Function** button on the **Formula bar** → select **Math & Trig** from **select a category** box → select **LN** → **OK**;

click in the left part of **MS Excel** window next to the **Formula Bar** · click **More Functions…;**
select **Lookup & Reference** from **select a category** box → select **INDEX** → **OK**;
in the **Select Arguments** dialog box select **array;row_num;column_num** · **OK;**

in the **INDEX** dialog box click **Row_num** to type **1,** click in **Array** box → click in the left part of **MS**

Excel window next to the **Formula Bar** ▪ click **More Functions…;**
select **Statistical** from **select a category** box → select **LOGEST** ▪ **OK**;
in **LOGEST** dialog box click **Known_y's** → enter **D3:D12** → click **Known_x's** → enter **C3:C12** ▪ click **OK;**
click the cell **B20** and enter the formula **=INDEX(LOGEST(D3:D12,C3:C12),2)**.
Format the table according to ***Fig. 3***.
Formatting instructions:
Font: **Arial**;
Size: **12**;
Style: cells **B2:D2** – **Bold Italic, A14, A15:A16, A18, A19:A20 – Bold**, other cells – **Regular**;
Horizontal alignment: **B2:D12** – **Center,** other cells – **by default** (don't change);
Apply cell borders to the table according to the ***Fig. 3***.
Draw the charts:
select cells **C3:D12;**
click the **Insert** tab, in the **Charts** group, select **Scatter**  category;
from the drop-down menu select **Scatter with only Markers**  chart type, the chart will appear in the worksheet.
click on the chart, click the **Chart Tools Layout** tab, in the **Analysis** group, select **Trendline**  ;
from the drop-down menu select **More Trendline Options…**;
in the **Trend/Regression Type** box choose **Linear;** in the **Forecast** box **Forward:** and **Backward:** type **2**; click **Display equation on chart** and **Display R-squared value on chart** ▪ click **Close;**
Format the chart according to the **Fig.3**.
In the same way construct an exponent regression line.

Note. **Trend/Regression Type** box choose **Exponential**.

Click ***Save***  .
Show teacher results of your work.
Close **MS Excel** document.

Attention*: After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:
Excel help & learning. Microsoft.com. from https://support.microsoft.com/en-us/excel
1) Rosenthal, D. A., & Kros, J. F. (2023). *Statistics for health care management and administration: Working with excel (4th ed.).* Jossey-Bass.
2) Quirk, T. J., & Cummings, S. M. (2020). *Excel 2019 for health services management statistics: A guide to solving practical problems.* Springer International Publishing.
3) Hoffman, J. I. E. (2019). *Biostatistics for medical and biomedical practitioners* (2nd ed.). Academic Press.
Additional
1) Forister, J. G., & Blessing, J. D. (2019). *Introduction to research and medical literature for health professionals (5th ed.).* Jones & Bartlett.
2) Cleophas, T. J., & Zwinderman, A. H. (2020). *Clinical data analysis on a pocket calculator*. Springer International Publishing.
3) Rothman, K. J., Lash, T. L., & Greenland, S. (2012). *Modern Epidemiology* (3rd ed.). Lippincott Williams and Wilkins.

Topic 8: ANALYSIS OF BIOSIGNALS, PROCESSING METHODS, VISUALIZATION OF MEDICAL-BIOLOGICAL DATA, AND MEDICAL IMAGE PROCESSING AND ANALYSIS.

Actuality: All living organisms, from single cells to complex systems, produce a variety of biological signals. These signals may be electrical, such as the depolarization of nerve cells or heart muscles, mechanical, like the sounds produced by heart valves, or chemical, including the concentration of PCO_2 in the blood. These biological signals are crucial for diagnosis, patient monitoring, and biomedical research. Throughout their lives, organisms continuously emit these signals, which are often obscured by other background signals and noise.
The primary goal of biosignal processing is to extract the relevant signals from this background noise and simplify the vast data stream into a few key parameters. These parameters are vital for medical decision-making, helping to address medical issues or enhance understanding of the biological processes involved. In this context, biosignal processing involves converting raw data into meaningful information, which aligns with the broader objective of using data to gain knowledge and inform decisions.

Educational aims of the lesson:

To know:

1. practical application of the analysis of biosignals and medical images, and the methods by which it is carried out;
2. the characteristics of biological systems as objects of study.

To be able to:

1. analyze bio signals and medical images and demonstrate skills in their processing.

The list of questions for the survey:

2. Biosignals and non-stationary signals. Types of signals.
3. Registration, transformation, and classification of signals.
4. Analysis of biosignals. Arts and application analysis of biosignals.
5. Means of obtaining medical images.
6. Processing of medical images. Problems of processing and image analysis.
7. Transformation of images. General and local transformation of images.
8. Modern trends of image processing.
9. Processing of two-dimensional and three-dimensional medical images.

The list of required practical skills:

1. analyzing and processing biosignals and medical images using a PC.

Brief theoretical information

Biomedical signals. The functional condition of the human body is a key indicator of health within the medical field. Evaluations of this functional state are integral to diagnostic, therapeutic, and preventive measures in medical practice. This assessment is also significant for health insurance, workplace health and safety, and the development of medical expert systems. One innovative approach in this area is the development of an electronic health record — a database that stores parameters describing the functional state of all human body organs and criteria for their evaluation.
Various methods are used to assess the human body's functional state, including electrical, electromagnetic, ultrasonic, fluorescent, biochemical, and mechanical techniques. A key parameter in these evaluations is the biomedical signal, which is extensively used in medical diagnostics and patient monitoring. Devices that record these biomedical signals are crucial for identifying normal and abnormal physiological variations.
Electrographic methods are commonly used for recording these signals. These techniques measure and monitor biopotentials naturally present or induced by external factors in various body parts and organs, providing essential data for health assessment and medical interventions.
Bioelectric potentials are voltages that develop in the cells, organs, and tissues of living organisms throughout their lives. These potentials arise from differences in voltage between excited and unexcited parts of cells, where the excited regions exhibit a lower potential compared to the unexcited ones. In tissues, the overall potential difference is a cumulative effect of the potentials from individual cells.

The measurement of bioelectric potentials involves using electrodes that are attached to the body's surface or directly to organs. Rather than measuring absolute potential, this process records the potential difference between two points on the surface, reflecting the bioelectric activity and underlying metabolic processes. These biopotentials provide crucial insights into the health and function of various organs.

Electrographic methods, which are used to record these potentials, include techniques like electrocardiography, electroencephalography, electromyography, and electrogastrography, among others. These methods are essential for diagnosing diseases, monitoring patients, and conducting biomedical research, offering valuable data on the physiological processes within the body.

Types of signals. Biosignals are generated through biological processes that take place within the body and are complex and dynamic. Typically represented as functions of time, s(t), biosignals extend beyond simple parameters like sine or cosine waves. The biological processes that produce these signals are continuously evolving and are characterized by their dynamic nature, making their behavior difficult to predict precisely. The parameters that describe these signal changes are continuous, reflecting the ongoing and variable activities within living organisms.

Concept of medical images. One of the key uses of computers in medicine involves managing graphical information, specifically through the ***analysis of medical images***, a specialized area of medical informatics. Medical imaging provides visual insights into the internal structures and functions of the human body using both radiological and non-radiological techniques.

Radiological Methods: These methods aim to convert invisible aspects of the body into visually perceivable images through *the use of radiation*, typically electromagnetic. The images produced by radiological diagnostics, such as *X-rays* and *MRIs*, serve as fundamental sources of health information by making internal bodily structures visible.

Non-Radiological Methods: This category includes techniques that capture images through devices like *endoscopes* or cameras used in various fields such as histology, pathology, and dermatology. These images, whether from endoscopy or microscopic photography, can be digitized and processed.

Ultimately, the term "*medical image*" refers to any spatial representation derived from any form of radiation that has been transformed into the visible spectrum, making it perceivable to the human eye. This broad definition involves a wide range of imaging methods used in medical diagnostics and research. Regardless of their method of obtaining, medical images can be categorized into two types: ***analog*** and ***digital***.

Analog Images: These images represent continuous information. Analog images capture a continuous spectrum of data, reflecting more natural and fluid transitions in the visual details. An example of an analog image would be the images produced by older X-ray machines that use photographic film to capture the image. The X-ray film records varying degrees of X-ray light passed through the body, capturing continuous variations in tissue density and structure. This results in a smooth gradation of shades from black to white, which helps doctors see different structures within the body, such as bones or organs, in a single, uninterrupted image.

Digital Images: Unlike analog images, which capture continuous information, digital images are composed of discrete units called pixels. Each pixel is a tiny square that represents a specific part of the image, and all the pixels together form the complete image. This digital format allows the image to be stored as data in a computer's memory.

Digital imaging technologies such as digital X-rays, CT scans, and MRIs use sensors to capture information about the body. Instead of film, digital sensors record this information directly as digital data. Here's how it typically works:

Image Capture: In a digital X-ray, for example, the X-ray passes through the body and hits a digital detector on the other side. This detector does not use traditional film but instead has sensors that convert the X-rays into electrical signals.

Signal Conversion: These electrical signals, which vary depending on the intensity of the X-rays that hit each sensor, are then converted into digital information, specifically into values that represent different shades of gray.

Pixel Formation: Each of these values is assigned to a pixel. The collective arrangement of these pixels forms an image that can be displayed on a computer screen.

Image Processing and Analysis: Once in digital form, these images can be easily manipulated and

enhanced to improve clarity and contrast, making it easier for medical professionals to diagnose conditions. They can be zoomed in on, brightness and contrast can be adjusted, and even colors can be added to differentiate between tissues, which is often done in images like CT scans and MRIs.

Storage and Sharing: Digital images can be stored in digital medical records and shared easily with other healthcare professionals via networks, which is crucial for diagnostics, treatment planning, and ongoing patient care.

Digital images are helpful in medicine because they allow for quick processing, precise analysis, easy storage, and efficient sharing. They can also be integrated with other digital healthcare systems, enhancing their utility in clinical settings. This technology represents a significant advance over older analog techniques, providing clearer, more detailed images that are crucial for accurate diagnosis and effective treatment.

In medical diagnostics, medical images can be presented in several formats. They may be available as ***hard copies*** like radiographs printed on paper or photographic paper. Alternatively, they can be stored on ***magnetic media*** such as tapes or disks like CDs. Images can also be viewed in an ***unfixed form*** directly on computer displays or X-ray diagnostic machines.

Medical images can depict various types of anatomical structures. These can be categorized as *rigid parts* of the body, such as bones, and more flexible parts, like *soft tissue* structures that can change shape. Furthermore, some parts of the images might show *static structures*, such as the skull, while others capture *dynamic movements*, like the heart in action.

Medical imaging techniques vary based on the **dimensionality** of the images they produce.

One-dimensional and Two-dimensional Medical Imaging:

1. Electromagnetic Radiation: This method involves using X-rays, which penetrate the body and create images based on the varying absorption rates of different tissues. These images help visualize the internal structure of the body.

2. Ultrasound: This technique uses high-frequency sound waves that echo off body structures. The returning echoes are converted into real-time images, commonly used in prenatal scans and examinations of internal organs.

Specific Methods for Two-dimensional Imaging:

1. Digital Radiology: This modern version of X-ray imaging captures data digitally, allowing for immediate processing and enhanced image clarity compared to traditional film X-rays.

2. Computed Tomography (CT): CT scans use a series of X-ray images taken from different angles around the body and computer processing to create cross-sectional images of bones, blood vessels, and soft tissues.

3. Nuclear Magnetic Resonance (MRI): MRI uses strong magnetic fields and radio waves to produce detailed images of organs and tissues. It is especially useful for imaging the brain, spinal cord, and nerves.

4. 2D-Ultrasound: Similar to standard ultrasound but specifically produces two-dimensional images, useful for examining internal organs, measuring blood flow, and guiding biopsy needles.

Methods for Three-dimensional Imaging:

1. Sequential Radiological or Tomographic Images of Dynamic Objects: This method involves taking multiple two-dimensional images at different times to capture changes in a dynamic object, such as the beating heart, and assembling them to create a three-dimensional representation.

2. Volumetric Tomographic Imaging of Static Objects: This technique gathers comprehensive data from a static object, such as a tumor, using methods like CT or MRI to produce a three-dimensional image that can be examined from various angles.

All radiological imaging techniques can be understood through a basic schematic (see fig. 1). At the beginning of this process, there is a ***radiation source***. This source can either be external to the patient, as seen in X-ray and ultrasound techniques, or internal, as used in radionuclide studies where radioactive materials are introduced into the body.

Following the radiation source is the ***radiation detector***. This component is crucial as it comes into direct contact with the ***patient***. Its function is to capture either electromagnetic radiation or sound waves (elastic vibrations) emitted from the patient's body and transform them into images or data that can be used for

diagnostic purposes.

The type of detector used varies depending on the specific imaging technique. It could be a fluorescent screen, which lights up when exposed to radiation, or a photographic film used in traditional X-ray imaging, among other possibilities. Each type of detector is designed to effectively convert the incoming radiation into useful medical information.

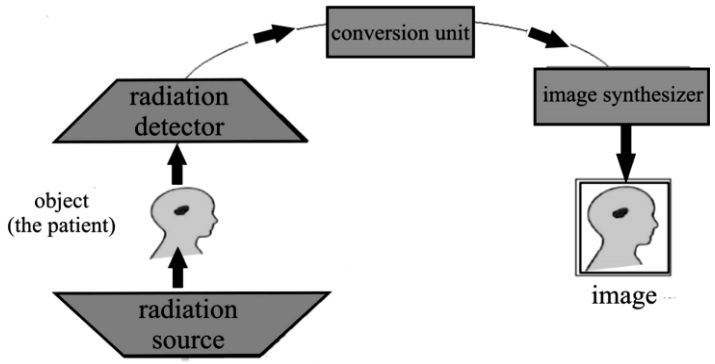


Fig.1. Imaging system in radiological diagnostic methods

In some imaging systems, the signals received from the detector are sent to a conversion unit. The primary function of this unit is to enhance the signal's clarity by increasing its data capacity, filtering out any interference or "noise," and transforming it into a format suitable for transmission. After conversion, these signals are forwarded to an image synthesizer, which constructs a visual representation of the target object, such as an organ or the entire body. The nature of these images can vary significantly depending on the imaging technique used.

The process of conducting radiological examinations is overseen by a diagnostic radiologist—a physician specially trained in radiology. The radiologist's role involves acquiring visual data, processing and interpreting these data and ultimately making diagnostic decisions based on the interpreted results.

Medical Imaging. Today, digital medical images have replaced analog ones. Digital imaging makes it easier to process, store, and share medical image data. Information technology supports every stage of medical image processing. Some images, like those from computed tomography (CT), positron emission tomography (PET), and magnetic resonance imaging (MRI), are created directly by computers and cannot be obtained otherwise.

Benefits of Digital Image Processing:

- Improving Image Quality: Enhances clarity, corrects recording defects, and reduces noise.
- Measuring Clinical Data: Calculates important parameters like distance, area, and volume.
- Easing Interpretation: Helps in analyzing structures, such as for radiation therapy dose calculations.

Image Compression and Storage:

Compressing images reduces memory usage and speeds up data transfer. Digital storage on electronic media makes organizing and accessing archives simpler. Transferring images digitally between hospitals enables quick expert consultations, aiding in faster and more accurate diagnosis and treatment decisions.

Basic Steps in Image Processing

Image processing and analysis involve several key steps:

1. Pre-treatment:

This step corrects errors caused by the image creation system and reduces noise. Specialized software enhances digital images, improving the visibility of specific anatomical structures.

2. Adjusting Image Contrast:

An image histogram is calculated to show the number of pixels at each gray level, helping adjust the contrast for better visibility.

3. Segmentation:

This step separates individual elements in the image, such as organs or cells, for further analysis.

4. Parameter Calculation:

Measurements of linear and volumetric features of anatomical structures are made to gather useful data.

5. Image Interpretation:

Automatic interpretation by computers is still challenging. For accurate results, a comprehensive knowledge base of normal and pathological anatomy is required. Identified structures must be compared

with known examples and classified correctly.

Modern Trends in Medical Imaging:

- Advanced two- and three-dimensional image processing is becoming common.
- Creating medical image databases is a growing area, such as the "**Visible Human Project**" (http://www.nlm.nih.gov/research/visible/visible_human.html), which provides data for anatomy studies, research, education, and diagnostics.

Processing of two-dimensional medical images.

The use of tomographic methods in medical practice has been increasing, especially over the past few decades, due to the development of new techniques for recording the state of internal body tissues. Techniques such as nuclear magnetic resonance (NMR) and electron paramagnetic resonance (EPR spectroscopy) are expected to gradually replace traditional X-ray-based tomography, which relies on measuring tissue absorption of X-ray beams.

The imaging principle (see fig. 2) involves the line-by-line registration of numerous beams that the **emitter** (**1**) sends through the **body under examination** (**3**) towards the **radiation detector** (**2**). In the illustration, two pairs of emitter-detector configurations are depicted, oriented in **horizontal (A)** and **vertical (V)** planes, showing a basic division of the setup. This method allows for detailed cross-sectional images of the body, providing critical insights into internal structures.

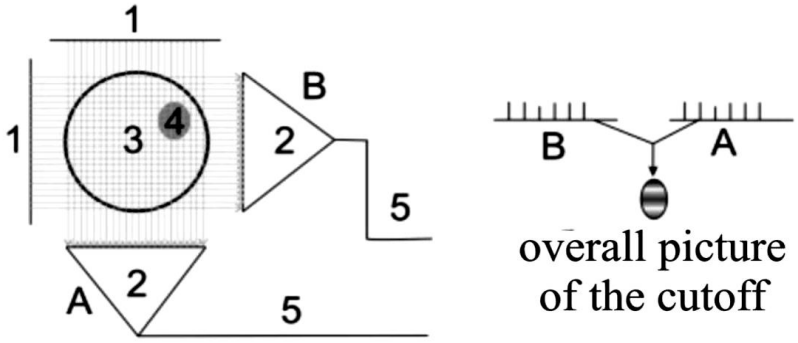


Fig. 2. Illustration of the principal signal recording with computed tomography

As rays pass through the tissue of the organ being studied, they are absorbed at varying levels across different areas. Let's consider that there is a **pathological center** (labeled as **4**) within the **organ** (**3**). The intensity profiles of the rays traverse through the body will appear as depicted in the diagram on the right. The areas of **lower intensity** in these profiles correspond to the location of the **pathological center**. By analyzing these two profiles, one can accurately determine the position of this pathological center within the organ's structure.

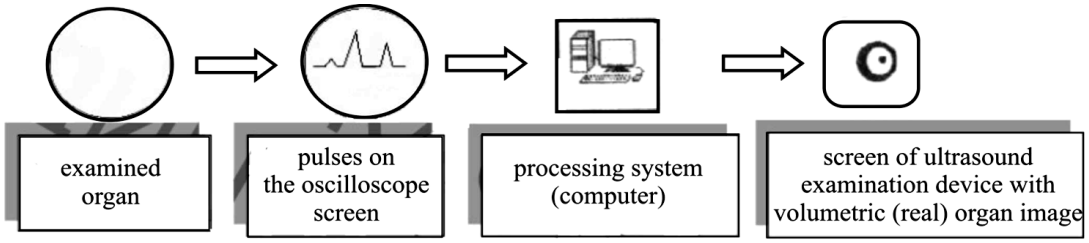


Fig. 3. Converting signals during ultrasound diagnostic

The operation of **ultrasonic diagnostic** systems shares similarities with the imaging principles described previously but differs in two key ways: firstly, it **uses mechanical vibrations** in the ultrasonic frequency range, and secondly, the **ultrasonic signals are transmitted through the body and reflected back, rather than just passing through**.

CTSim is a software that simulates the process of X-rays being projected through a phantom object—an object used as a stand-in during imaging to simulate human tissue. CTSim not only projects these X-rays but also reconstructs the interior structure of the object based on these projections. It incorporates a range of visualization and analytic tools to aid in this process.

The operation of **CTSim** starts with a **phantom object** composed of geometric shapes. The user specifies a scanner, and the software simulates the collection of X-ray data or projections. This projection data is then reconstructed using various algorithms controlled by the user to create an image of the phantom object. The resulting images can be visually and statistically compared to the original phantom object to assess accuracy.

CTSim primarily works with **two types** of objects: the **phantom** and the **scanner**. The phantom itself is made up of one or more geometric elements such as rectangles, triangles, ellipses, sectors, and segments. These elements allow for the construction of standard phantoms commonly referenced in CT literature. CTSim offers the ability to load published phantom designs like those by Herman and Shepp-Logan and can also read text files containing user-defined phantoms.

Practical tasks for students. Instructions for execution of practical work

1. Start the PC and load **Windows** OS.
2. Start the program **Microsoft Excel**.
3. Start the **Microsoft Excel**.
4. Save your file on the Desktop: **File** → **Save** → **Desktop**, type the title of the file: **Biological signals**.

Attention: *Don't forget to click the icon* ***Save***  *on the* ***Quick Access toolbar*** *every few minutes during the lesson to avoid losing your work.*

Perform the following tasks:

****

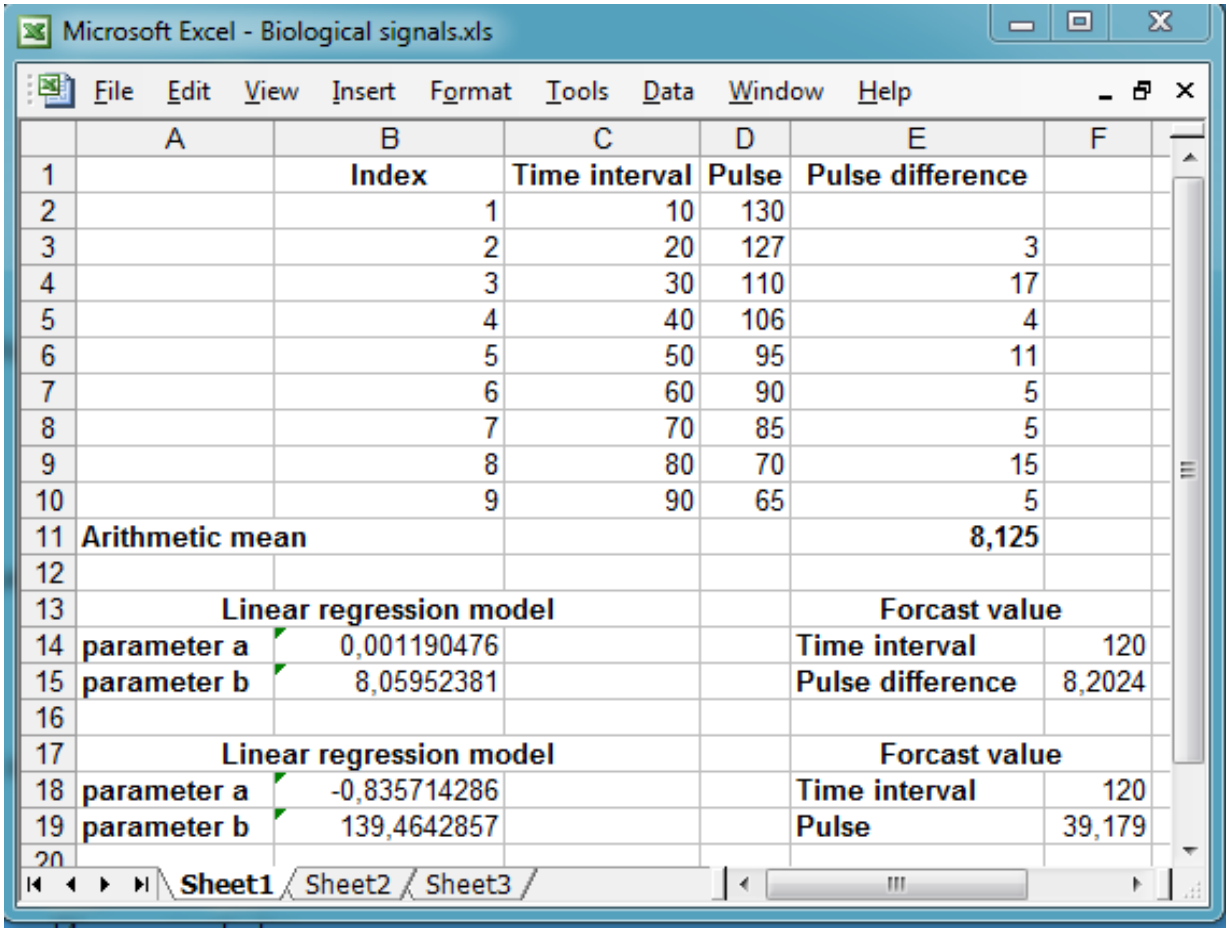
Task №1. *The following data were obtained as a result of experimental research:*

Index	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Time Interval, t, s	10	20	30	40	50	60	70	80	90
Pulse, bps	130	127	110	106	95	90	85	70	65

Using facilities of the **MS Excel** *program, analyze the biosignals (pulse frequencies in different time intervals):*

- *plot the volume diagram of pulse change over the specified time intervals;*
- *calculate a difference between the pulse values;*
- *plot the graph of pulse difference over time;*
- *calculate the arithmetic mean of pulse differences;*
- *predict the future pulse and pulse differences values 110 s after the first measurement;*
- *refer to* ***Fig.4*** *to construct a table in Excel. Then, employ Excel's mathematical and statistical functions to compute the values, as shown in* ***Fig.5.***

This guide provides a clear sequence of steps for using Excel's robust data analysis capabilities to effectively manage and interpret medical data.



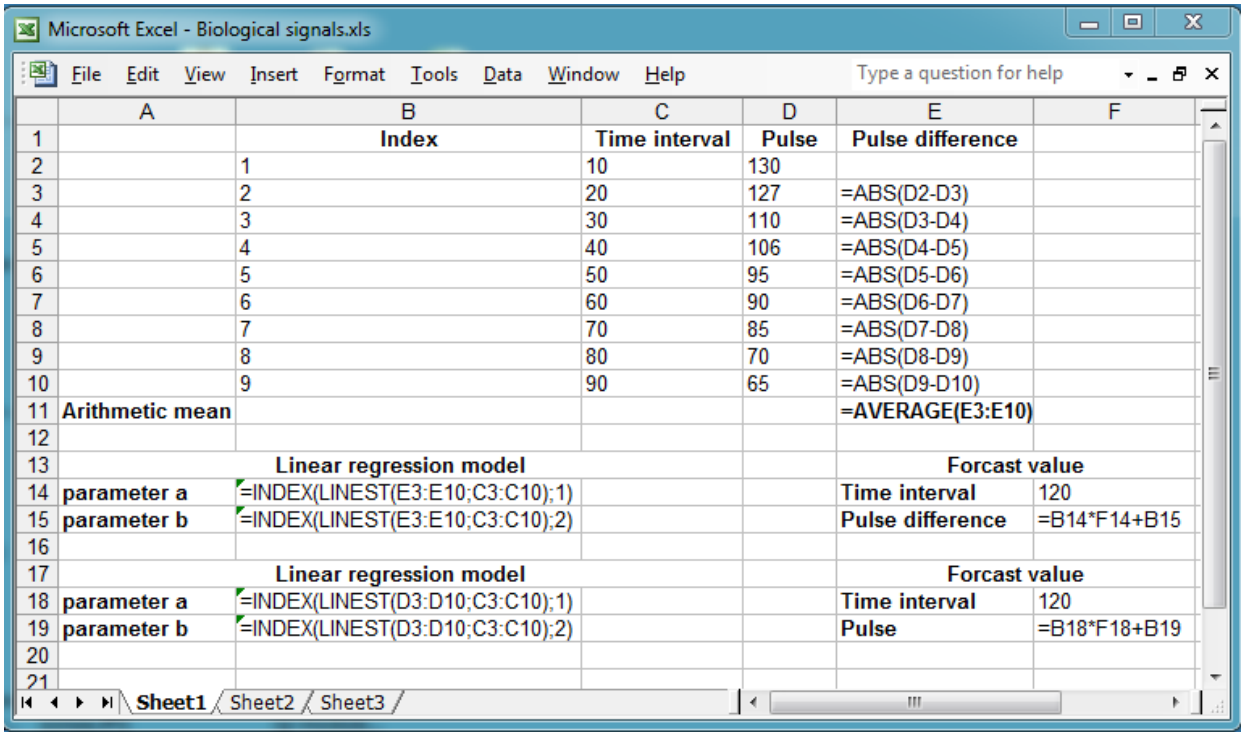
Microsoft Excel - Biological signals.xls

File Edit View Insert Format Tools Data Window Help

	A	B	C	D	E	F
1		Index	Time interval	Pulse	Pulse difference	
2		1	10	130		
3		2	20	127	3	
4		3	30	110	17	
5		4	40	106	4	
6		5	50	95	11	
7		6	60	90	5	
8		7	70	85	5	
9		8	80	70	15	
10		9	90	65	5	
11	Arithmetic mean				8,125	
12						
13	Linear regression model				Forcast value	
14	parameter a	0,001190476			Time interval	120
15	parameter b	8,05952381			Pulse difference	8,2024
16						
17	Linear regression model				Forcast value	
18	parameter a	-0,835714286			Time interval	120
19	parameter b	139,4642857			Pulse	39,179
20						

Sheet1 Sheet2 Sheet3

Fig. 4



Microsoft Excel - Biological signals.xls

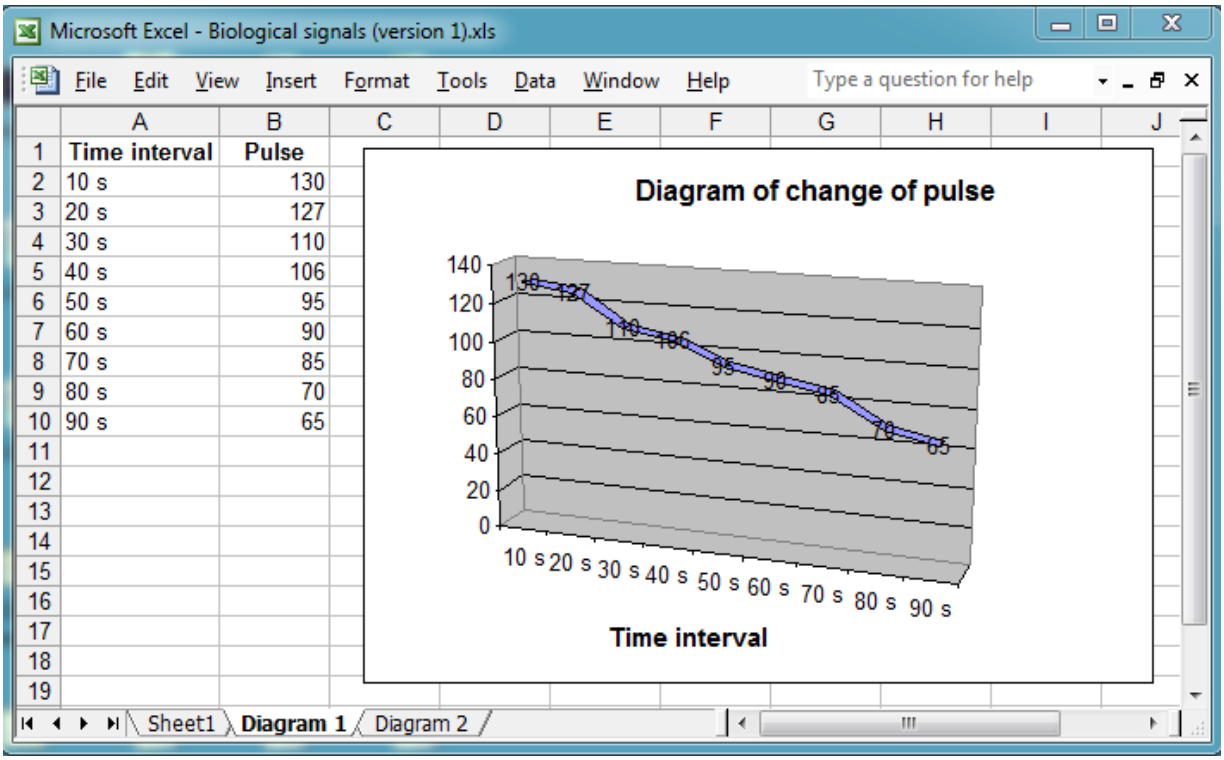
File Edit View Insert Format Tools Data Window Help Type a question for help

	A	B	C	D	E	F
1		Index	Time interval	Pulse	Pulse difference	
2		1	10	130		
3		2	20	127	=ABS(D2-D3)	
4		3	30	110	=ABS(D3-D4)	
5		4	40	106	=ABS(D4-D5)	
6		5	50	95	=ABS(D5-D6)	
7		6	60	90	=ABS(D6-D7)	
8		7	70	85	=ABS(D7-D8)	
9		8	80	70	=ABS(D8-D9)	
10		9	90	65	=ABS(D9-D10)	
11	Arithmetic mean				=AVERAGE(E3:E10)	
12						
13	Linear regression model				Forcast value	
14	parameter a	=INDEX(LINEST(E3:E10;C3:C10);1)			Time interval	120
15	parameter b	=INDEX(LINEST(E3:E10;C3:C10);2)			Pulse difference	=B14*F14+B15
16						
17	Linear regression model				Forcast value	
18	parameter a	=INDEX(LINEST(D3:D10;C3:C10);1)			Time interval	120
19	parameter b	=INDEX(LINEST(D3:D10;C3:C10);2)			Pulse	=B18*F18+B19
20						

Sheet1 Sheet2 Sheet3

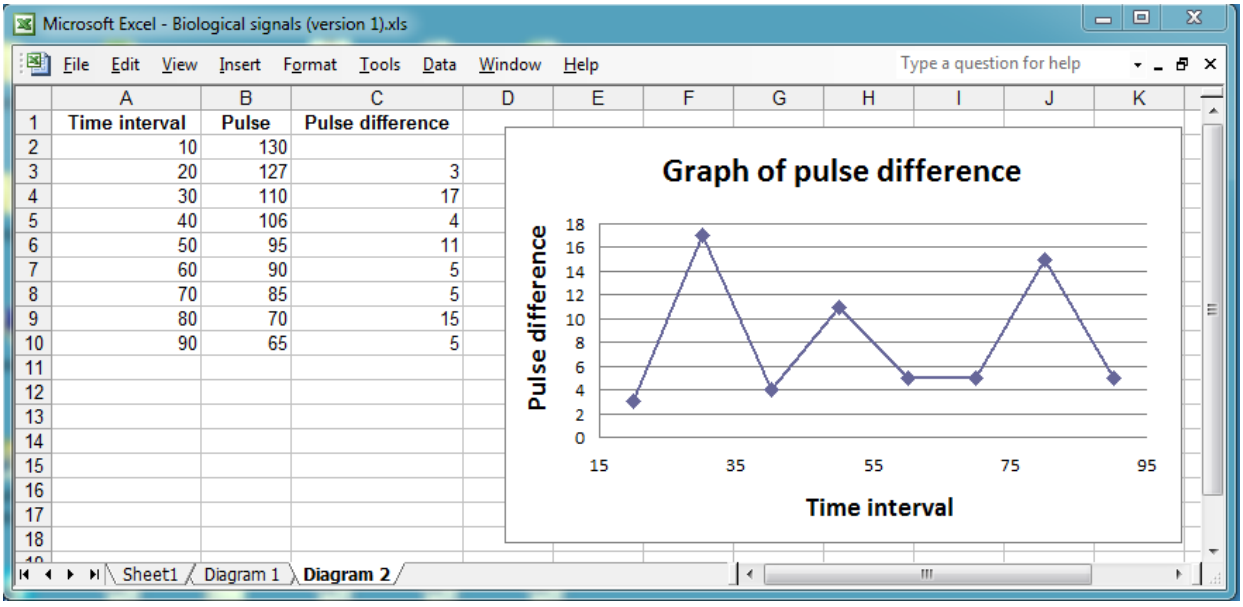
Fig. 5

plot the diagram of pulse changes according to **Fig.6**;
draw a graph of pulse differences according to **Fig.7**;



	A	B
1	Time interval	Pulse
2	10 s	130
3	20 s	127
4	30 s	110
5	40 s	106
6	50 s	95
7	60 s	90
8	70 s	85
9	80 s	70
10	90 s	65

Fig. 6

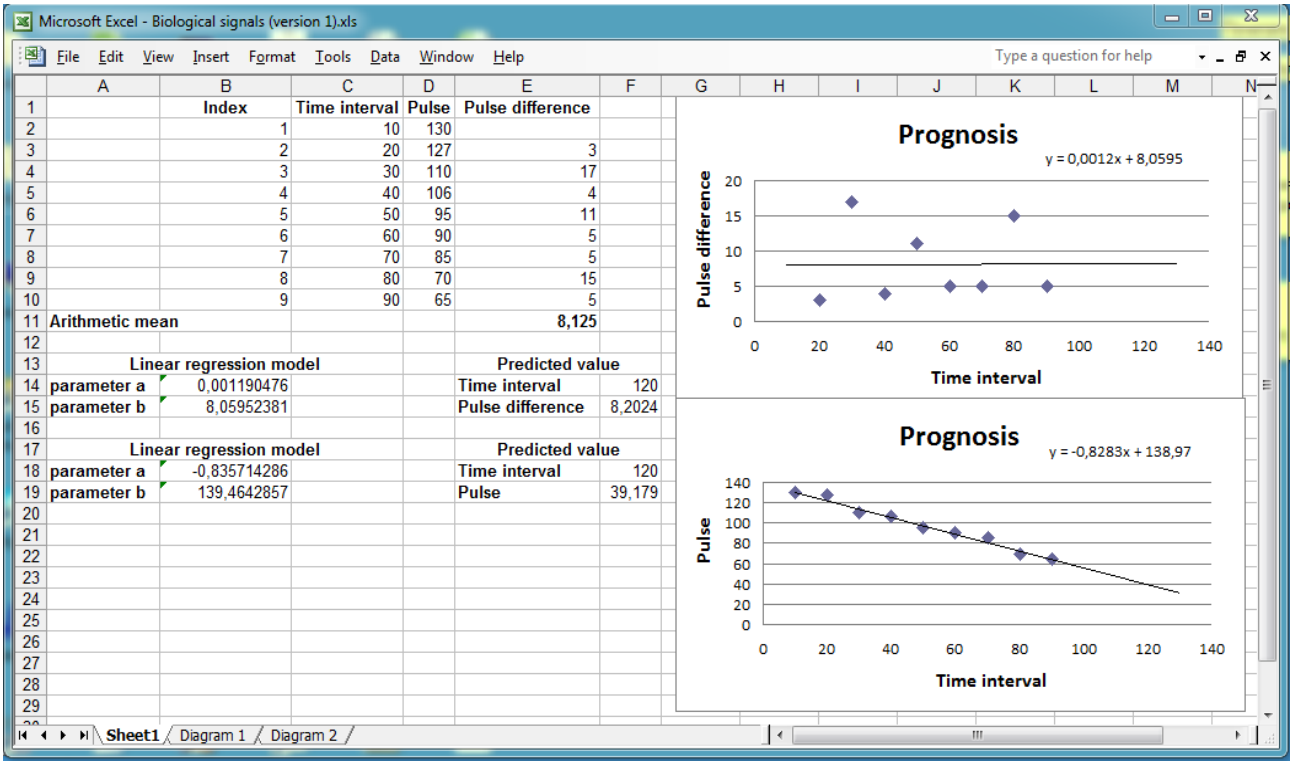


	A	B	C
1	Time interval	Pulse	Pulse difference
2	10	130	
3	20	127	3
4	30	110	17
5	40	106	4
6	50	95	11
7	60	90	5
8	70	85	5
9	80	70	15
10	90	65	5

Fig. 7

plot the graphs of the linear regression model according to **Fig. 8;**

Note. When constructing graphs for the linear regression model, be sure to set the **Prognosis ahead on 40 units**.



	A	B	C	D	E	F
1		Index	Time interval	Pulse	Pulse difference	
2		1	10	130		
3		2	20	127	3	
4		3	30	110	17	
5		4	40	106	4	
6		5	50	95	11	
7		6	60	90	5	
8		7	70	85	5	
9		8	80	70	15	
10		9	90	65	5	
11	Arithmetic mean				8,125	
12						
13	Linear regression model				Predicted value	
14	parameter a	0,001190476			Time interval	120
15	parameter b	8,05952381			Pulse difference	8,2024
16						
17	Linear regression model				Predicted value	
18	parameter a	-0,835714286			Time interval	120
19	parameter b	139,4642857			Pulse	39,179

Fig. 8

5. Show the teacher the results of your work.

****

Start the program **CTSim**.

Task №2. *Using the* **CTSim** *program, obtain and analyze the reconstruction images of the head phantom*.

• In the **CTSim** window, use the left mouse button (**LMB**) to navigate through the menu: go to **File** and select **Create Phantom**.

• In the **Select Phantom** window, find the **Phantom** field. Use the left mouse click (**LCM**) to activate the option for **Herman Head**. Confirm your selection by clicking **OK**;

• With the **Herman Head** window active, navigate to the menu **Process** and select **Rasterize**.

• In the **Set Rasterization Parameters** window, adjust the settings according to the standard shown in **figure 9**. Once settings are adjusted, click **OK.**

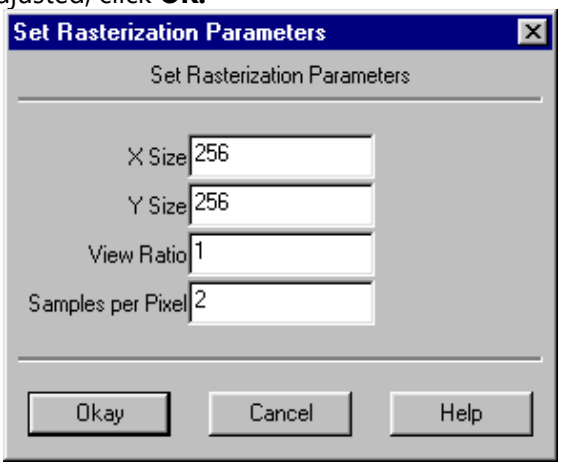


Fig. 9

• With the **Herman Head** window active, navigate to the menu **Process** and select **Rasterize**.

• In the **Set Rasterization Parameters** window, adjust the settings according to the standard shown in **figure 10**. Once settings are adjusted, click **OK.**

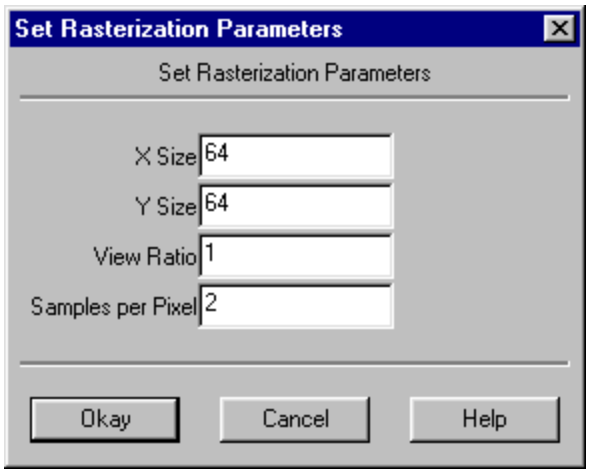


Fig. 10

- compare the images and conclude.
- With the **Herman Head** window active, navigate to the menu **Process** and select **Rasterize**.
- In the **Set Rasterization Parameters** window, adjust the settings according to the standard shown in **figure 11**. Once settings are adjusted, click **OK.**

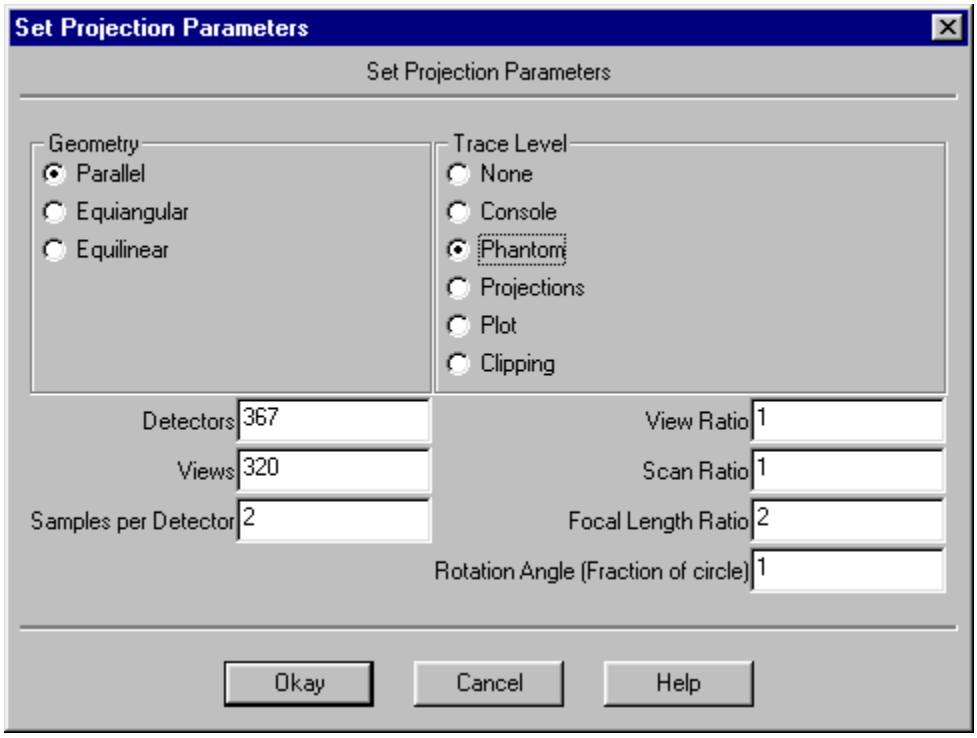


Fig. 11

- Trace changes occurring in the **Collect Projections** window.
- In the active window **unnamed4**, access the menu and select **Reconstruct → Filtered Backprojection...**
- In the **Set Reconstruction Parameters** window, adjust settings according to the standard shown in **fig. 12.**
- Monitor the updates in the **Reconstruction** window as the process takes place (**fig. 12**).

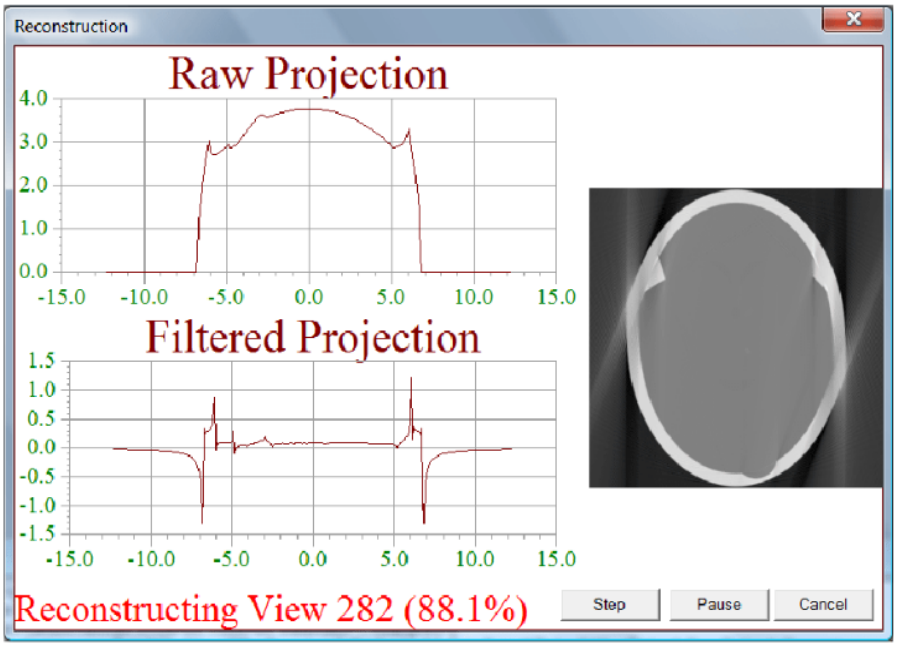


Fig. 12

- With the **unnamed4** window still active, select **Convert** → **Polar Image** from the menu.
- In the **Convert Polar** window, configure the settings as per the standard in **figure 12**, and click **OK**.
- The image for analysis will display in a window labeled **unnamed5**.
- Repeat steps **2 to 6** as needed, ensuring settings in the **Set Reconstruction Parameters** and **Convert Polar** are adjusted according to the standards shown in figures 13 and 14 respectively.
- In the active **unnamed5** window, use the LBM to execute commands from the menu items **Image** and **Analyze** to perform detailed image analysis.

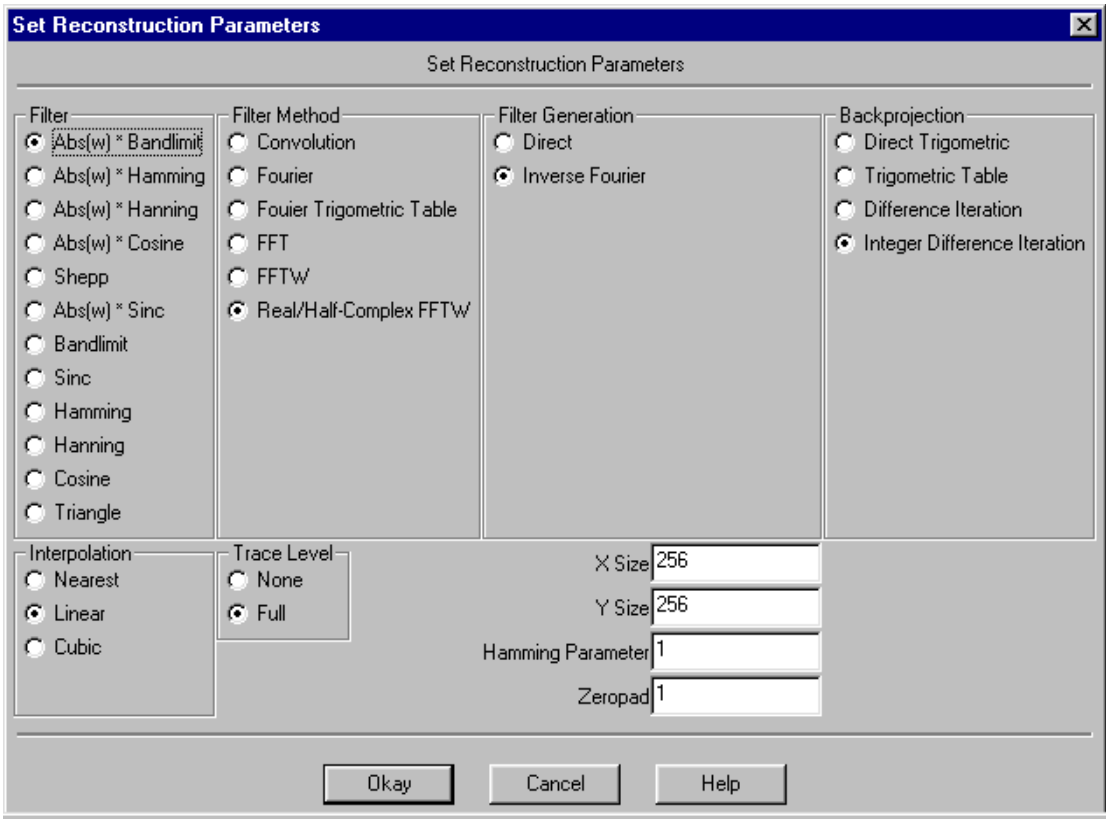


Fig. 12

- Trace changes occurring in the **Collect Projections** window;
- in a **CTSim** window close all opened windows;

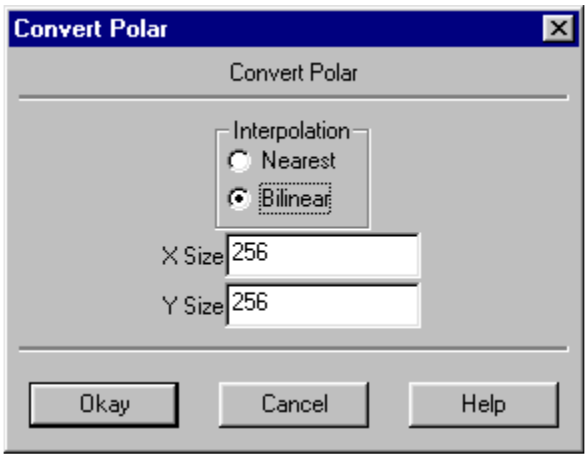
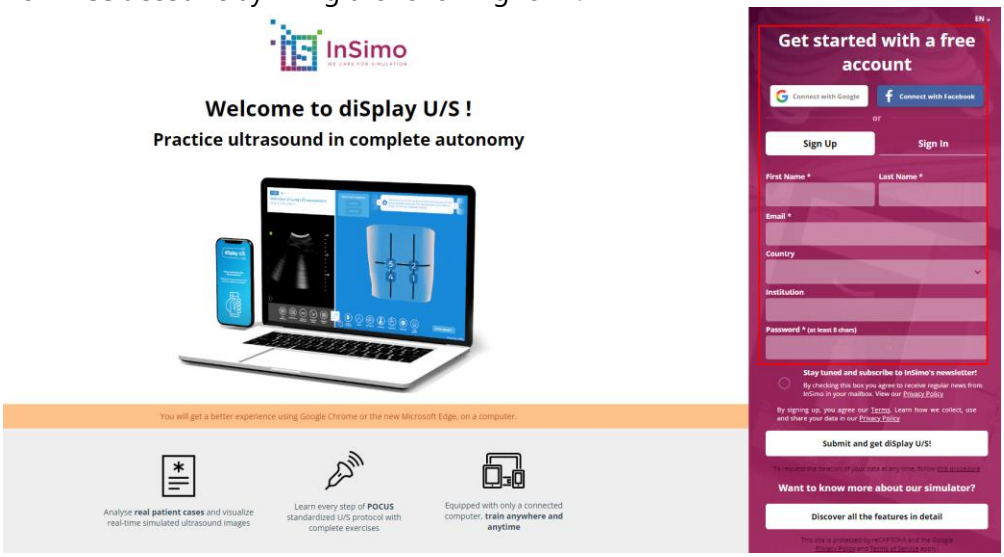


Fig. 13

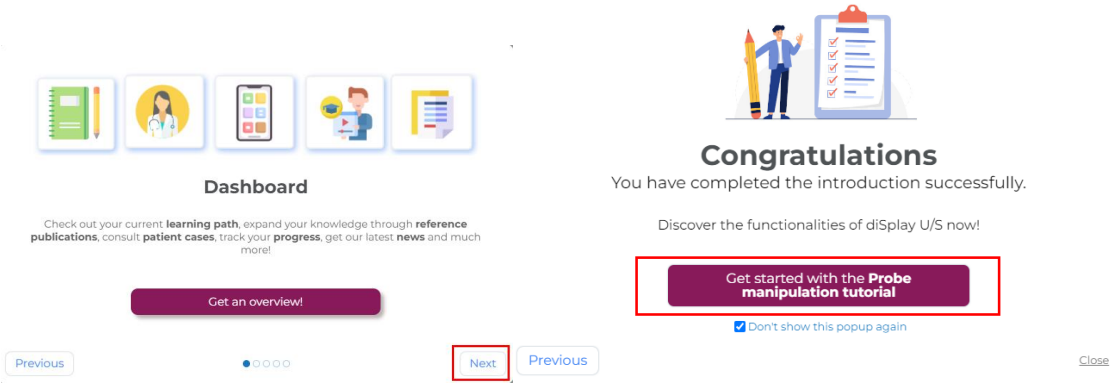
• In the **CTSim** window, choose **File** → **Create Phantom**.
• In the window **Select Phantom**, select the **Phantom** option, activate the **Shepp-Logan** option. Click **OK**.

Task №2(*). *Using the* **InSimo Ultrasound Simulator** *overview the demonstration case.*
https://display.insimo.com/login/

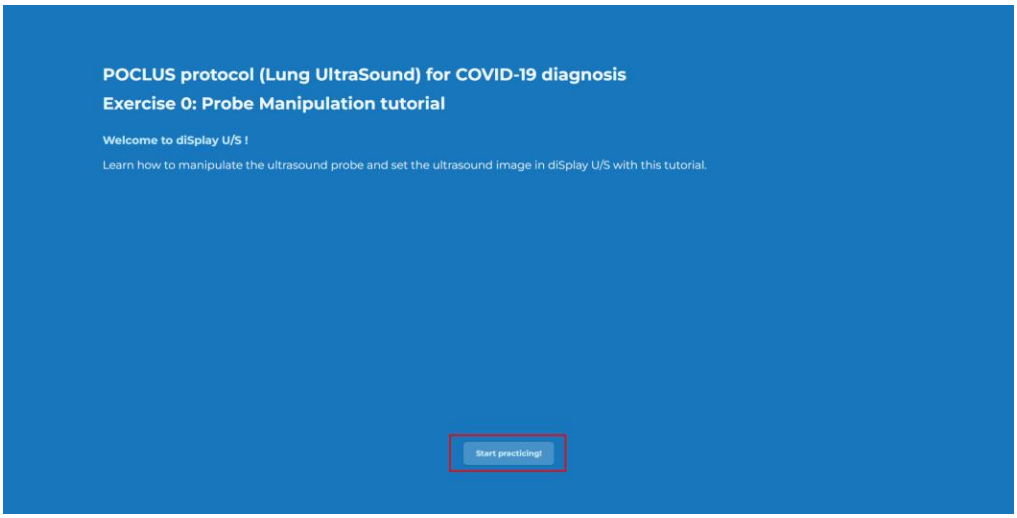
1. **Register** new **free account** by filling the following form:



2. Overview **the dashboard** by clicking **Next** and **Previous** buttons



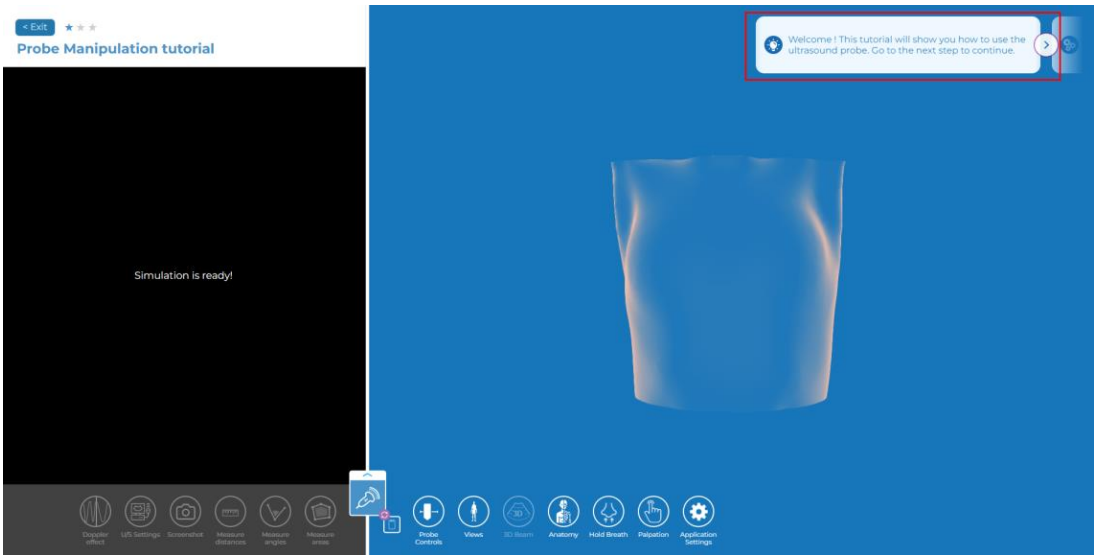
3. Start the **Probe manipulation tutorial.**



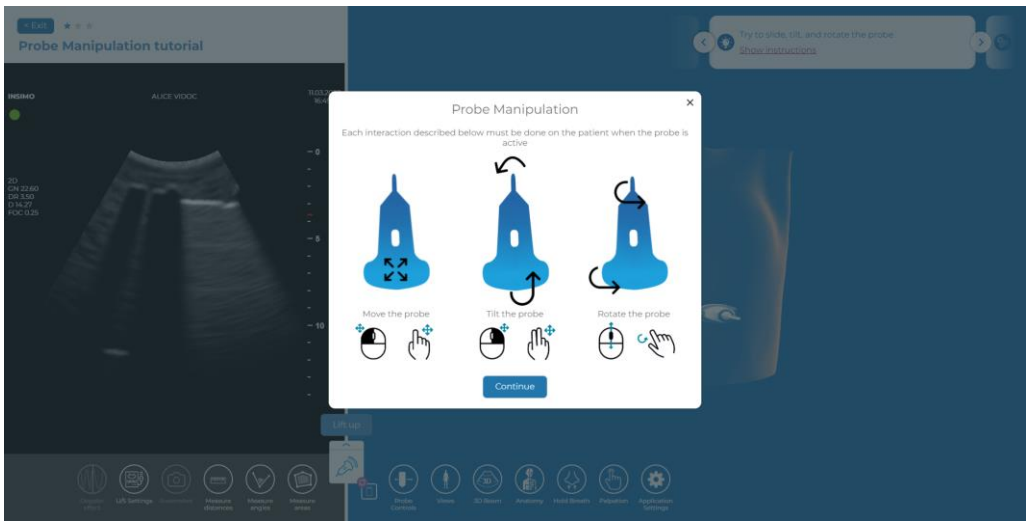
Probe Manipulation tutorial

Miss Vidoc arrived at your office with slight fever, and a dry cough.
These symptoms being indicators of a COVID-19 suspicion and having at disposal an ultrasonic ecograph, you decide to perform a pleuro-pulmonary ultrasound to check for signs of the virus.
Age 47 years old.
Situation Married, no child.
Profession Train driver.

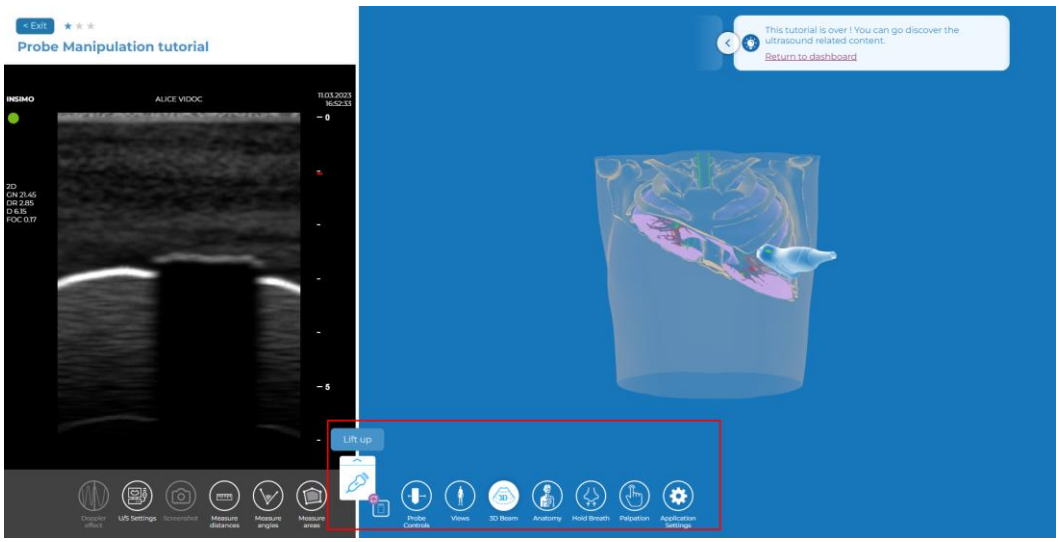
4. To complete the tutorial, follow the instructions on the top right corner of the screen.



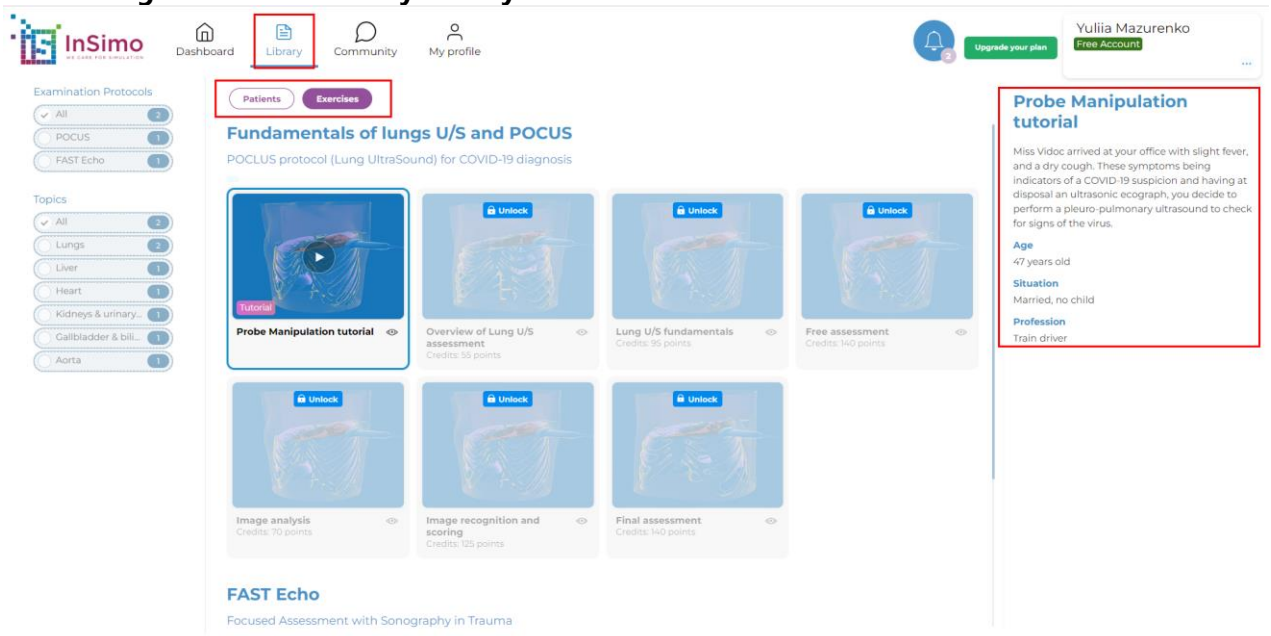
5. Manipulate the probe to overview lungs of miss Vidoc.

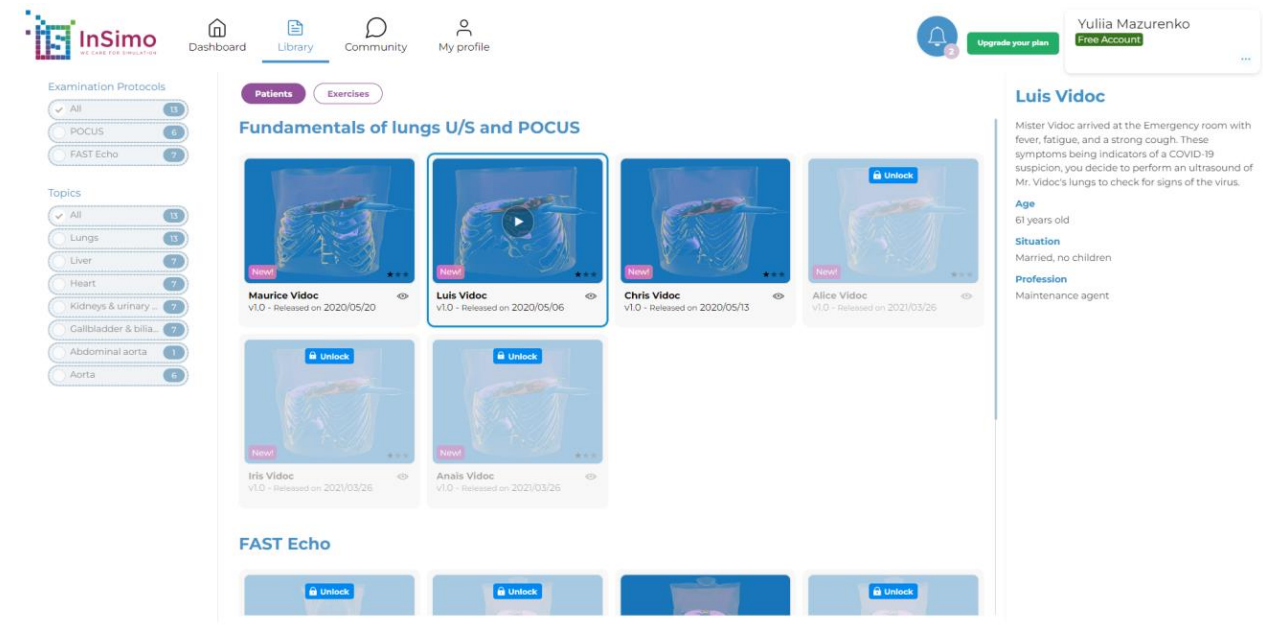


6. Complete the tutorial by following instructions on the top right corner of the screen.
You can change probes and other settings in the menu below.

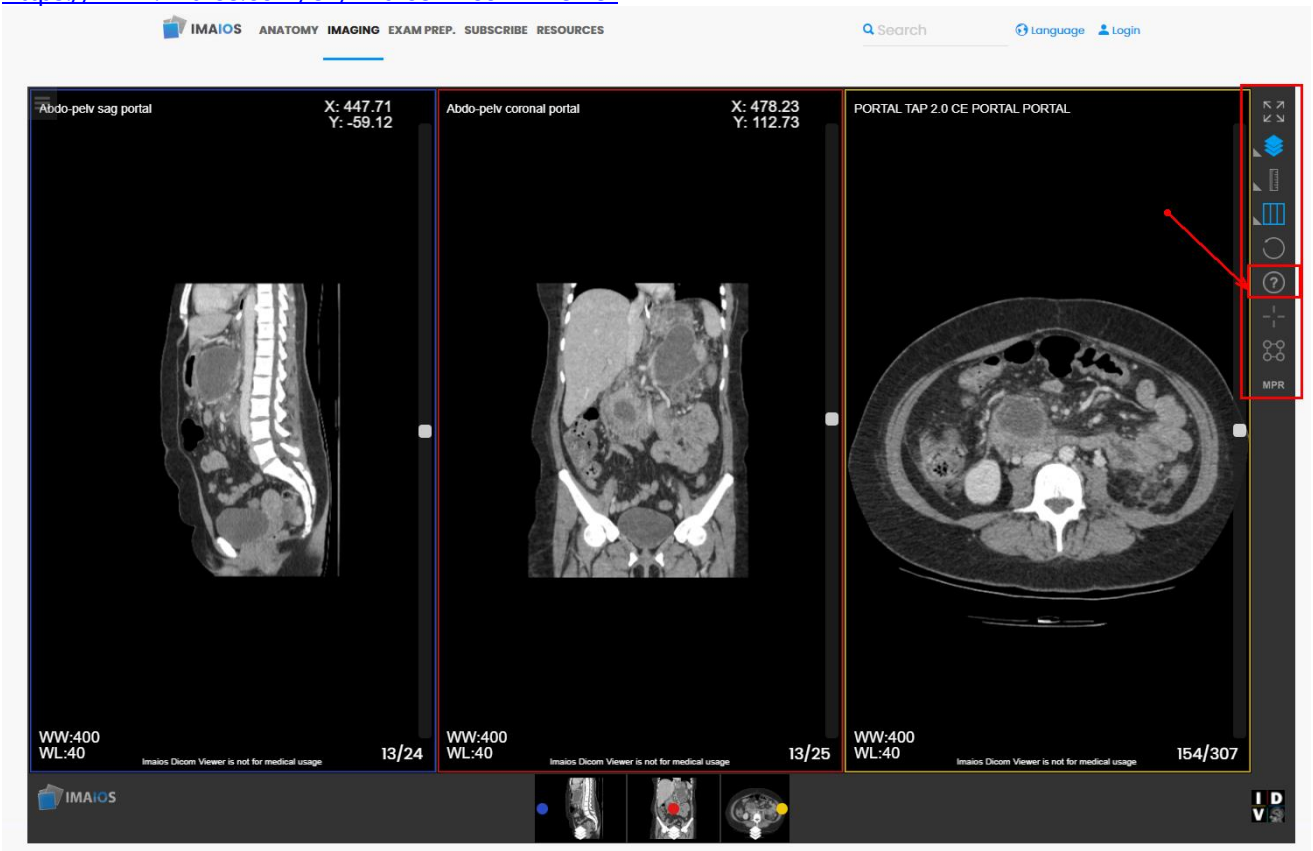


7. You can go to the case library and try other cases and exercises.

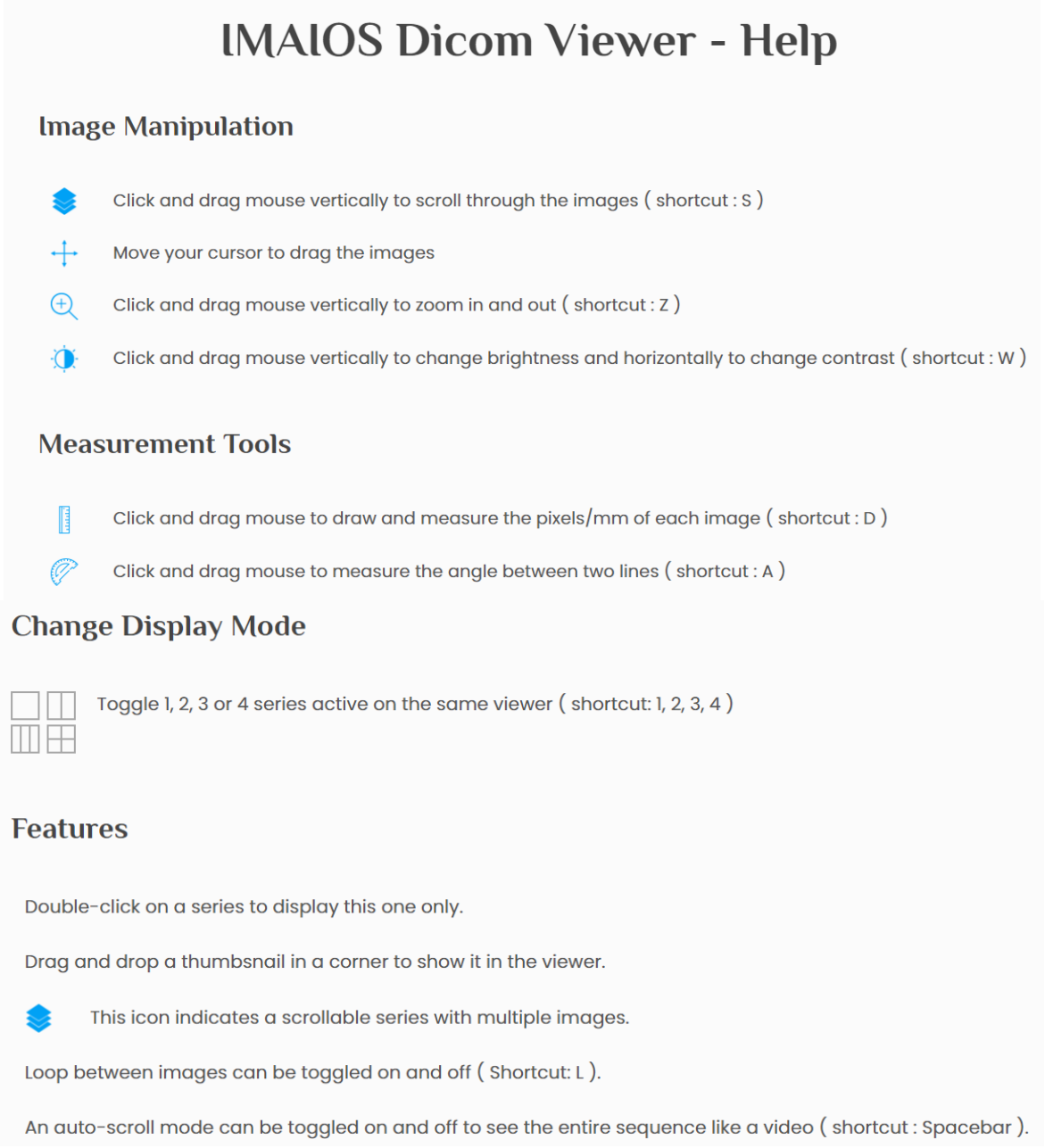




Task №3. *Using the* **IMAIOS Dicom Viewer** *overview the demonstration case* https://www.imaios.com/en/Imaios-Dicom-Viewer



- *Read information in* ***Help***  *menu;*

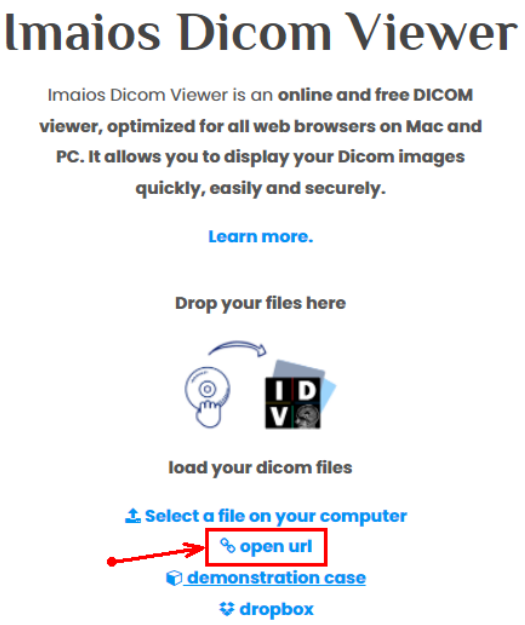


Task №4. *Using the* **IMAIOS Dicom Viewer (**https://www.imaios.com/en/Imaios-Dicom-Viewer**)** *perform the following tasks*

- *Upload* ***case4*** *using link https://www.dropbox.com/s/ltbuo0j3n22lq66/case4.zip?dl=0*

If the link is not opening, download the .zip archive on your computer and load the case using the ***Select file on your computer*** *option. You have to select the .zip file,* ***don't*** *unzip it.*

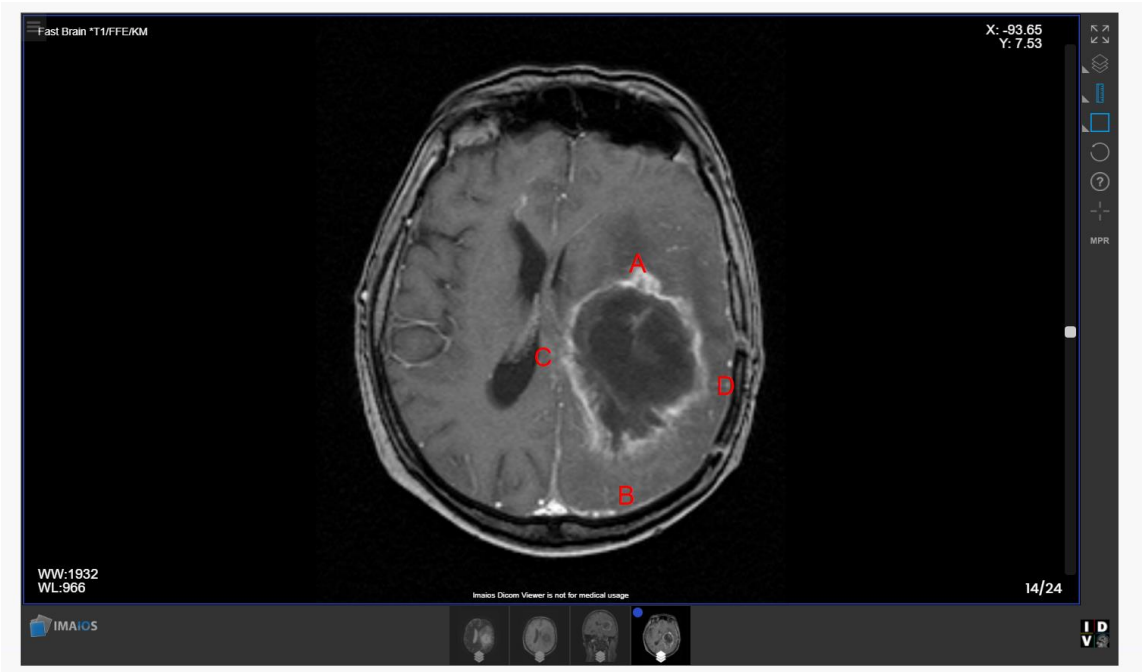
(*)additional link
https://drive.google.com/drive/folders/1KXyGpbjfLU2EXuLak9X-88v9WCVQEZJV?usp=sharing



● Change **Display Mode** to 1 series active 

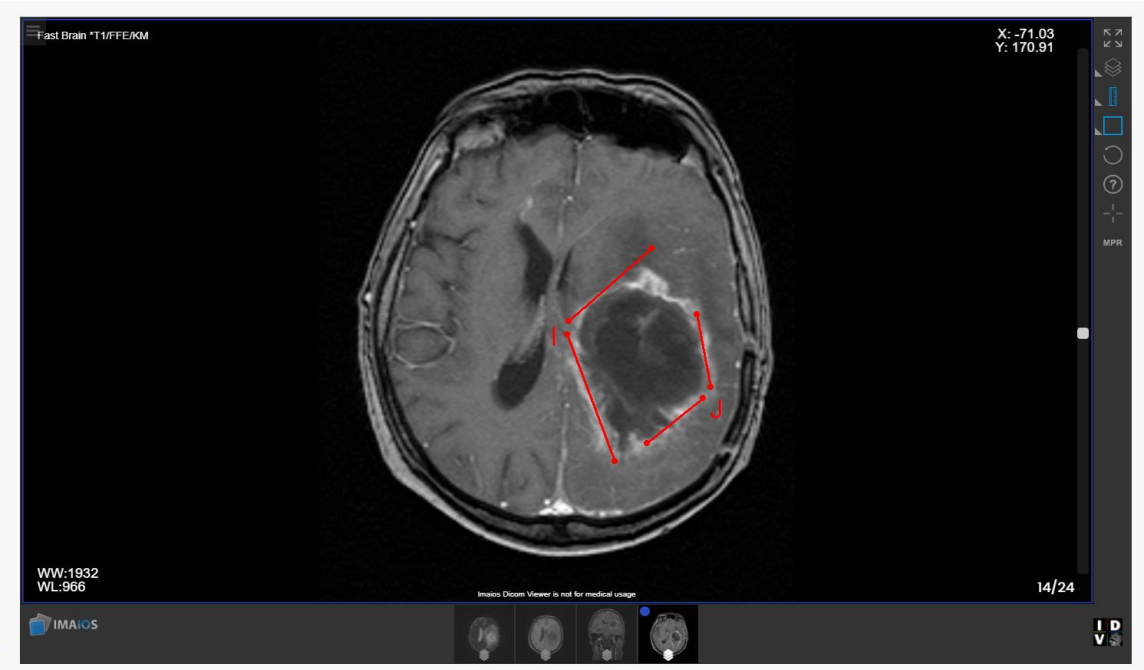
● Using **keyboard** directions buttons (**arrows**) **Left** and **Right** switch to image **Fast Brain *T1/FFE/KM**

● Using **keyboard** directions buttons (**arrows**) **Up** and **Down to** find scan **14/24**



● Using **Measure measurement tool**  determine distance **A-B** and **C-D** according to the figure and fill in the table;

● When the task is done, take a screenshot of the **IMAIOS Dicom Viewer** window, and insert the screenshot in the new slide of the **MS PowerPoint** document.

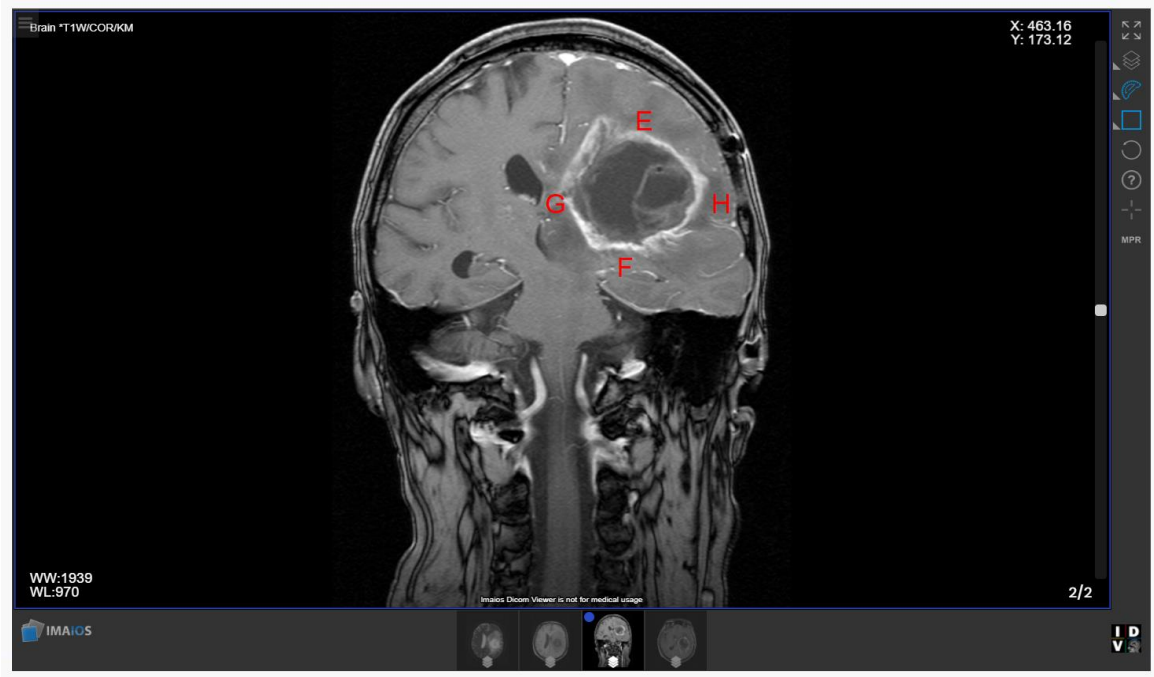


● Using **Measure Angle measurement tool**  determine angles **I** and **J** according to the figure and fill in the table;

● When the task is done, take a screenshot of **IMAIOS Dicom Viewer** window, insert the screenshot in the new slide of **MS PowerPoint** document.

● Using **keyboard** directions buttons (**arrows**) **Left** and **Right** switch to image **Brain *T1W/COR/KM**

● Using **keyboard** directions buttons (**arrows**) **Up** and **Down** find scan **2/2**



● Using **Measure measurement tool**  determine distance **E-F** and **G-H** according to the figure and fill in the table;

● When the task is done, take a screenshot of the **IMAIOS Dicom Viewer** window, and insert the

screenshot in the new slide of the **MS PowerPoint** document.

● *Create the following table in the next slide of the* **MS PowerPoint** document**. Fill it in with your results.**

No	Task	Results of measurements
1	Distance from point A to B (mm)	
2	Distance from point C to point D (mm)	
3	Distance from point E to F (mm)	
4	Distance from point G to point H (mm)	
5	Angle I	
6	Angle J	

Literature:

Main:

Excel help & learning. Microsoft.com. from https://support.microsoft.com/en-us/excel

1. Asadpour Vahid, Karakuş Selcan, Koprowski Robert (eds.) Biosignal Processing. ITexLi, 2022. — 278 p. — ISBN 1803555629.

2. Rangayyan R.M. Biomedical Signal Analysis: A Case-Study Approach. N.-Y.: Wiley-IEEE Press, 2001. — 555p.

Additional:

1. Analyze biomedical signals with signal processing techniques https://www.mathworks.com/discovery/biomedical-signal-processing.html

2. Healthcare Data Visualization: Examples, Benefits & Challenges https://tateeda.com/blog/healthcare-data-visualization-examples-benefits-challenges

3. Analyze and visualize medical images using computational methods https://www.mathworks.com/discovery/medical-image-analysis.html

Topic 10: FORMALIZATION AND ALGORITHM DEVELOPMENT FOR MEDICAL TASKS.

Actuality: The formalization and algorithm development for medical tasks is vital in modern healthcare, where precision and standardization are critical. Tools like Mathcad support this process by enabling accurate calculations, data analysis, and the creation of reproducible solutions. Its ability to combine mathematical notation, graphs, and text in a single document is especially valuable for managing medical data, modeling physiological processes, and optimizing treatment strategies. Mathcad ensures consistency and compliance, making it an essential tool for addressing complex medical challenges.

Educational aims of the lesson:

To know: capabilities of Mathcad; Mathcad toolbars.

To be able to: create, edit and save Mathcad files; insert text; build and edit expressions; define and evaluate variables and functions; write an equation; plot the graph; perform summations, products, derivatives, integrals, and Boolean operations.

The list of questions for the survey:

1. The Mathcad Workspace
2. Inserting Math.
3. Building and editing Expressions in Mathcad.
4. Math Styles.
5. Working with Arrays in Mathcad.
6. Text and Paragraph Properties.
7. Text Styles.
8. Equations in Text.
9. Text Tools.
10. Defining and Evaluating Variables.
11. Defining and Evaluating Functions.
12. Units and Dimensions.
13. Solving and Optimization Functions.
14. 2D and 3D Plots.
15. Symbolic Calculation.

The list of required practical skills:

1. Creating, editing, and saving Mathcad files.
2. Inserting text.
3. Building and editing expressions.
4. Defining and evaluating variables and functions.
5. Writing equations.
6. Plotting graphs.
7. Performing summations, products, derivatives, integrals, and Boolean operations.

Brief theoretical information

Bases of algorithm development of medical tasks

An algorithm is a step-by-step method for solving a problem or doing a task. An algorithm is a sequence of unambiguous instructions for solving a problem. The number of steps of an algorithm will be countable and finite. It is a sequence of instructions (or set of instructions) to make a program more readable, a process used to answer a question.

Brief Definition:

An Algorithm is a detailed sequence of simple steps needed to solve a problem.

Properties of Algorithm

Finiteness - there is an exact number of steps to be taken, and an algorithm has an end.

Absence of Ambiguity - means that every instruction is precisely described and specified.

A sequence of Execution - instructions are performed from top to bottom.

Input and Output - the unknowns of the problem and the expected outcome are defined.

Effectiveness - the solution prescribed is guaranteed to give a correct answer and that the specified process is faithfully carried out.

Scope Definition - applies to a specific problem or class of problems.

There are several ways of presenting algorithms: verbal, symbolic, and graphic.

A verbal method is quite bulky and may have conflicting interpretations of the algorithm.

The symbolic method makes a recording of the algorithm very brief, but not clear.

Graphical method - represents the algorithm as a block diagram, which consists of separate blocks. This way of presenting the algorithm is the most convenient and clear.

Methods of Specifying Algorithm

There are two commonly used tools to help to document program logic (the algorithm). These are ***flow charts*** and ***Pseudocode***.

Pseudocode – specifies the steps of an algorithm using essentially natural language of superimposed control structure.

Flowchart - a traditional graphical tool with standardized symbols. Show the sequence of steps in an algorithm.

Types of algorithms

According to the sequence of actions, which are performed, the algorithms are divided on:

Linear algorithms – algorithms, in which actions are implemented sequentially in the order in which they are set.

Branched algorithms

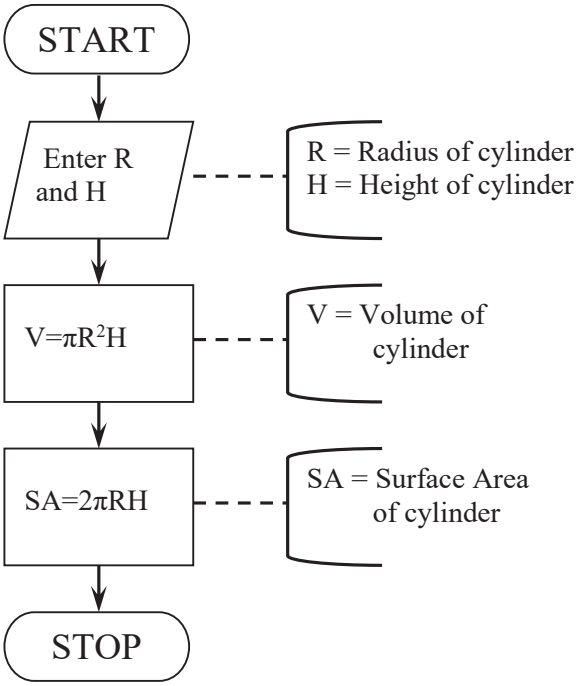
An algorithm, the implementation of which is divided into different sequences of actions depending on the truth of a given condition, is called branched.

Cyclic algorithms

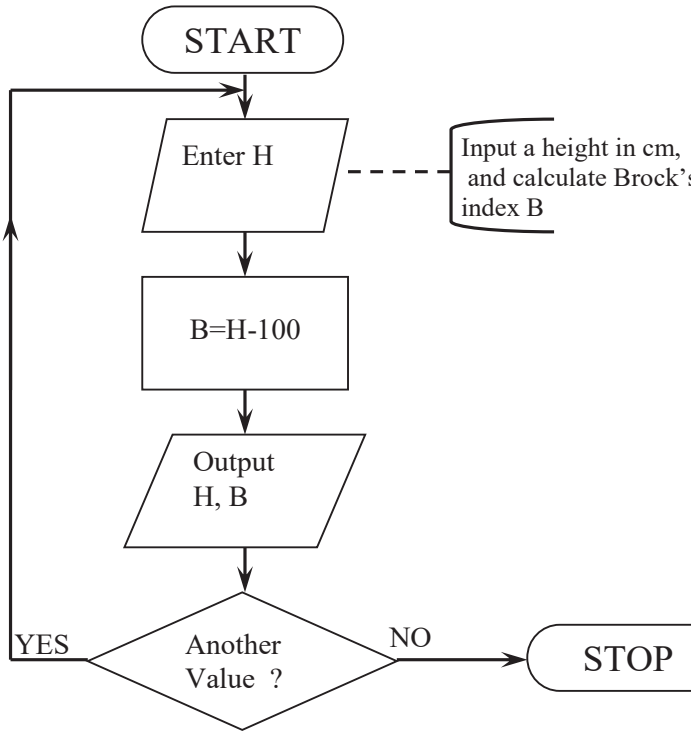
Cycle - an action, or group of actions that are repeated multiple times depending on the truth of the certain statement.

Very often some of the actions have to be executed repeatedly. Algorithms, in which a group of actions are implemented the necessary number of times, are called cyclical.

Linear algorithm



Branched cyclic algorithm



Mathcad is one of the most popular ***math software*** and ***computer algebra systems (CAS)*** in the world. Like other CASs, it has the capabilities to perform algebraic operations, calculus operations, and draw a

graph of 2 or 3 dimensions. We can use it to get numerical, symbolic, and graphic solutions to the math problem. Besides the above common capabilities, it has some features: its word processor function is better than other CAS. This feature makes it look like a scientifical word processor, and it is easy to create a worksheet.

The **Mathcad** workspace is considerably different from most "spreadsheet style" data analysis programs (like Excel). Equations, data tables, graphs, and descriptive text can all be combined in one **Mathcad** document, making this software particularly handy for application development.

Mathcad Tollbars

Click **View** → **Toolbars** to see the list of **Mathcad Toolbars (Fig. 1)**. **Math Toolbar** contains all the subs toolbars such as **Calculator** or **Arithmetic**, **Graph**, **Matrix**, **Evaluation**, **Calculus**, **Boolean**, **Programming**, **Greek,** and **Symbolic**.

If you don't see some of them in the **Mathcad** window, click **View** → **Toolbars** and click on the needed one.

Types Of the Equal Signs

Mathcad uses four different **equal signs:**

The **Assignment Equals Sign** :=. It is used to define variables or functions and is typed in by clicking the icon in **Evaluation Toolbar** or pressing the ***colon*** (**:**) key.

The **Evaluation Equals Sign** =. It is used to display the value of a variable. **Mathcad** returns the underlined result after the = has been typed. It is typed in by clicking the icon in **Evaluation Toolbar** or pressing the ***equals*** (**=**) key on the keyboard.

The **Priority Equals Sign** ≡. It is very similar to **Assignment Equals Sign** but additionally, the defined value of the variable is now true anywhere on the worksheet. **Mathcad** finds these equations and evaluates them before proceeding with all other calculations. It is typed in by clicking the icon in **Evaluation Toolbar** or pressing the ***tilde*** (~) key on the keyboard.

The Boolean Equals Sign (logical) **=**. It symbolizes a relationship between variables. It is typed in by clicking the icon in the **Boolen Toolbar** or pressing simultaneously the ***Ctrl*** and ***equals*** (**=**) keys on the keyboard.

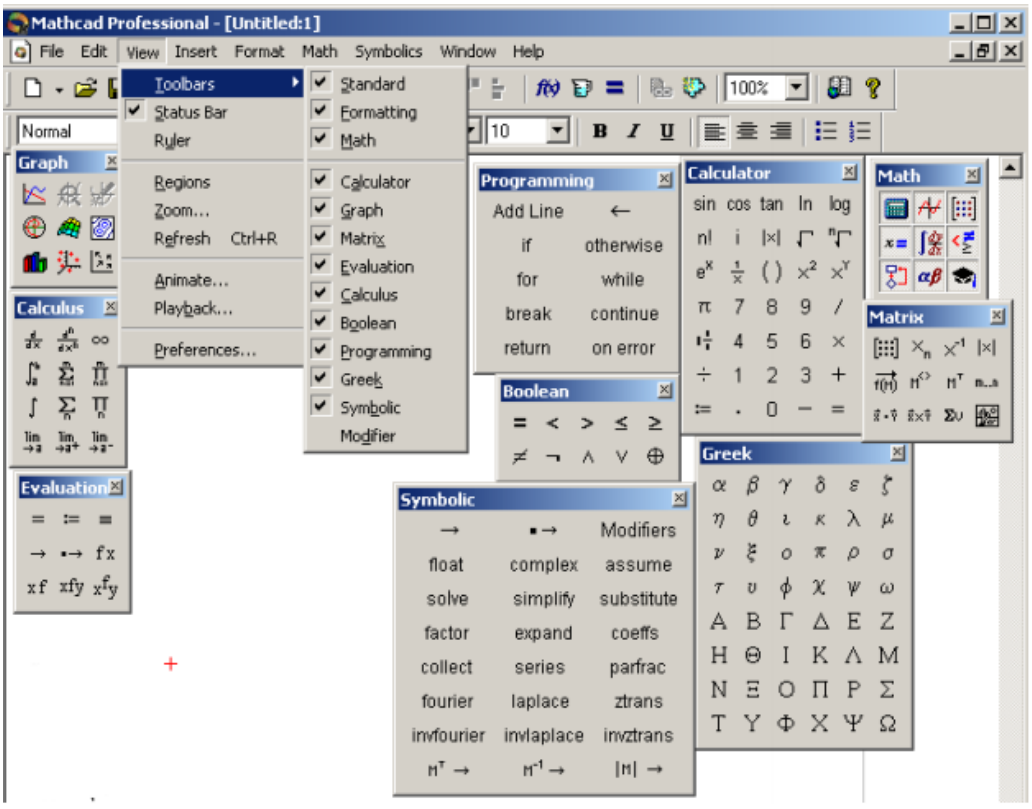


Fig. 1

Defining Variables in Mathcad

To define a variable in Mathcad:

Type the variable name (e.g., x).

Enter a **colon** (**:**) or use the **Calculator Toolbar** to insert the definition symbol ≔.

Assign a value to the variable. The value can be a single number or a formula that uses previously defined variables.

Creating a Graph

Mathcad lets you create various graphs, including **2D X-Y** and **polar plots**, as well as **3D scatter**, **contour**, and **surface plots**.

To create an X-Y plot for a function d(t):

Define the function by typing **d(t):=** followed by its formula.

Click on a blank area of your worksheet.

Go to the **Insert** menu, select **Graph**, and choose **X-Y Plot**, or use  on the **Graph Toolbar**.

Fill in the placeholders:

Enter **t** for the x-axis (bottom placeholder).

Enter **d(t)** for the **y-axis** (left placeholder).

These placeholders can also contain other expressions or variables.

Click outside the graph or press **Enter**.

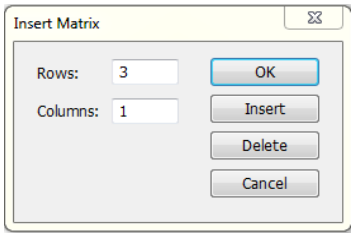
Mathcad will automatically assign axis limits, but you can customize them by clicking on the graph and editing the numbers at the ends of the axes.

Working with Vectors and Matrices

To insert a vector or matrix:

Click in a blank area or math placeholder.

Go to the **Insert** menu and select **Matrix** or use the **Matrix Toolbar** to open the **Insert Matrix**  dialog box.



Specify the number of **rows** and **columns** (e.g., 3 rows and 1 column for a 3-element vector). Click **OK**.

An **array** with empty placeholders will appear.

Fill in the placeholders with numbers or math expressions. Use the **Tab** key to move between placeholders.

Creating a Range of Values

To calculate equations over a range of values:

Define the starting value of the range by typing **t:=10**.

Enter the next value by typing ,**11**. The difference between values determines the **step size** (**e.g., 1**).

Use the range operator  (two dots **..**) to set the ending value. For example, type **..20** to end the range at 20.

The range will look like this: **t:=10,11..20**.

Mathcad will compute the equations for all values within this range.

Practical tasks for students.

Instructions for execution of practical work

Start the PC and load **OS Windows**.

Start the program **Mathcad**.

After starting **Mathcad** to perform such tasks:

****

Task №1. *Overview of the **Mathcad 15**window*:

in **Mathcad 15- [math_ 1]** overview the main menu.

in **Mathcad 15- [math_1]** overview the **Standard Toolbar**

and the **Formatting Toolbar**

Choose **Toolbars ® Math** from the **View** menu to see the **Math** toolbar, whose buttons bring up toolbars of math operators**.**

Calculator toolbar
Evaluation toolbar
Programming toolbar
Graph toolbar
Calculus toolbar
Greek Symbol toolbar
Vector and Matrix toolbar
Boolean toolbar
Symbolic Keyword toolbar

****

Task №2. *Using* ***Boolean, Calculus, Calculator, Graph, Evaluation, Matrix, and Greek*** *to compute the next mathematical expressions, draw the graph* **(Fig. 2)** *and save them as* **Calculations.**

in **Mathcad 15 - Calculations,** click LBM anywhere on the white worksheet **® Insert ® Text Region ®** activate **Font ® Arial Cyr** on the **Formatting** toolbar **®** type the text according to **Fig. 2 ® Enter;**
click LBM anywhere on the white worksheet of **Mathcad 15 - [Calculations] ®** type the first mathematical expression **(Fig. 2**), using the corresponding buttons of palettes and keyboard **®** click LBM on another blank part of the worksheet;
type all text and all mathematical expressions according to **Fig. 2;**
File ® Save;
Shut down **Mathcad 15 - [Calculations]** document.

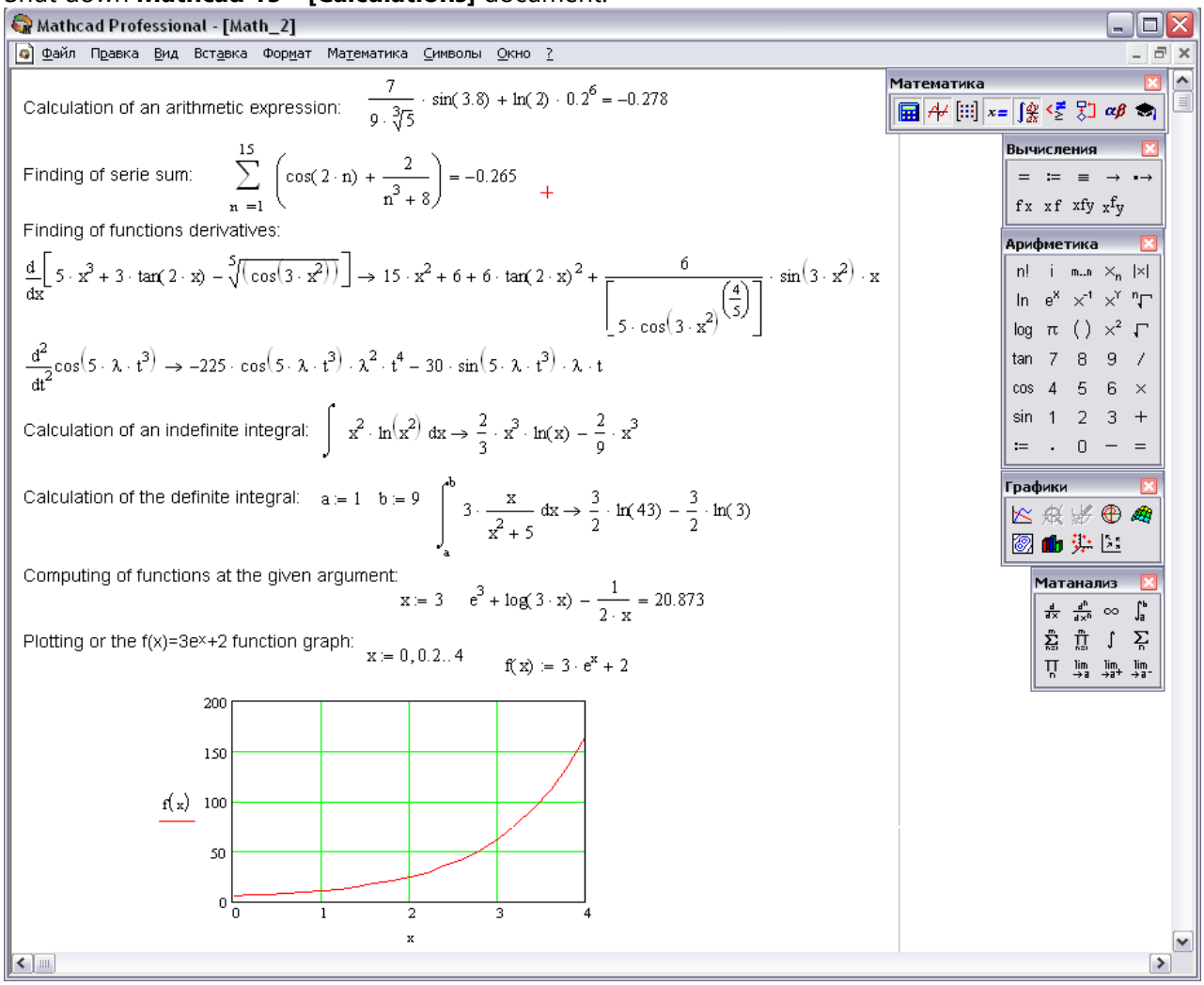


Fig. 2

****

Task N°3. *Using the palettes of* ***Mathcad 15,*** *solve the following problem:*
It is necessary to make a blend containing chemical substances A, B, and D, which are contained in raw materials of three types in concentrations given in the table:

Raw materials	The concentration of chemical substances			Cost of raw materials unit
	A	B	D	
1	3	2	4	4
2	4	4	3	5
3	5	2	4	6

The content of substance ***A*** *in the mixture must be not less than* ***8 units****, the content of substance* ***B*** *– not less than* ***10 units****, and substance* ***D*** *– not less than* ***12 units****. The cost of the mixture must be minimal.*
Save this document as a **Problem.**
type text and mathematical expressions according to **Fig. 3;**

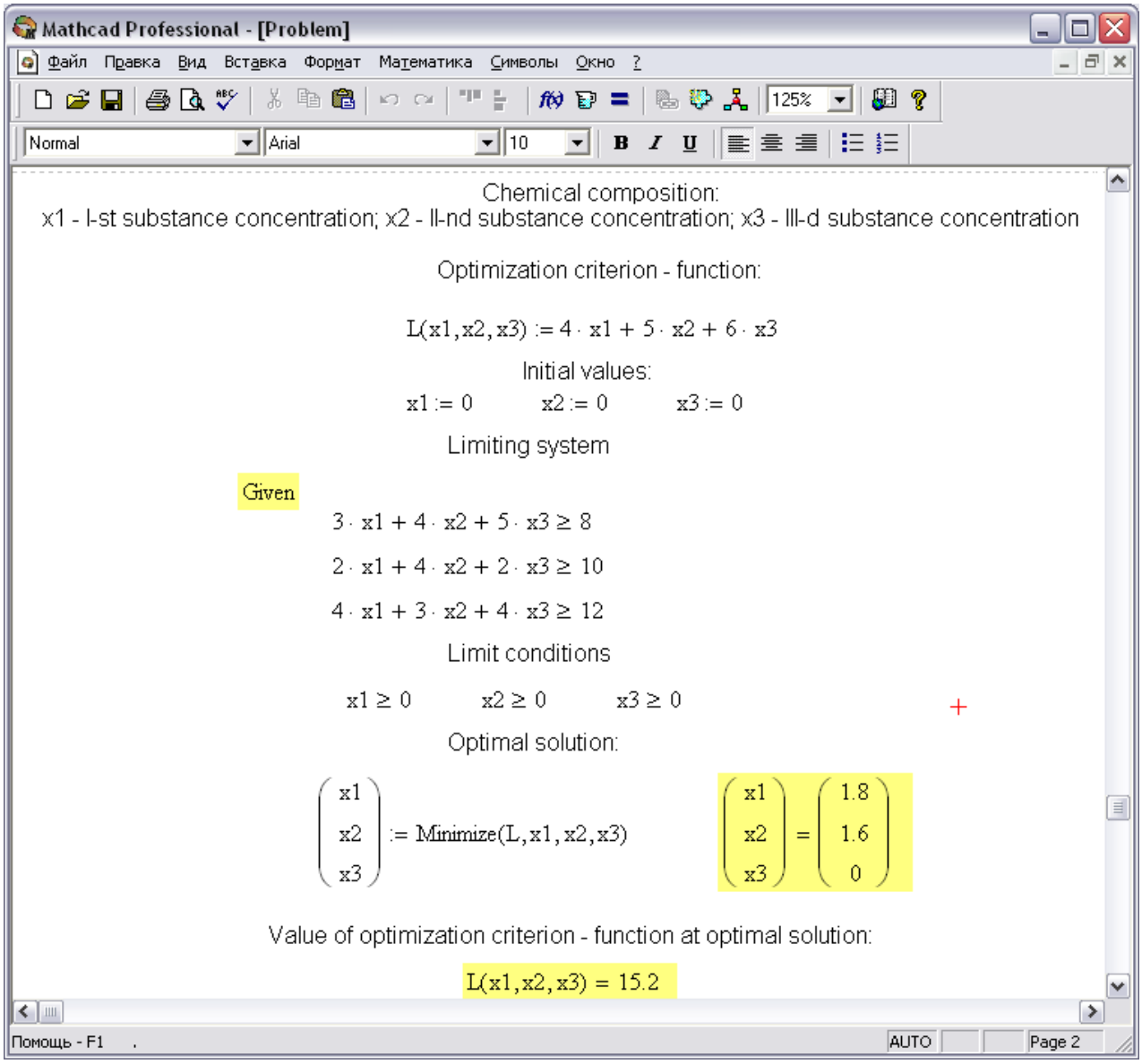


Fig. 3

4. Click LBM **File** → **Save.**
5. Show the teacher the results of your work.
6. Close the **Mathcad 15** document.

***Attention**: After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:

1) https://www.mathcad.com/en/blogs/complete-beginners-guide-ptc-mathcad

2) Benker Hans. Practical Use of Mathcad: solving mathematical problems with a computer algebra system. Translated by Anthony Rudd. — Springer, 1999. — 505 p. — ISBN: 978-1-85233-166-5

Additional

1) Maxfield B. Engineering with Mathcad: Use Mathcad to create and organize your engineering calculations. Butterworth-Heinemann, 2006. — 512 p.

2) Medical Informatics: Practical Guide for the Healthcare Professional 2007. Robert Hoyt, Melanie Sutton, Ann Yoshihashi. Lulu.com, - 2007. - 250p., (https://books.google.com.ua/)

Topic 11: COMPUTER MODELING AND SOLVING OF PHYSICO-CHEMICAL PROBLEMS.

Actuality: In clinical practice and advanced medical studies, the need frequently arises to address physicochemical problems using computers. Consequently, students in medical fields must understand the basics of structuring medical tasks into algorithms. They should be capable of translating these problems into formats that a computer can process and utilize software tools to solve equations and their systems.

Educational aims of the lesson:

To know:

1. basis of algorithm development of medical tasks;
2. syntax of MathCad solve blocks;
3. syntax of MathCad functions that are used for solving differential equations and their systems.

To be able to:

1. solve physical-chemical problems;
2. solve differential equations and their systems using the MathCad application.

The list of questions for the survey:

1. Models. Types of models that are used in medicine and biology.
2. Bases of algorithmization of medical tasks.
3. Types of algorithms.
4. Using MathCad application for physical-chemical problems solving:

4.1. solving nonlinear equations;

4.2. solving differential equations and their systems.

The list of required practical skills:

1. solving physical-chemical problems;
2. solving differential equations and their systems using the MathCad application.

Brief theoretical information

Models. Types of models that are used in medicine and biology

A model is a simplified version of something that exists in real life. The purpose of a model is to represent the object, system, or idea so we can study and understand it better without directly working with the original, especially if the original is too complex, expensive, or impossible to observe directly. The main purpose of making models is to help create better and more accurate explanations of how things work. However, models and theories are different. A theory explains why something happens, while a model is just a tool that shows or represents it in a simple way.

In medicine and biology, there are four main types of models:

1. **Biological Models:** These are used to study general biological processes, the effects of treatments, and different therapies. Examples include laboratory animals, isolated organs, and experiments in test tubes.

2. **Physical Models:** These are physical systems or devices designed to act like the objects they represent. For instance, the flow of blood in large vessels can be mimicked using electrical circuits with capacitors and resistors. Devices that replace or mimic organs, like ventilators or artificial hearts, are also physical models. These models are widely used in medical research and practice.

3. **Cybernetic Models:** These are mostly electrical devices used to replicate processes in living organisms, such as how the body controls movements or adjusts the size of the pupil. They simulate information and control systems within the body.

4. **Mathematical Models:** These use formulas, functions, and equations to describe how certain phenomena or processes work. For example, Poiseuille's Law describes blood flow in vessels, and dynamic changes over time are often represented using differential equations. The use of computers has greatly advanced mathematical modeling, allowing researchers to study complex systems and improve medical research and applications.

Using MathCad application for physical-chemical problems solving

Solving nonlinear equations

Many equations and systems do not have analytical solutions. But they can be solved by numerical methods with a given error.

For the simplest equations of form **f(x) = 0** solutions are found using the function **root(f(x), x)**, which returns the value of **x** at which the function **f(x)** is equal to zero. Before using this function it is necessary to set the initial value (guess value) of the variable. If the function root is written in a form **root(f(x), x, [a, b])** it is no need to set the guess value of x, **root** finds **x** on the interval **[a,b]**.

The **root** function can only solve one equation in one unknown. To solve several equations simultaneously **Find** or **Minerr** functions can be used [1].

In solving systems of nonlinear equations a special *solve block* with the keyword **Given** is used [2]:

Initial conditions
Given
Equation
Restrictive conditions
Expressions with functions **Find**, **Minerr**, **Maximize** and **Minimize**

The initial conditions set the initial values of variables. The keyword **Given** always opens *solve block*.

The equation is specified in the form **expr_left = expr_right** with the use of a **Boolean Equal sign**. In the *solve block* one of the functions **Find(var1, var2, ..., varn)** or **Minerr(var1, var2, ..., varn)** is used. If you use the function **Find(var1, var2, ..., varn)** values of **var1, var2, ..., varn** will give exact solutions of equations or systems of equations.

If you use the function **Minerr(var1, var2, ..., varn)** values of **var1, var2, ..., varn** will give approximate solutions of equations or systems of equations.

The fundamental difference between these functions is that the first function is used when a solution exists, although it is not analytical, and the second function tries to find the maximum approximation even to the non-existent solution.

For finding the values of **var1, var2, ..., varn** that make the function **f(var1, var2, ..., varn)** take on its smallest or largest value functions **Minimize(f, var1, var2, ..., varn) and Maximize(f, var1, var2, ..., varn)** are used.

Solving differential equations and their systems

Solving many physical and chemical problems is based on solving differential equations and their systems.

Systems of differential equations in MathCad should be presented in the form:

$$\begin{cases} y_1(x_0) = y_{0,1} \\ y_2(x_0) = y_{0,2} \\ \quad \cdots \\ y_n(x_0) = y_{0,n} \end{cases},$$

$$\begin{cases} y_1 = f_1(x, y_1, y_2, \ldots, y_n) \\ y_2 = f_2(x, y_1, y_2, \ldots, y_n) \\ \quad \cdots \\ y_n = f_n(x, y_1, y_2, \ldots, y_n) \end{cases},$$

The first system sets the initial conditions and the second one is a system of ordinary differential equations.

These systems can be represented in vector form:

$$Y(x_0) = Y_0,$$
$$Y' = F(x, Y).$$

For the solving systems of such class, **MathCad** has several functions [2]:

rkadapt(y, x1, x2, acc, n, F, k, s) – returns a matrix of solutions within the interval from **x1** to **x2** for a system of ordinary differential equations calculated by the Runge-Kutta method with adaptive step size and initial conditions in the vector **y** (right sides of equations are written in the vector **F**, **n** is number of steps, **k** is a maximum number of intermediate steps of solving, **s** is a minimum interval between steps);
Rkadapt(y, x1, x2, n, F) – returns a matrix of solutions within the interval from **x1** to **x2** for a system of ordinary differential equations calculated by the Runge-Kutta method with adaptive step size and initial conditions in the vector **y** (right sides of equations are written in the vector **F**, **n** is number of steps);
rkfixed(y, x1, x2, n, F) – returns a matrix of solutions within the interval from **x1** to **x2** for a system of ordinary differential equations calculated by the Runge-Kutta method with initial conditions in the vector **y** (right sides of equations are written in the vector **F**) at *fixed* number of steps **n**;
Function **Rkadapt** due to automatic change of step gives a more accurate result, then **rkfixed** function, but it loses in speed of calculations.
For solving differential equations also **odesolve(x, b, [steps])** function is used, which returns solutions of differential equations, that are described in **Given** solve block at given initial conditions and an end of integration interval **b**.

Practical tasks for students.
Instructions for execution of practical work

Start the PC and load **OS Windows**.
Start the program **Mathcad**.
After starting **Mathcad** to perform such tasks:

****

Task №1. *Using **MathCad** application calculate the acidity of the solution if it is represented by a model in the form of the following equation:*

$$\frac{\left(e^{-pH\cdot 2,3}\right)^2 - K_w}{K_a} + e^{-pH\cdot 2,3} - \frac{K_w}{e^{-pH\cdot 2,3}} - C = 0,$$

*if concentaration **C=0,1 mol/l**, ionization constant **K_a = 1,86·10^{-5}**, ionic product for water **K_w = 10^{-14}**.*

Start the **MathCad** application: **Start→Programs/All Programs→MathSoft Apps → MathCad**.
Save your file on the Desktop: **File → Save → Desktop**, type the title of the file: **Task 1**.

> ***Attention***: *Don't forget to click the icon **Save** on the **Quick Access toolbar** every few minutes during the lesson to avoid losing your work.*

Type text and mathematical expressions according to **Fig. 1**.

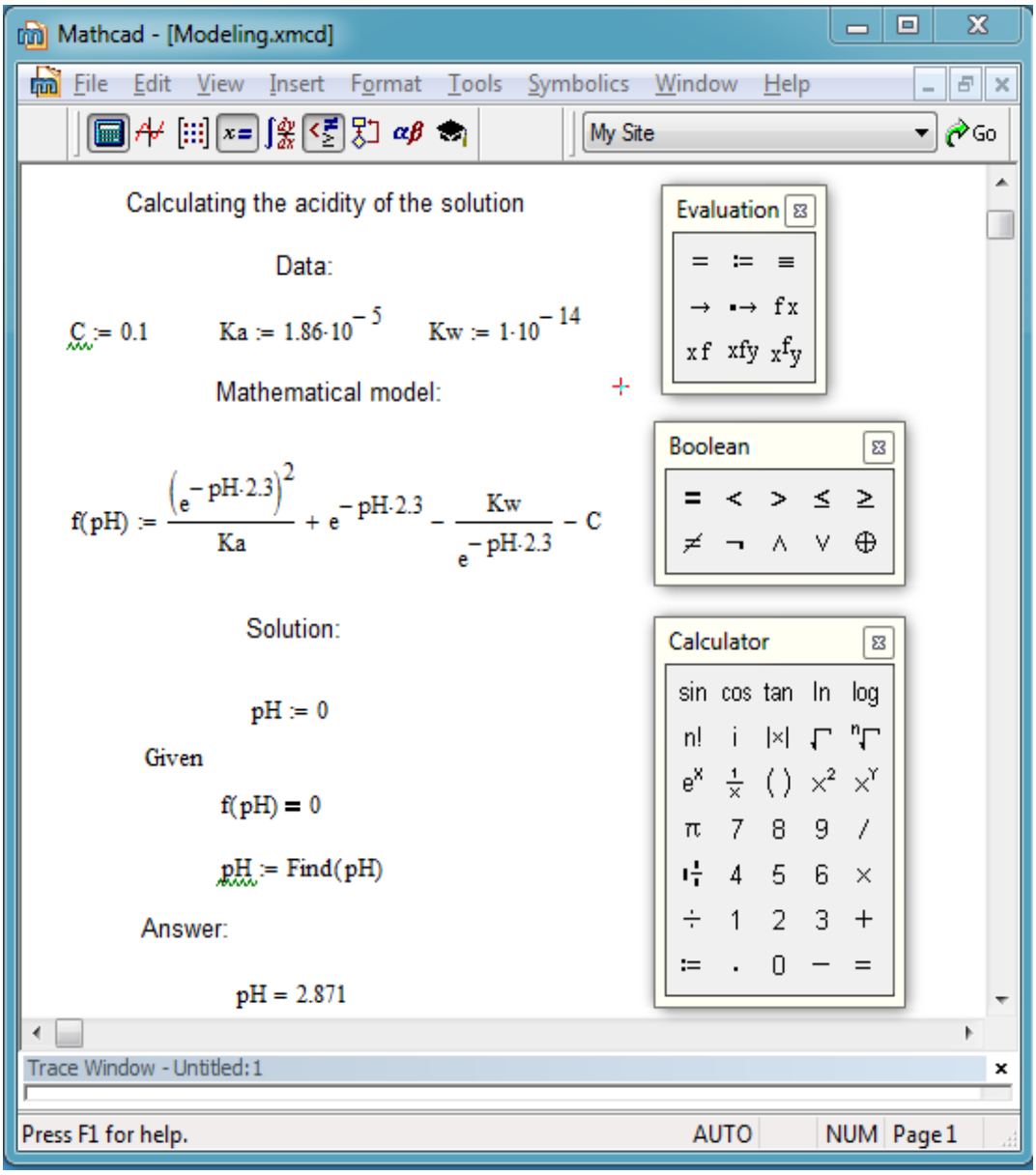


Fig. 1

****

Task №2. *Using **MathCad** application calculate the acidity of the solution if it is represented by a model in the form of the following equations:*

$$\frac{\left(e^{-pOH\cdot 2,3}\right)^2 - K_w}{K_a} + e^{-pOH\cdot 2,3} - \frac{K_w}{e^{-pOH\cdot 2,3}} - C = 0,$$

$$pH = 14 - pOH,$$

*if concentaration **C=0,1 mol/l**, ionization constant **K_a = 1,79·10^{-5}**, ionic product for water **K_w = 10^{-14}**.*

Start the **MathCad** application: **Start→Programs/All Programs→MathSoft Apps → MathCad**.
Save your file on the Desktop: **File → Save → Desktop**, type the title of the file: **Task 2**.

Attention: *Don't forget to click the icon **Save** on the **Quick Access toolbar** every few minutes during the lesson to avoid losing your work.*

Type text and mathematical expressions according to **Fig. 2**.

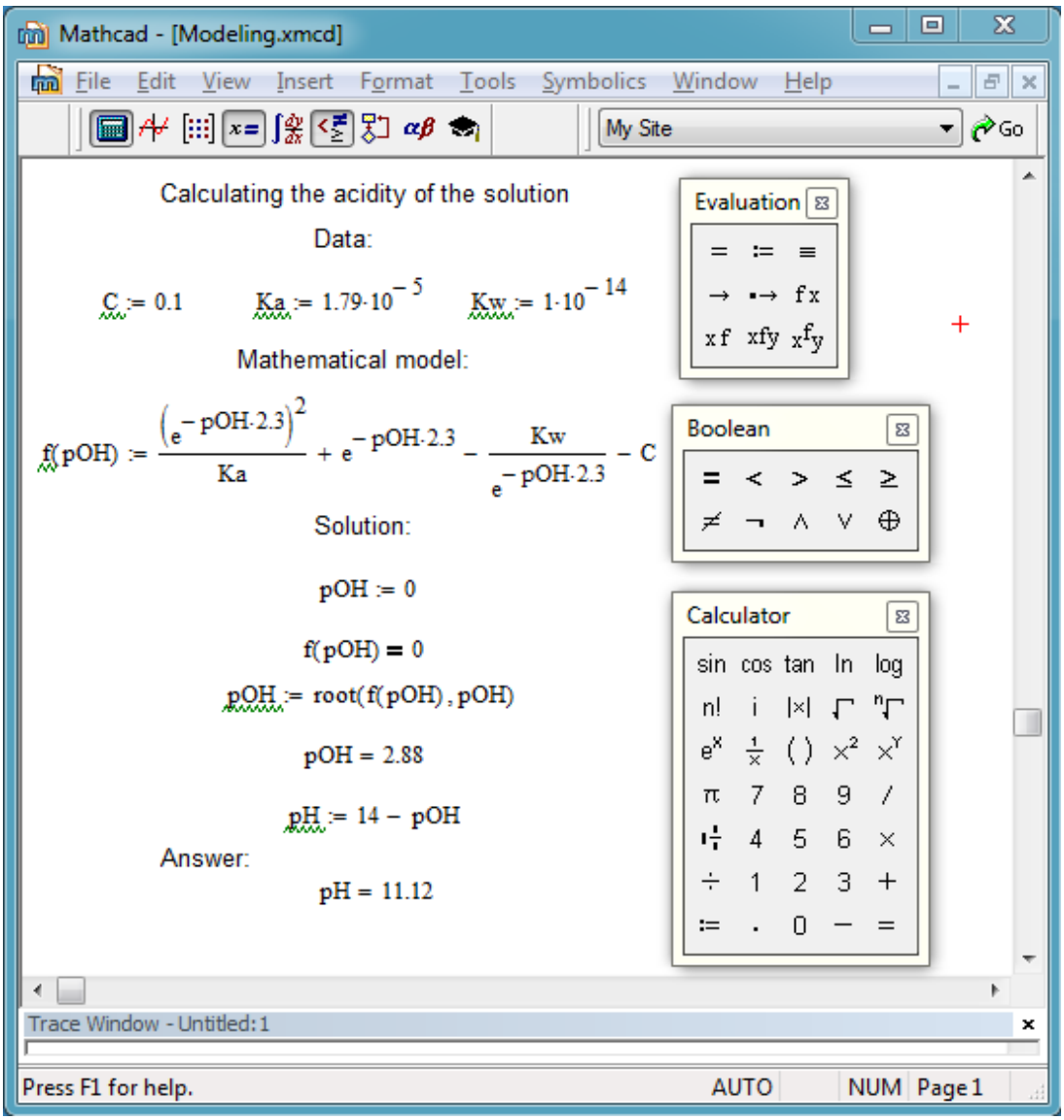


Fig. 2

****

Task №3. *Using **MathCad** application:*
*- plot the graph of concentration **C** of medication "Glukopirin for injections 1,0%" versus time;*
*- determine the time that will pass after the beginning of medication "Glukopirin for injections 1,0%" store until the final concentration of glucosamine hydrochloride in it will be equal to 90% of the initial value of concentration **C_0**;*
- determine the concentration of glucosamine hydrochloride after 90 days, half a year and 1,5 of years, if process of decay of the basic substance (glucosamine hydrochloride) is described by mathematical model in the form of the following differential equation:

$$\frac{dC}{dt} = -k \cdot C,$$

*where **C** is a concentration of glucosamine hydrochloride, **k** – reaction constant, which according to Arrhenius equation is defined by a formule $k = k_0 \cdot e^{-\frac{E}{R \cdot T}}$, if **R = 8,31 J/(mol·K)**, **k_0 = 2,189·10^{-3} day^{-1}**, **E = 2,438·10^3 J/mol**, **C_0 = 480 mg/g**.*
*Determine the storage time of medicine at the temperature **T = 263 K** (**t = -10 °C**), **T = 308 K** (**t = 35 °C**).*

Start the **MathCad** application: **Start→Programs/All Programs→MathSoft Apps → MathCad**.
Save your file on the Desktop: **File → Save → Desktop**, type the title of the file: **Task 3**.

Attention: *Don't forget to click the icon* ***Save*** *on the* ***Quick Access toolbar*** *every few minutes during the lesson to avoid losing your work.*

Type text and mathematical expressions according to **Fig. 3 – Fig. 4**.

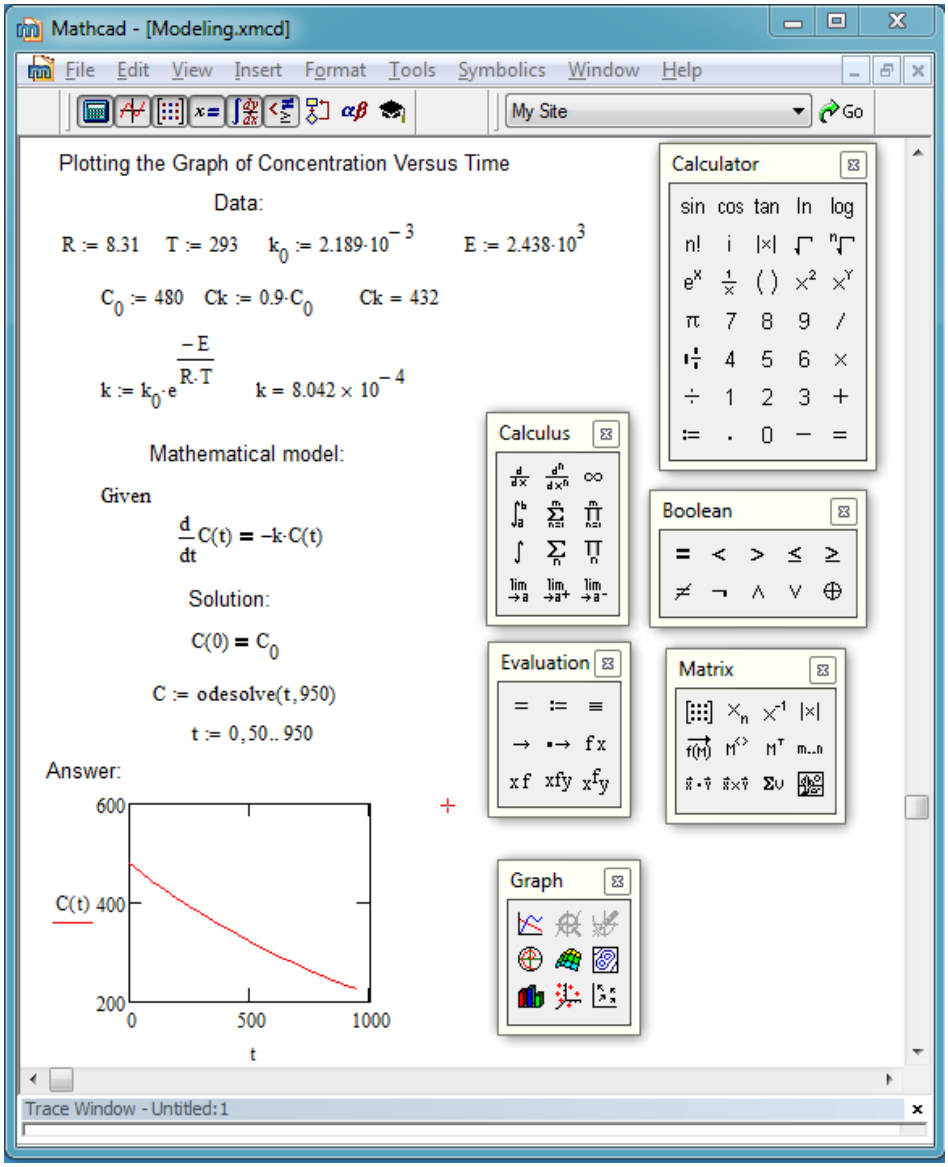


Fig. 3

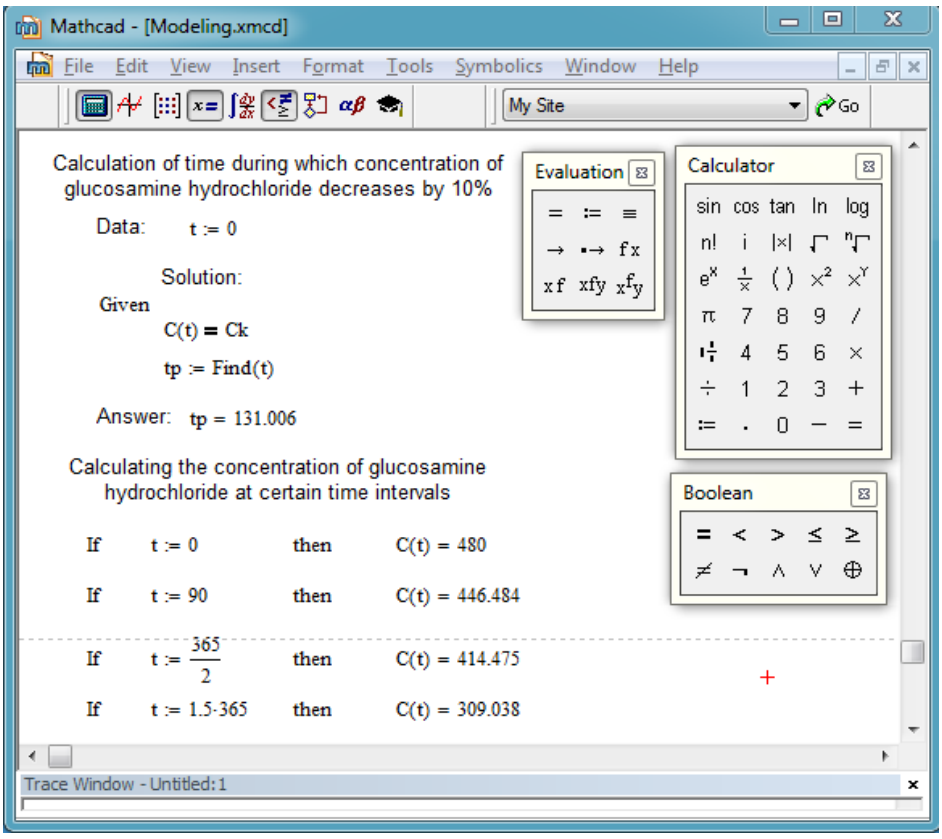


Fig. 4

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Task №4. *Using **MathCad** application:*
- plot the time dependency graphs of concentration of reagent C_A and product output C_S of reverse chemical reaction of type $A \underset{k_2}{\overset{k_1}{\rightleftarrows}} S$ *, which kinetics is described by mathematical model in the form of the following system of equations:*

$$\begin{cases} \dfrac{dC_A(t)}{dt} = -k_1 C_A(t) + k_2 C_S(t) \\ \dfrac{dC_S(t)}{dt} = k_1 C_A(t) - k_2 C_S(t) \\ k_1(T) = k_{10} \cdot e^{-\frac{E_1}{R \cdot T}} \\ k_2(T) = k_{20} \cdot e^{-\frac{E_2}{R \cdot T}} \end{cases},$$

if $C_{A0} = 5$ *mol/m*^{3}, $C_{S0} = 0$, $E_1 = 48604$ *J/mol*, $E_2 = 124024$ *J/mol*, $t = 0, \ldots, 200$ *c*, $k_{10} = 3 \cdot 10^7$ *c*$^{-1}$, $k_{20} = 2{,}668 \cdot 10^{19}$ *c*$^{-1}$, $T = 298$ *K*, $R = 8{,}31$ *J/(mol°K);*

- determine the equilibrium degree of conversion of reaction $X_p = \dfrac{K - \dfrac{C_{S0}}{C_{A0}}}{K+1}$, *where* $K = \dfrac{k_1}{k_2}$.

Start the **MathCad** application: **Start→Programs/All Programs→MathSoft Apps → MathCad**.
Save your file on the Desktop: **File → Save → Desktop**, type the title of the file: **Task 4**.

Attention: *Don't forget to click the icon **Save** on the **Quick Access toolbar** every few minutes during the lesson to avoid losing your work.*

Type text and mathematical expressions according to **Fig. 5 – Fig. 7**.

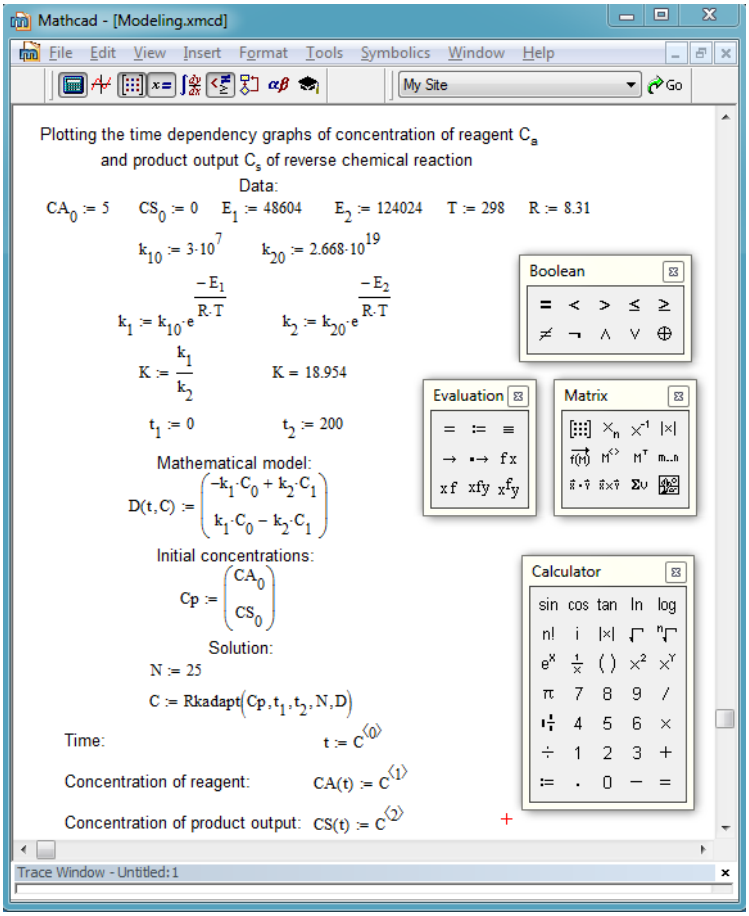
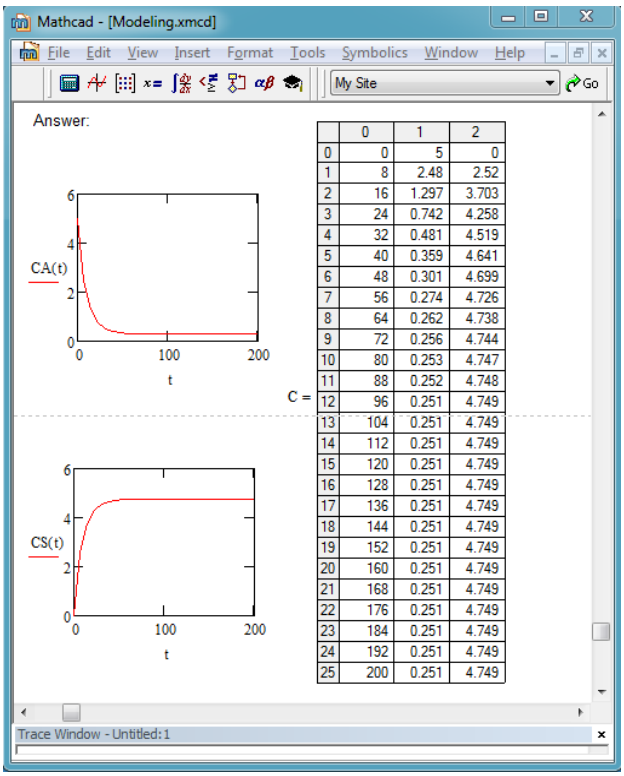


Fig. 5



	0	1	2
0	0	5	0
1	8	2.48	2.52
2	16	1.297	3.703
3	24	0.742	4.258
4	32	0.481	4.519
5	40	0.359	4.641
6	48	0.301	4.699
7	56	0.274	4.726
8	64	0.262	4.738
9	72	0.256	4.744
10	80	0.253	4.747
11	88	0.252	4.748
12	96	0.251	4.749
13	104	0.251	4.749
14	112	0.251	4.749
15	120	0.251	4.749
16	128	0.251	4.749
17	136	0.251	4.749
18	144	0.251	4.749
19	152	0.251	4.749
20	160	0.251	4.749
21	168	0.251	4.749
22	176	0.251	4.749
23	184	0.251	4.749
24	192	0.251	4.749
25	200	0.251	4.749

Fig. 6

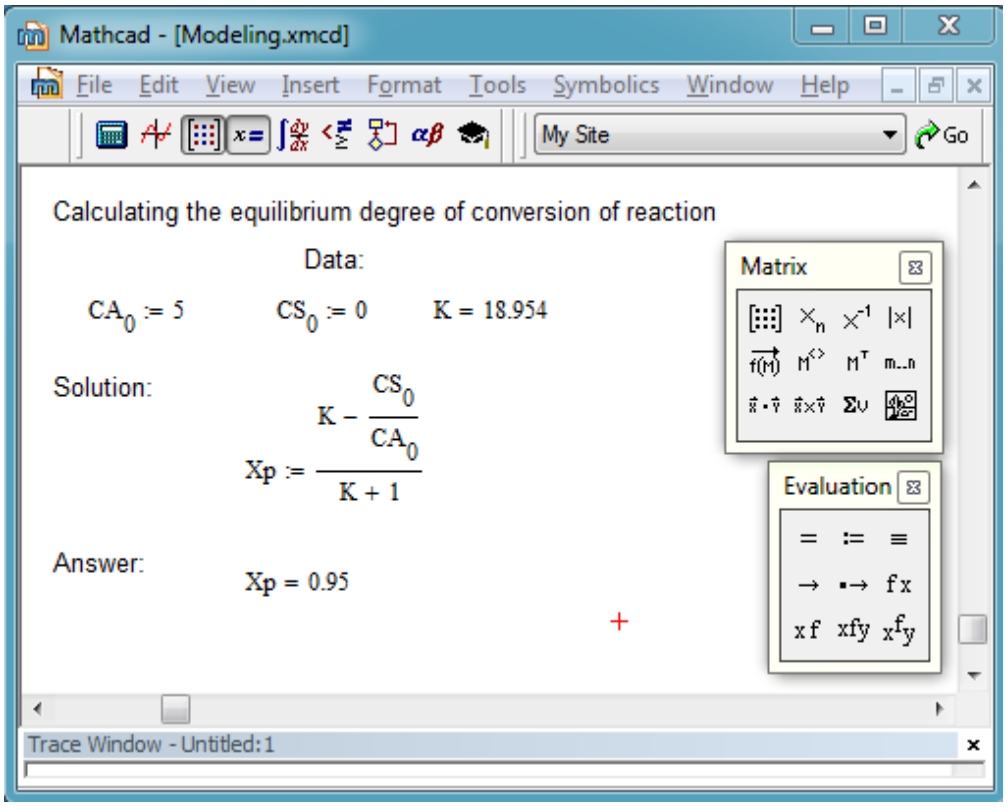


Fig. 7

3. Show the teacher the results of your work.
4. Close **MathCad** document.

Attention: *After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:

1) PTC help center. https://support.ptc.com/help/mathcad/r10.0/en/index.html#page/PTC_Mathcad_Help/example_using_minerr_for_nonlinear_least_squares_fitting.html

2) *Complete beginners guide to using PTC Mathcad.* Mathcad.com. Retrieved May 8, 2024, from https://www.mathcad.com/en/blogs/complete-beginners-guide-ptc-mathcad

3) Benker Hans. Practical Use of Mathcad: solving mathematical problems with a computer algebra system. Translated by Anthony Rudd. — Springer, 1999. — 505 p. — ISBN: 978-1-85233-166-5

Additional

1) Maxfield B. Engineering with Mathcad: Use Mathcad to create and organize your engineering calculations. Butterworth-Heinemann, 2006. — 512 p.

2) Medical Informatics: Practical Guide for the Healthcare Professional 2007. Robert Hoyt, Melanie Sutton, Ann Yoshihashi. Lulu.com, - 2007. - 250p., (https://books.google.com.ua/)

Topic 12: FORMAL LOGIC IN DIAGNOSTIC, TREATMENT, AND DISEASE PREVENTION TASKS.

Actuality: Logical thinking is a quality of intelligence and is integral to every level of medical practice. It plays a crucial role in patient interaction, diagnosis, treatment planning, and conducting laboratory studies. Diseases are characterized by specific symptom complexes, which help accurately diagnose and differentiate between various conditions. Utilizing technology can advance this process. Specifically, by using Microsoft Excel, healthcare professionals can construct logical expressions and automatically validate them, enhancing efficiency and accuracy in medical decision-making.

Educational aims of the lesson:
To know: the MS Excel logical functions and capabilities of MS Excel for database creation.
To be able: to create databases using MS Excel, find data in databases using logical operators, and use logical functions for the creation of logical expressions in solving medical-biological tasks.

The list of questions for the survey:

1. **MS Excel** logic functions.
2. Logical function **IF**.
3. Logical function **AND**.
4. Logical function **OR**.
5. Formatting of cells and cell ranges in **MS Excel**.
6. Formatting of cell borders in **MS Excel**.

The list of required practical skills:

1. Creating databases using MS Excel.
2. Finding data in databases using logical operators.
3. Using logical functions for the creation of logical expressions at medical-biological tasks solving.

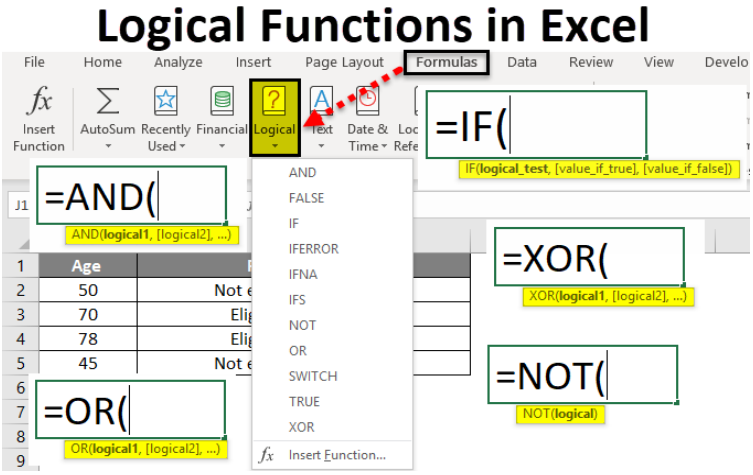
Brief theoretical information

Microsoft Excel provides four logical functions that work with the logical values [1]. The functions are **AND**, **OR**, **XOR,** and **NOT**. You use these functions when you want to carry out more than one comparison in your formula or test multiple conditions instead of just one. Excel logical functions return either **TRUE** or **FALSE** when their arguments and logical operators are evaluated.
The following table provides a short summary of what each logical function does to help you choose the right formula for a specific task [https://www.ablebits.com/office-addins-blog/excel-and-or-xor-not-functions/]:

Function	Description	Formula Example	Formula Description
AND	Returns **TRUE** if **all** of the arguments are evaluated to **TRUE**.	**=AND(A2>=10, B2<5)**	The formula returns **TRUE** if a value in cell A2 is greater than or equal to 10, and a value in B2 is less than 5, FALSE otherwise.
OR	Returns **TRUE** if **any** argument is evaluated as **TRUE**.	**=OR(A2>=10, B2<5)**	The formula returns **TRUE** if A2 is greater than or equal to 10 or B2 is less than 5, or both conditions are met. If neither of the conditions it met, the formula returns **FALSE**.
XOR	Returns a logical "Exclusive OR" of all arguments.	**=XOR(A2>=10, B2<5)**	The formula returns **TRUE** if either A2 is greater than or equal to 10 or B2 is less than 5. If neither of the conditions is met or both conditions are met, the formula returns **FALSE**.

NOT	Returns the **reversed logical value** of its argument. I.e., If the argument is **FALSE**, then **TRUE** is returned and vice versa.	**=NOT(A2>=10)**	The formula returns **FALSE** if a value in cell A1 is greater than or equal to 10; TRUE otherwise.

In addition to the four logical functions outlined above, Microsoft Excel provides 3 "**conditional**" functions - **IF**, **IFERROR,** and **IFNA** [1].



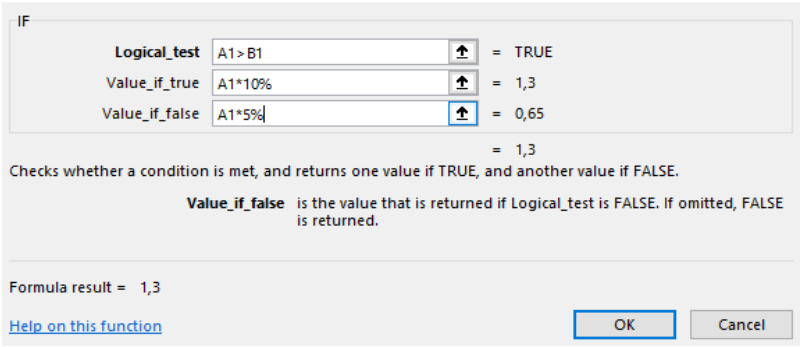
[from https://earnandexcel.com/blog/in-excel-what-do-most-formulas-begin-with/]

IF Function

The **IF** function checks whether a condition is true, and returns one value if **TRUE** and another value if **FALSE**.

IF function syntax: **=IF(logical_test; [value_if_true]; [value_if_false])**.

For example: **=IF(A1>B1;A1*10%;A1*5%).**



AND Function

The **AND** function returns **TRUE <u>if all</u>** conditions are true and returns **FALSE <u>if any</u>** of the conditions are false.

AND function syntax: **=AND(logical1; [logical2]; ...)**.

For example: **=AND(A1>A2;A1<A3)** (if A1 is greater than A2 AND less than A3, then return TRUE otherwise return FALSE).

OR Function

The **OR** function returns **TRUE <u>if any</u>** of the conditions are **TRUE** and returns **FALSE <u>if all</u>** conditions are false.

OR function syntax: **=OR(logical1; [logical2]; ...)**.

For example: **=OR(A1>A2;A1<A3)**

(if either A1>A2 **OR** A1<A3 is true, then return **TRUE**. If neither is true, return **FALSE**).

NOT Function

The **NOT** function reverses the logic of its argument.
NOT function syntax: **=NOT(Logical)** (Logical Value is any value to be reversed).
For example: **NOT(A)**. **A=**TRUE reverses to **A=**FALSE.

TRUE function

The logical value is set to **TRUE**. The logical function **TRUE** verifies two arguments and returns the **TRUE** value if both values match.
TRUE function syntax: **=TRUE()**.

FALSE function

The **FALSE** function returns the logical value **FALSE**.
FALSE function syntax: **=FALSE()**.

Practical tasks for students. Instructions for execution of practical work

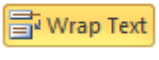
1. *Start a computer* and wait for the loading **Windows OS**.

2. After completing the loading of **Windows OS,** *start* **Microsoft Excel**.
3. *Save the document on* ***the Desktop***.

Attention: *Don't forget to click the icon* ***Save***  *on the* ***Quick Access toolbar*** *every few minutes during the lesson to avoid losing your work.*

4. Perform the following tasks:

****

Task №1. *Create a table "**Ideal Weight Calculation**" (**Fig.1**) and, using the logical functions of the **MS Excel** program, conclude the patient's health.*
For this purpose, do the following:
*Create a new electronic table as shown in the **Fig. 1***:
• select cells **A2:I2** on the **Sheet1**, on the **Home** tab, in the **Alignment** group, click **Merge and Center**  ;
• in the same way merge cells **A3:A4, B3:B4, C3:D3, E3:E4, F3:F4, G3:G4, H3:H4, I3:I4, A16:B20, A15:I15, G16:I20, C16:C20**;
• type text into cells **A2:I4, A5:E14, A16:F20, A15:I15** according to **Fig. 1**;
Note:
To change the width of columns to fit the contents, select the column or columns that you want to change, and then double-click the boundary to the right of a selected column heading.
To change the width of one column, drag the boundary on the right side of the column heading until the column is the width that you want.
*To insert symbols, click the **Insert** tab, then click the **Symbol** button in the **Symbols** group and select the desired symbol on the **Symbols** tab.*
*You can use the **Alt+Enter** keyboard shortcut while entering information in order to force your data onto multiple lines in a single cell (or pressing **Wrap Text*** 

*command on **Home** tab).*
To vertically align text to the center in the cell, click the **Middle Align** *command in the* **Alignment** *group of the* **Home** *tab.*
*To decrease or increase decimal places, select the needed cell, column, or row, navigate to the **Home** tab, and from the **Numbers** group, click on the **Decrease Decimal***  *or **Increase Decimal***  *option, respectively.*

*Calculate the **Brock's index without correction** by the formula:*

$$A = L - 100,$$

*Where **A** is Brock's weight in kg, **L** is height in cm.*

• enter the formula **=D5-100** in cell **F5** (select cell **F5**, press **=**, click LBM **D5**, press **-** (minus), type **100**, press **Enter**);

• select cell **F5** and copy the formula to the cells **F6:F14** by drag and drop method (press LBM on cell **F5**, drag the lower right corner of the cell down to the cell **F14**);

*Calculate the **optimal weight according to Ott** by the formula:*

$$O_f = A - 2*(A-52)/5 \text{ for women} \quad \textit{and} \quad O_m = A - (A-52)/5 \text{ for men},$$

*where **A** is **Brock's weight without correction**.*

• enter the formula **=F5-2*(F5-52)/5** in cell **G5** (select cell **G5**, press **=**, click LBM **F5**, press **-** (minus), type **2*(**, click LBM **F5**, press **-** (minus), type **52)/5**, press **Enter**);

• type the formula **=F6-(F6-52)/5** in cell **G6** (select cell **G6**, press =, click LBM **F6**, press **-** (minus), type **(**, click LBM **F6**, press **-** (minus), type **52)/5**, press **Enter**);

• copy the formula from cell **G5** to those cells from the range **G7:G14**, which correspond to a female patient, and from cell **G6** to the cells from the range **G7:G14**, which correspond to a male patient;

*Calculate the **excessiveness of weight** in % by the formula:*

$$E = w/O*100 - 100,$$

*where **w** is patient's weight, **O** - optimal weight according to Ott (**O=O$_f$** for women, **O=O$_m$** for men).*

• type the formula **=C5/G5*100-100** in cell **H5** (select cell **H5**, press =, click LBM **C5**, press **/**, click **G5**, type ***100-100** and press **Enter**);

• select cell **H5** and copy the formula to the cells **H6:H14** by drag and drop method (press LBM on cell **H5**, drag the lower right corner of the cell down to the cell **H14**);

*Make a conclusion using **Excel** logical function **IF**:*

• select cell **I5** and click the **Insert Function** f_x button next to the **Formula** bar or press **Shift+F3** on the keyboard;

• in the **Insert Function** dialog box in the **Function Category** list box select **Logical**, in the **Function Name** list box, select **IF** and click **OK**;

• in **Function Arguments** dialog box, in **Logical_test** field type **H5<15**, in **Value_if_true** field type **Excess weight**, click **Value_if_false** field and click **IF** button next to **Formula Bar**;

• in **Function Arguments** dialog box in **Logical_test** field type **H5<30**, in **Value_if_true** field type **I-st rate of obesity**, click **Value_if_false** field and click **IF** button next to **Formula Bar**;

• in **Function Arguments** dialog box in **Logical_ test** field type **H5<50**, in **Value_if_true** field type **II-nd rate of obesity**, click **Value_if_false** fiels and click **IF** button next to **Formula Bar**;

• in **Function Arguments** dialog box in **Logical_ test** field type **H5<101**, in **Value_if_true** field type **III-rd rate of obesity**, in **Value_if_false** field type **IV-th rate of obesity**, click **OK**;

Note. If you do everything right, in the cell **I5** will be written a formula **=IF(H5<15,"Excess weight",IF(H5<30,"I-st rate of obesity",IF(H5<50,"II-nd rate of obesity",IF(H5<101,"III-rd rate of obesity","IV-th rate of obesity"))))**.

• select cell **I5** and copy the formula to the cells **I6:I14** by drag and drop method (click cell **I5**, drag the lower right corner of the cell down to the cell **I14**);

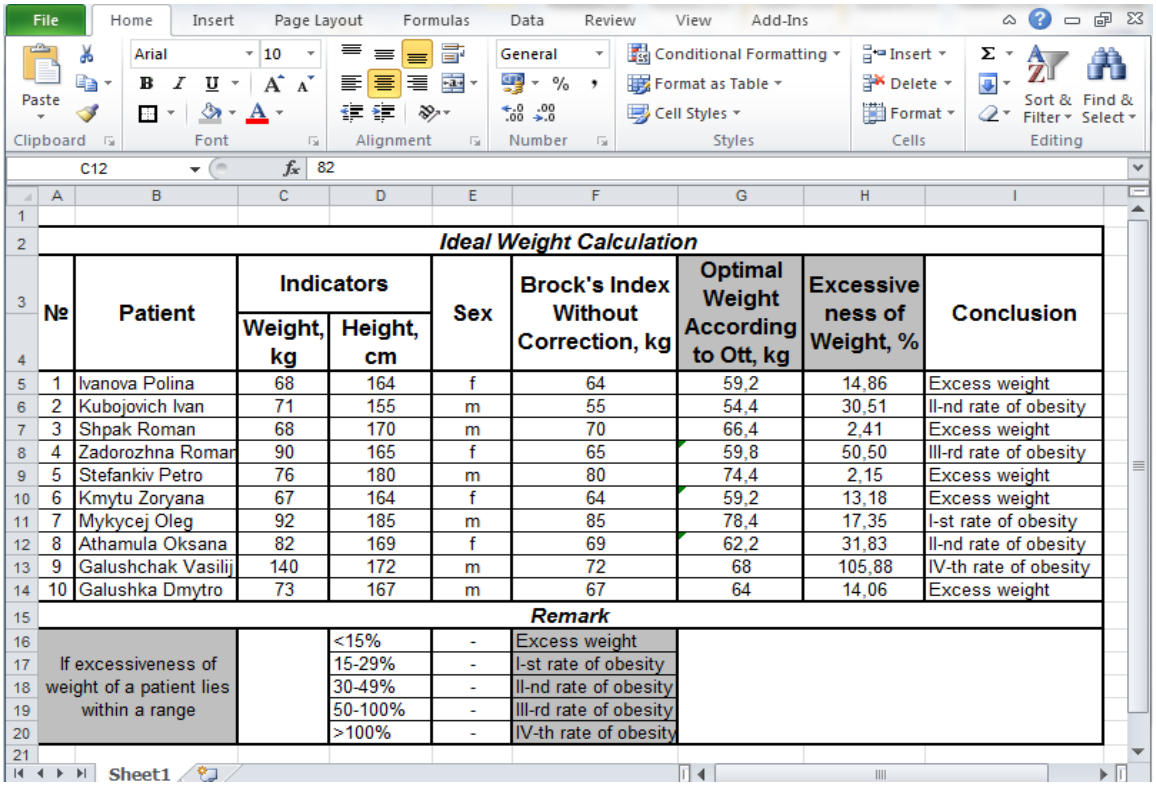
*Format the table according to the example on the **Fig. 1**;*

Formatting instructions:

Font: **Arial**;
Size: cells **A2:I4** – **12**, cells **A15:I15** – **11,** cells **A5:I14, A16:F20** – **10**;
Style: cells **A2:I2, A15:I15** – **Bold Italic**, cells **A3:I4** – **Bold,** other cells – **Regular**;
Horizontal alignment: cells **A2:I4, A5:A14, C5:H14, B16:B20, A15:I15, E16:E20** – **Center**, cells **B5:B14, I5:I14, D16:D20, F16:F20** – **Left**;
Vertical alignment: cells **A3:I4, B16:B20** – **Center;**
Shading: cells **G3:H4**, **A16:B20**, **F16:F20** – **White, Background 1, Darker 25 %.**

Detailed formatting instructions:

• select cells **A2:I20**, on the **Home** tab, in the **Font** group, select **Arial** in the **Font** box Arial;
• select cells **A2:I4**, on the **Home** tab, in the **Font** group, select **12** in the **Font Size** box 12;
• select cells **A15:I15**, on the **Home** tab, in the **Font** group, select **11** in the **Font Size** box;
• select cells **A5:I14**, on the **Home** tab, in the **Font** group, select **10** in the **Font Size** box;
• in the same way change the **Font Size** of cells **A16:F20** to **10**;
• select cells **A2:I2**, on the **Home** tab, in the **Font** group, click **Bold** **B**, **Italik** *I*;
• in the same way change the **Font Style** of cells **A15:I15** to **Bold** **B** **and Italik** *I*;
• select cells **A3:I4**, on the **Home** tab, in the **Font** group, click **Bold** **B**;
• select cells **B5:B14**, on the **Home** tab, in the **Alignment** group, click **Align Text Left**;
• in the same way align to the left text in the cells **I5:I14, D16:D20, F16:F20**;
• select cells **A2:I4**, on the **Home** tab, in the **Alignment** group, click **Center**;
• in the same way align to the center text in the cells **A5:A14, C5:H14, B16:B20, A15:I15, E16:E20**;
• select cells **A3:I4,** on the **Home** tab, in the **Alignment** group, click **Middle Align** command
• in the same way vertically align to the center text in the cells **B16:B20;**
• select cells **G3:H4**, on the **Home** tab, in the **Font** group, click **Fill Color**, select **White, Background 1, Darker 25 % from the drop-down menu that appears;**
• in the same way apply shading effect to cells **A16:B20** and **F16:F20.**



Ideal Weight Calculation

№	Patient	Indicators		Sex	Brock's Index Without Correction, kg	Optimal Weight According to Ott, kg	Excessiveness of Weight, %	Conclusion
		Weight, kg	Height, cm					
1	Ivanova Polina	68	164	f	64	59,2	14,86	Excess weight
2	Kubojovich Ivan	71	155	m	55	54,4	30,51	II-nd rate of obesity
3	Shpak Roman	68	170	m	70	66,4	2,41	Excess weight
4	Zadorozhna Roman	90	165	f	65	59,8	50,50	III-rd rate of obesity
5	Stefankiv Petro	76	180	m	80	74,4	2,15	Excess weight
6	Kmytu Zoryana	67	164	f	64	59,2	13,18	Excess weight
7	Mykycej Oleg	92	185	m	85	78,4	17,35	I-st rate of obesity
8	Athamula Oksana	82	169	f	69	62,2	31,83	II-nd rate of obesity
9	Galushchak Vasilij	140	172	m	72	68	105,88	IV-th rate of obesity
10	Galushka Dmytro	73	167	m	67	64	14,06	Excess weight

Remark

If excessiveness of weight of a patient lies within a range	<15%	-	Excess weight
	15-29%	-	I-st rate of obesity
	30-49%	-	II-nd rate of obesity
	50-100%	-	III-rd rate of obesity
	>100%	-	IV-th rate of obesity

Fig. 1

*Apply cell borders to the table according to the **Fig. 1***:
• select the cells you want to format, and click the down arrow beside the **Borders** button in the **Font** group
on the **Home** tab. A drop-down menu appears with all the border options you can apply to the cell selection. Click the type of line you want to apply to the selected cells.

****

Task №2. *Create a table "**Calculation of Goods Cost**" on Sheet2* (***Fig. 2***).
For this purpose, do the following:
*Create a new electronic table as shown on the **Fig. 2***:
• select cells **A2:F2**, on the **Home** tab, in the **Alignment** group, click **Merge and Center** ;
• in the same way merge cells A11:F11, A13:C13, D12:F12, A14:A16, D13:E13, D14:E14, D15:E15, D16:E16;
• type text into cells **A2:F3, A4:C10, E4:E10, B12:C12** and **A13:E16** according to **Fig. 2**;

Calculate price with tax:

• enter the formula **=C4+C4*$C$12** into the cell **D4** (select cell **D4**, press **=** button, click **C4**, press **+**, click **C4**, press ***, click **C12**, press **F4 function key** on the keyboard, press **Enter**);
• select cell **D4** and copy the formula to the cells **D5:D10** by drag and drop method;
• enter the formula **=D4*E4** into the cell **F4** (select cell **F4**, press **=**, click **D4,** press ***,** click **E4,** press **Enter**);
• select cell **F4** and copy the formula to the cells **D5:D10** by drag and drop method;
• select cell **F13** on the **Formulas** tab, in the **Function Library** group, click **Autosum** and change the region of cells in the brackets to F4**:F10** (If you do everything right, in the cell **E9** will be written a formula =**SUM(F4:F10)**). Press **Enter.**
• enter the formula **=IF(F13>800,C16*F13,IF(F13>399,C15*F13,IF(F13>199,C14*F13,0)))** into the cell **F14;**
• enter the formula **=F13-F14** into the cell **F15**, press **Enter**;
• enter the formula **=F15-F15/120*100** into the cell **F16**, press **Enter**;

F18

	A	B	C	D	E	F
1						
2	**Calculation of Goods Cost**					
3	**No**	**Goods**	**Price, $**	**Price with Tax, $**	**Amount**	**Cost, $**
4	**1**	Canefron	27,92	33,50	5	167,52
5	**2**	Palyn	15,50	18,60	5	93,00
6	**3**	Furamag	22,00	26,40	10	264,00
7	**4**	5-NOK	9,00	10,80	12	129,60
8	**5**	Cystone	7,75	9,30	10	93,00
9	**6**	Oro-Gran	7,33	8,80	4	35,18
10	**7**	Nevigramon	72,00	86,40	6	518,40
11						
12		**Tax**	20%			
13	Cost of purch			**Cost of purch**		1300,70
14	**Discount**	cost 200-399 $	3%	**Discount**		91,05
15		cost 400-900 $	5%	**Cost**		1209,65
16		cost >800 $	7%	**Tax**		201,61
17						

Sheet1 Sheet2

Fig. 2

*Format the table according to example on the **Fig. 2**;*

Formatting instructions:
Font: **Arial**;
Size: cells **A2:F2** – **11**, other cells – **10**;
Style: cells **A2:F2** – **Bold Italic**, cells **A3:F3, A4:A10, B12, A14:A16, D13:E16** – **Bold,** other cells – **Regular**;
Horizontal alignment: cells **A2:F3**, **A4:A10**, **A13:C13**, **A14:A16**, **D13:E16** – **Center,** cells **B4:B10**, **B14:B16** – **Left**, other cells – **Right**;
Vertical alignment: cells **A3:F3, A14:A16** – **Center;**

*Apply cell borders to the table according to the **Fig. 2**:*

****

Task №3. *Create the database on **Sheet 3** (**Fig. 4**) and save it as a **Patients and medications** document.*

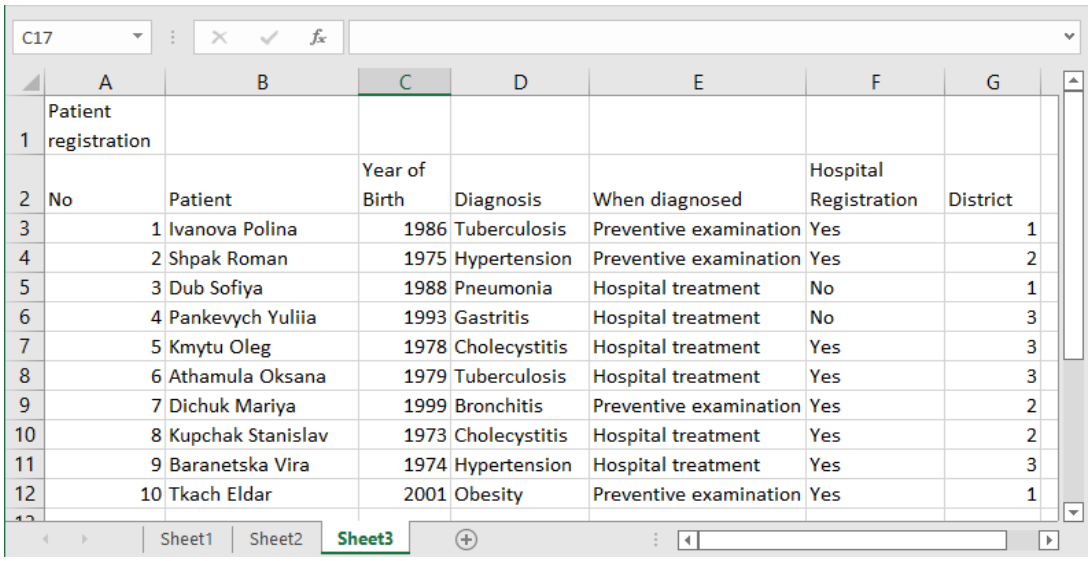


Fig. 3

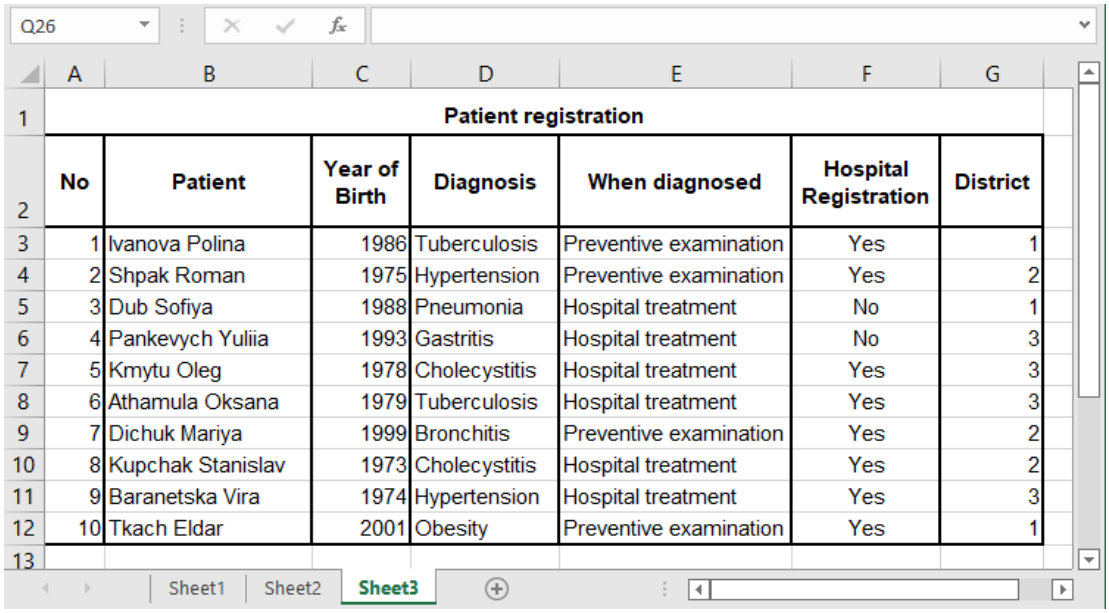


Fig. 4

For this purpose, do the following:
*Create the table on **Sheet 3** according to **Fig. 3**.*

*Format the table according to **Fig. 4**.*

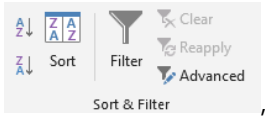
Formatting instructions:
Font: **Arial**;
Size: **10**;
Style: cells **A1:G2** – **Bold,** other cells – **Regular**;
Horizontal alignment: cells **A1:G2**, **F3:F12** – **Center,** other cells – by default (don't change);
Vertical alignment: cells **A1:G2** – **Center.**
*Apply cell borders to the table according to the **Fig. 4***:

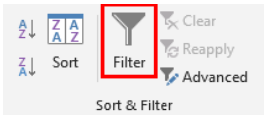
5. Show the teacher the results of your work.

****

Task №4. *Using MS Excel search for information in the database **Patients and Medications**.*
For this purpose, do following:

• select cells **A2-G2**;

• on the **Data** tab find **Sort&Filter** group 

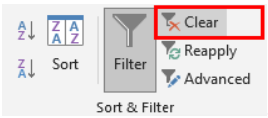
, click on **Filter** icon 

.

• click with LMB on the triangle icon (▼) of the **Diagnosis** field.

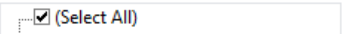
• in the drop-down menu, uncheck the box (**Select All**) 

and then check the **Tuberculosis** option, press **OK** button.

• on the **Data** tab find **Sort&Filter** group and click with LMB on the **Clear** icon 

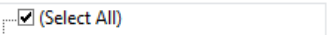
.

• click with LMB on the triangle icon (▼) of the **Hospital Registration** field.

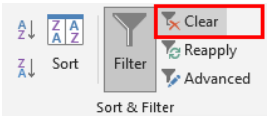
• in the drop-down menu uncheck the box (**Select All**) 

and then check **Yes** option, press **OK** button.

• click with LMB on the triangle icon (▼) of the **When diagnosed** field.

• in the drop-down menu uncheck the box (**Select All**) 

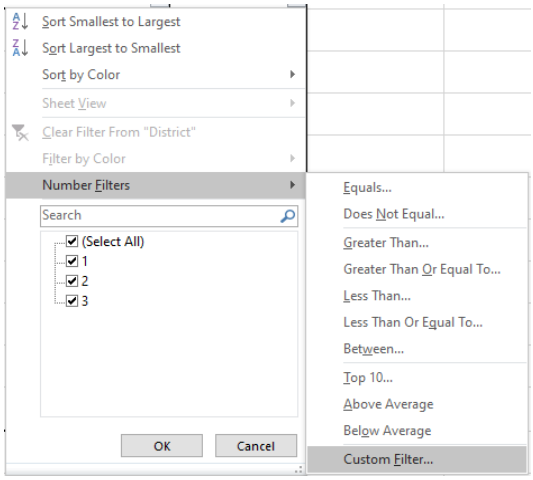
and then check **Preventive examination** option, press **OK** button.

• on the **Data** tab find **Sort&Filter** group and click with LMB on the **Clear** icon 

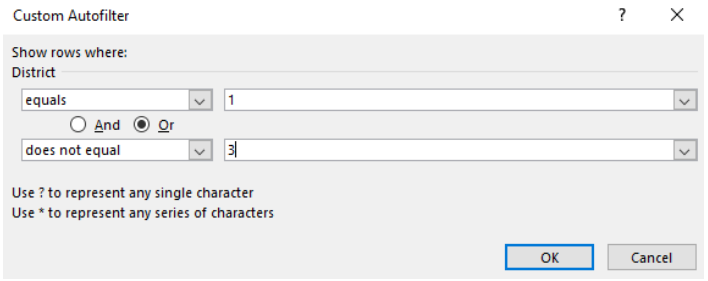
.

• click with LMB on the triangle icon (▼) of the **District** field.

• in the drop-down menu choose **Number Filters → Custom Filer…**

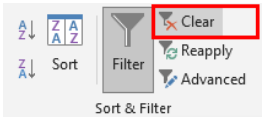


• in the **Custom Filer** window set the next search conditions:



press **OK** button

• view filtering results;

• on the **Data** tab find **Sort&Filter** group and click with LMB on the **Clear** icon 

.

• on the **Quick Access Toolbar**  click on the **Form** icon  .

Note:
If there is no **Form** icon on the **Quick Access Toolbar**, you need to activate it:

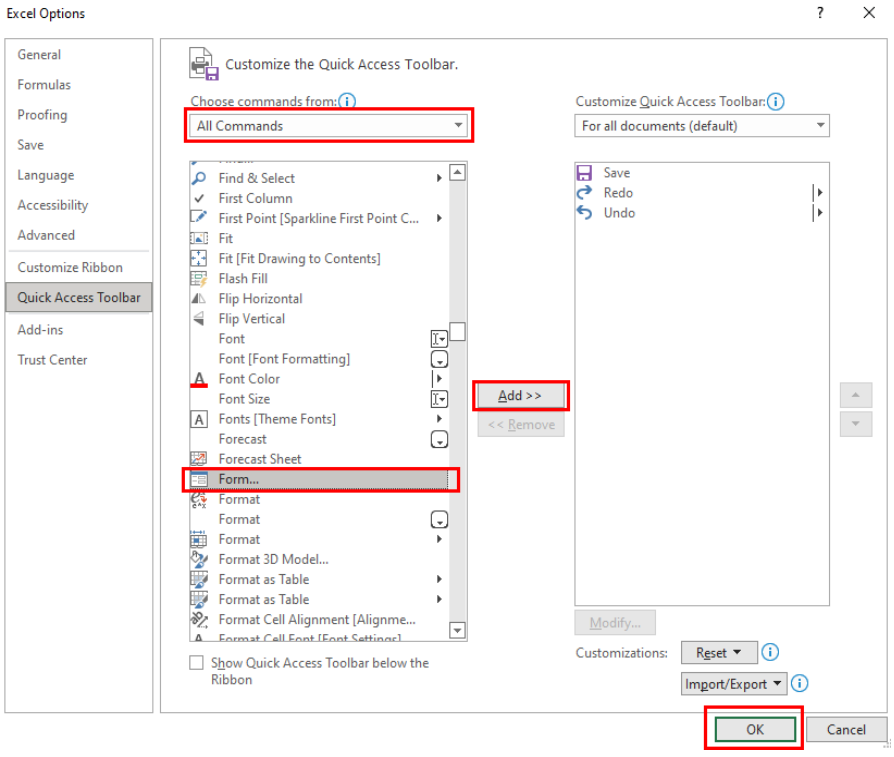
○ on the **Quick Access Toolbar**  click on the **Customize Quick Access Toolbar** icon 

○ in the drop-down menu choose **More Commands...** 

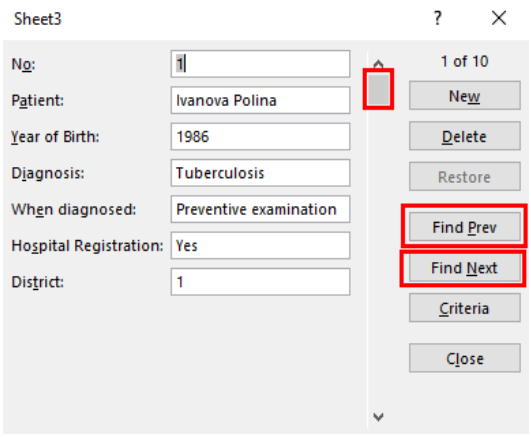
.

○ in the window select **All commands** in the **Choose command from** drop-down list.

○ find in the list **Form** option, select it and click **Add >>** button. Press **OK** button.



• overview **Form** window using **Vertical Scroll Bar** and buttons **Find Prev** and **Find Next**.



- click the **Close** button.
- Show the teacher the results of your work.
- Close **MS Excel** document.

Attention: *After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:

Excel help & learning. Microsoft.com. from https://support.microsoft.com/en-us/excel

1) Cheusheva S. Logical functions in Excel: AND, OR, XOR and NOT [Internet]. ablebits.com. 2014 [cited 2024 Nov 20]. Available from: https://www.ablebits.com/office-addins-blog/excel-and-or-xor-not-functions/

2) Health Informatics Online for Nelson and Staggers: Health Informatics: an Interprofessional Approach. Elsevier Science Health Science, 2017.

3) Добровольська А. М. Медична інформатика. Тестові завдання. Івано-Франківськ: Видавець Супрун В. П., 2018. 224 с.

4) Basham, S. (2021). Microsoft Word in easy steps: Also covers word in Microsoft 365 suite. In Easy Steps Limited.

5) John, P. (2021). Microsoft Office 365 for Beginners & Advanced Learners: a Step-by-Step Practical Guide to Mastering Word, Excel & PowerPoint 365. Independently published.

Additional

1) Добровольська А. М. Медична інформатика. Практикум. Івано-Франківськ: Сімик, 2013. 440 с.

2) Бондаренко Т.І. Основи медичної інформатики. Практикум: навчальний посібник. Всеукраїнське спеціалізоване видавництво «Медицина», 2018. 128с.

3) Медична інформатика в модулях: Практикум. 2-ге вид., випр. / За ред. І. Є. Булах. Київ: ВСВ "Медицина", 2009. 208 с.

Topic 13: DEVELOPMENT OF MATHEMATICAL MODELS BASED ON MEDICAL-BIOLOGICAL RESEARCH RESULTS.

Actuality: Computational modeling uses computers, physics, and math to study and simulate complex systems. It works by programming many variables into a model that represents the system being studied. Scientists can change these variables one at a time or in combinations to see what happens. This helps them gather useful information without running physical experiments. By running thousands of these simulations, researchers can figure out which experiments in the lab are most likely to solve a problem. Computational modeling is used in many fields, like discovering new medicines, predicting the weather, simulating flights, and researching medical treatments [from: https://www.nibib.nih.gov/science-education/science-topics/computational-modeling].

Educational aims of the lesson:

To know:

1. theoretical bases of two-level full factorial design;
2. syntax of MS Excel functions that are used in a two-level full factorial design.

To be able to:

1. apply possibilities of MS Excel for performing of two-level full factorial design;
2. calculate Cochran criteria using MS Excel statistical functions.

The list of questions for the survey:

1. Full factorial design.
2. Levels, and factors.
3. The design matrix.
4. Cochran's Q test.
5. The F-test.
6. Regression coefficients.
7. Statistical functions MS Excel for full factorial design.

The list of required practical skills:

1. applying possibilities of MS Excel for conducting of two-level full factorial design;
2. calculating Cochran criteria using MS Excel statistical functions.

Brief theoretical information

Computational modeling uses math, physics, statistics, and computer science to simulate and understand how complex systems work. A model includes many variables that represent parts of the system being studied. By changing these variables, scientists can observe how those changes influence the system's behavior and predictions.

Modern computational models can explore biological systems on different levels. For example, models of disease progression can include molecular changes, interactions between cells, and the impact on tissues and organs. This approach of studying systems at various levels is **called multiscale modeling (MSM).**

How Can Computational Modeling Improve Healthcare and Research?

Tracking Infectious Diseases: Computational models help track the spread of infectious diseases, find effective ways to control them, and adjust interventions as needed. This is essential during pandemics to save lives and reduce pressure on healthcare systems.

Supporting Clinical Decisions: These models analyze patient-specific data to guide doctors in choosing the best treatments. They also ensure smooth patient care as individuals move between hospital departments and undergo tests, helping deliver consistent and informed medical care.

Predicting Drug Side Effects: Researchers use computational modeling to design safer drugs with fewer side effects. This method speeds up the drug development process, reducing the time needed to create effective medications.

Mathematical modeling in biology and medicine

A **model** is an abstraction of some system such as a man-made system or a natural system. There are various types of models: iconic, graphical, analog, and mathematical.

Modeling is the act of building a model.

A **simulation** is a process of using a model to study the behavior and performance of an actual or theoretical system. In a simulation, models can be used to study existing or proposed characteristics of a

system.

Mathematical models – are the systems of formulas, functions, and equations, that describe some properties of the investigated phenomena, object, or process.

The Verhulst-Pearl Equation

The **Verhulst-Pearl Equation**, also known as the **logistic equation**, is a mathematical model used to describe the growth of a biological population. Pierre Verhulst introduced this equation in the mid-19th century to simulate how populations grow in an ideal environment.

The equation assumes the population grows in an environment without significant external restrictions (like resource limitations or predation) initially. At the start, the population increases at a constant rate, proportional to its size.

Unlike exponential growth, where a population grows indefinitely, the logistic model introduces the concept of a carrying capacity (**K**). Carrying capacity is the maximum population size that the environment can sustain over time. As the population approaches this carrying capacity, the growth rate slows down due to competition for resources, space, or other environmental factors.

The general form of the logistic equation is:

$$\frac{dP}{dt} = rP\left(1 - \frac{P}{K}\right)$$

Where **P** is the population size at time **t**;

r is the growth rate (how quickly the population grows when resources are abundant);

K is the carrying capacity (maximum sustainable population);

dP/dt is the rate of change of the population over time.

How It Works:

Initial Phase: When **P** is much smaller than K, the term **1−P/K** is close to **1**, and the population grows approximately exponentially.

Middle Phase: As **P** increases, the growth slows because **1−P/K** becomes smaller, reducing the rate of growth.

Final Phase: When **P** is close to **K**, growth approaches zero, and the population stabilizes at the carrying capacity.

Applications: This model is widely used in fields like biology, ecology, and sociology to understand population dynamics, resource management, and even the spread of diseases or information within a population.

EXAMPLE 1. *Using **WolframAlpha** computational knowledge engine (https://www.wolframalpha.com/) perform the following tasks:*

A public health department is monitoring the spread of a contagious disease within a city. Initially, only a few individuals are infected, but the disease spreads as more people come into contact with the infected individuals. However, the spread slows over time as the population reaches a saturation point due to recovery, immunity, or preventive measures.

Problem:

Using the **Verhulst-Pearl Logistic Growth Equation**, model the number of infected individuals over time and determine when the infection rate begins to decline.

Parameters:

- Initial Population Infected ($\mathbf{P_0}$): 50 individuals.
- Maximum Population Susceptible to Infection (**K**): 10,000 individuals.
- Infection Growth Rate (**r**): 0.1 per day.
- Time Frame: Simulate the spread over 100 days.

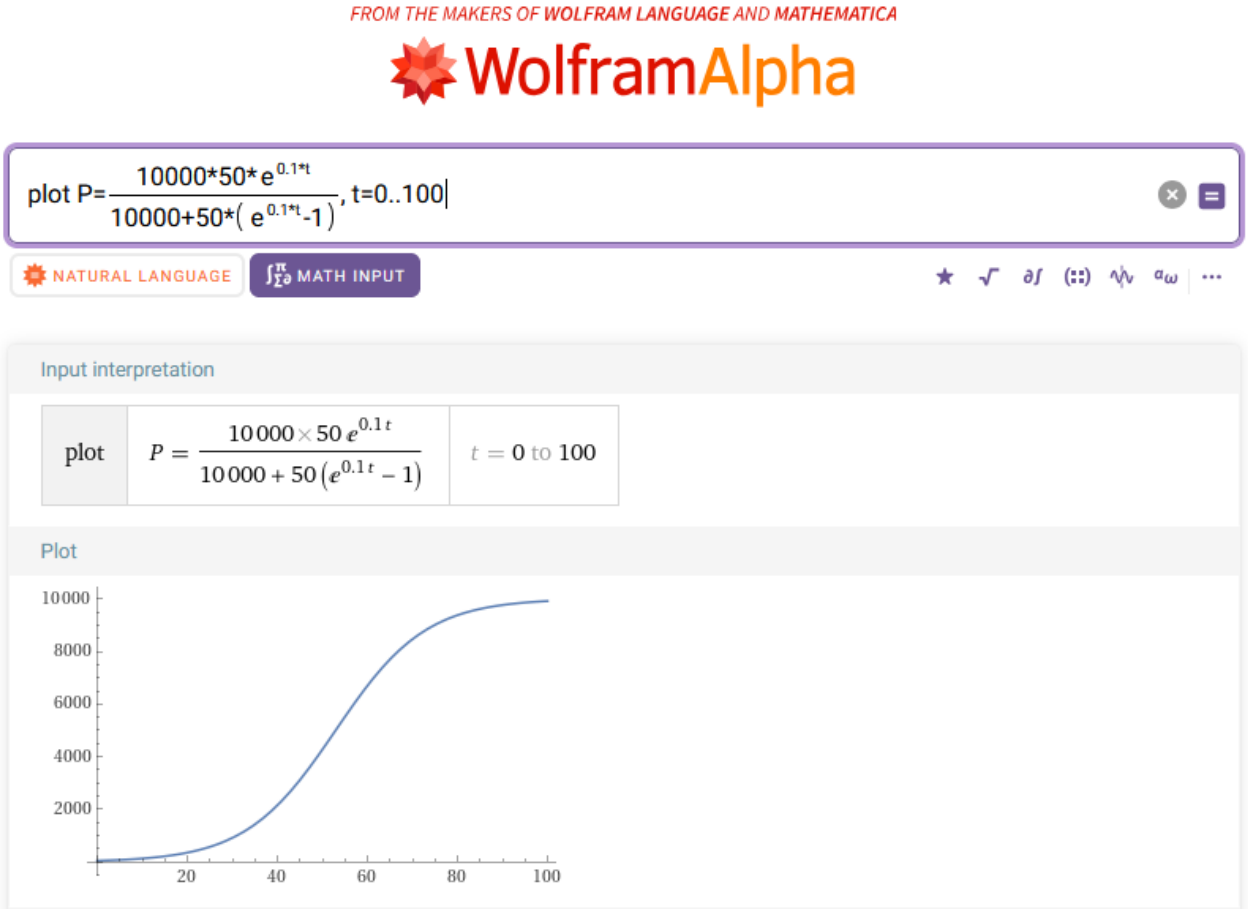
Task:

1. Simulate the number of infected individuals (P) over time using the logistic growth equation.
2. Identify the time at which the infection rate begins to slow significantly.
3. Determine the total number of infected individuals at the end of the simulation period (100 days).

Simulate logistic growth using the equation $\frac{dP}{dt} = rP\left(1 - \frac{P}{K}\right)$, set K=10000, P_0=50, and r=0.1, time interval 0 to 100.

SOLUTION.

The solution of **Verhulst-Pearl** differential equation is $P(t) = \frac{K \cdot P_0 \cdot e^{rt}}{K + P_0(e^{rt} - 1)}$

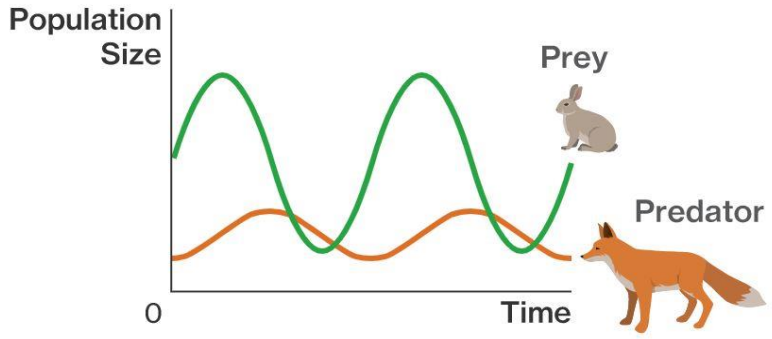


The Lotka-Volterra Model of Predation

The **Lotka-Volterra Model of Predation** is a pair of equations that describe the interactions between two species: a **predator** population and its **prey**. This model, introduced by Alfred Lotka and Vito Volterra in the early 20th century, explains how the populations of predators and prey influence each other over time.

Key Features:

The model focuses on **two species**: **prey** (food source) and **predators** (depend on the prey for survival). The prey population grows exponentially in the absence of predators, while predators rely on prey for reproduction and survival. The populations of predators and prey tend to ***oscillate over time***. When prey numbers increase, predator numbers also grow, which then reduces the prey population, leading to a subsequent decline in predators.



[https://www.mylearning.org/resources/ecological-cycle-predator-and-prey]

The model assumes there are no external environmental factors, such as carrying capacity or competition, affecting the populations. Prey population decreases only due to predation. Predator population increases only due to predation success.

The model consists of two coupled differential equations:

$$\begin{cases} \frac{dP}{dt} = aP - bPZ \\ \frac{dZ}{at} = -cZ + dPZ \end{cases}$$

Where:
P is the **Prey population;**
Z is the **Predator population;**
a is the **Prey growth rate** (natural reproduction of prey);
b is the **Predation rate** (how effectively predators capture prey)
c is the **Predator death rate** (natural mortality of predators)
d is the **Predator reproduction rate** (based on prey consumption)

How It Works:
Prey Growth: Without predators (***Z=0***), the prey population grows exponentially at a rate **aP**.
When predators are present, the prey population decreases due to predation at a rate proportional to **bPZ**.
Predator Growth: Predators die naturally at a rate **−cZ** if there is no prey (***P=0***).
The predator population increases when they consume prey, at a rate proportional to **dPZ**.
Population Oscillations: If prey numbers rise, predators have more food and their population increases.
As predator numbers grow, they overconsume the prey, leading to a decline in prey population.
With less prey, predator numbers fall, allowing the prey population to recover, starting the cycle again.
Applications:
Ecology: Studying population dynamics in predator-prey systems.
Conservation Biology: Managing predator-prey balances in wildlife reserves.
Epidemiology: Analyzing host-parasite interactions, where the parasite acts as the "predator."
Economics: Modeling competition and interactions between businesses or markets.
This model is a foundational concept in understanding interspecies interactions but is often expanded with more complex factors like environmental limits or additional species interactions to reflect real-world scenarios more accurately.

EXAMPLE 2:
A hospital is studying the interaction between harmful bacteria and the immune system of patients. The immune system produces white blood cells (WBCs), which act as predators by attacking the bacteria (prey). To optimize antibiotic treatment, the hospital wants to predict how the bacteria and WBC populations will change over time without antibiotics and after administering a specific dose.
Problem:
Use the **Lotka-Volterra Model of Predation** to simulate the interaction between WBCs (predators) and

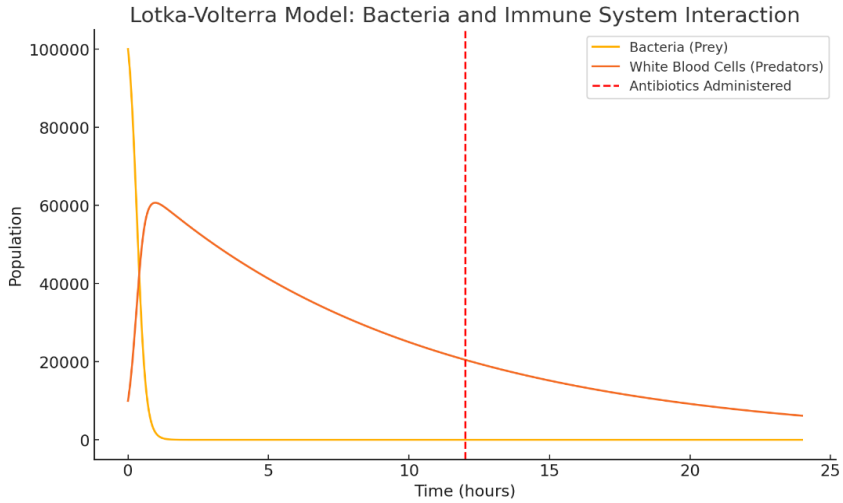
bacteria (prey) under the following conditions:

- Initially, there are 100,000 bacteria and 10,000 WBCs.
- The bacteria reproduce at a rate of **a**=0.3 per hour.
- WBCs attack and destroy bacteria at a rate of **b**=0.0001 per encounter.
- WBCs die naturally at a rate of **c**=0.1 per hour.
- For every 1,000 bacteria destroyed, WBCs reproduce at a rate of **d**=0.00005.

Task:

1. Simulate the interaction over 24 hours without antibiotics.
2. Introduce a dose of antibiotics after 12 hours that reduces the bacterial reproduction rate to a=0.1 and repeat the simulation.
3. Compare the results and determine whether the antibiotics significantly improve the immune system's ability to control the bacteria.

SOLUTION.



The graph above shows the simulation results of the bacteria (prey) and white blood cells (predators) interaction over 24 hours.

First 12 Hours (No Antibiotics):

The bacteria population grows at a natural rate (a=0.3), while white blood cells attack and reduce their numbers. The immune system (predators) thrives on the presence of bacteria, leading to an increase in white blood cells due to predation success.

12-24 Hours (After Antibiotics):

At hour 12, antibiotics are administered, reducing the bacteria's growth rate (a=0.1). This intervention significantly slows the bacteria's reproduction, allowing the immune system to reduce their numbers more effectively. The predator population also stabilizes as fewer bacteria are available for consumption.

Conclusion: The use of antibiotics helps control the bacteria more effectively, allowing the immune system to stabilize. This demonstrates the combined impact of medical treatment and the natural immune response in combating infections.

EXAMPLE 3. *Using **WolframAlpha** computational knowledge engine (https://www.wolframalpha.com/) perform the following tasks:*

A medical research team is studying how the immune system (predators) interacts with cancer cells (prey). The team wants to test whether a new immunotherapy drug enhances the ability of white blood cells (predators) to control the cancer cell population.

Problem:

Using the Lotka-Volterra Model of Predation, simulate the interaction between cancer cells and the immune system under the following conditions:

- Initially, there are 500,000 cancer cells and 50,000 immune cells (white blood cells).
- Cancer cells grow at a rate of **a**=0.2 per day.
- Immune cells attack cancer cells at a rate of **b**=0.0002 per encounter.

- Immune cells naturally die at a rate of **c**=0.1 per day.
- For every 10,000 cancer cells killed, the immune cell population increases at a rate of **d**=0.0001.
- The immunotherapy drug is administered after 5 days, increasing the predation efficiency of immune cells (b) to 0.0005.

Task:

1. Simulate the interaction over 10 days without the drug and with the drug introduced on day 5.
2. Compare cancer cell populations before and after the drug is administered.
3. Evaluate whether the immunotherapy significantly improves the immune system's ability to control cancer cell growth.

SOLUTION.

Initial Phase (0–5 days):

The cancer cells (prey) grow steadily at a rate of a=0.2, while the immune cells (predators) attempt to reduce their numbers through predation at b=0.0002.

The immune cells also die naturally at c=0.1. The balance between these processes leads to moderate control of the cancer cell population, but it still grows overall due to a relatively low predation rate.

After Immunotherapy (5–10 days):

At day 5, the immunotherapy drug is administered, increasing the predation efficiency (b) to 0.0005.

This significantly enhances the immune system's ability to target and destroy cancer cells, leading to a more rapid reduction in the cancer cell population.

The boost in immune cell numbers due to increased prey consumption further helps control the cancer.

Impact of Immunotherapy:

Before immunotherapy, the cancer cell population grows steadily, and immune cells struggle to keep up.

After the drug is introduced, cancer cell growth is controlled, and the immune cell population stabilizes at a higher level, indicating a more effective immune response.

This simulation demonstrates how immunotherapy can improve the immune system's ability to manage cancer by increasing the effectiveness of predation on cancer cells.

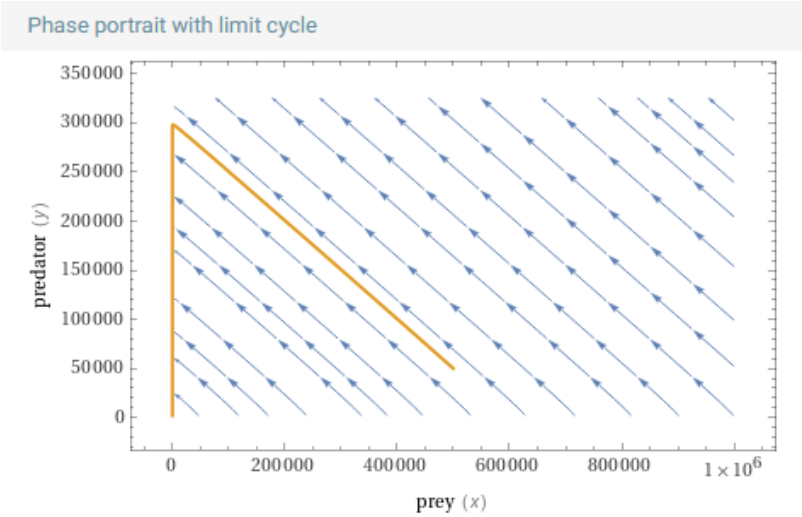
Write and implement a computer simulation using numerical integration of the **Lotka-Volterra predation model**. Set the following constants of the model:

Prey population growth parameter	a = 0.2
Predator population extinction parameter	c = 0.1
Species interaction parameter 1	b = 0.0002
Species interaction parameter 2	d = 0.0001
Initial prey population	500000
Initial predator population	50000

Computational Inputs:

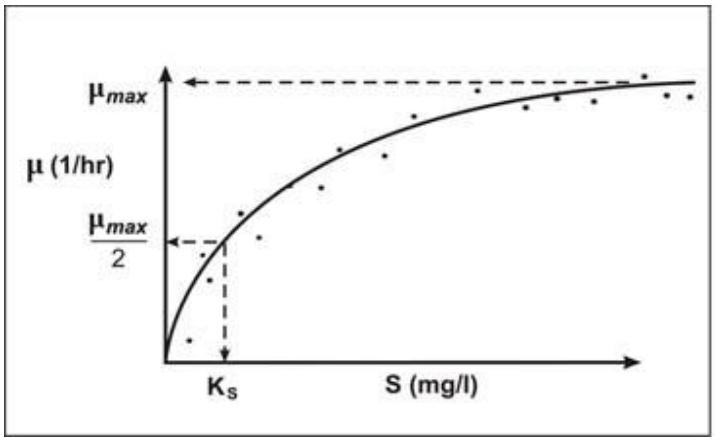
» prey population growth parameter :	0.2
» predator population extinction parameter :	0.1
» species interaction parameter 1:	0.0002
» species interaction parameter 2:	0.0001
» initial prey population:	500000
» initial predator population:	50000

Compute



The Monod Model of Microbial Growth

The Monod model, proposed by Jacques Monod in 1949, describes the growth of microorganisms as a function of substrate concentration. It is widely used in microbiology and biotechnology to understand and predict microbial behavior in environments where nutrients are limited.



$$\mu = \mu_{max}\left(\frac{S}{S+K_S}\right) \quad (5)$$

Graph of the growth rate of the bacterial species *Escherichia coli* at different concentrations of lactose. Based on data from Monod (1942)

Key Features:

Nutrient-Limited Growth: The model focuses on how microbial growth depends on the availability of a specific nutrient or substrate. At low substrate concentrations, growth is limited by nutrient availability.

Growth Saturation: At high substrate concentrations, microbial growth reaches a maximum rate (μ_{max}), as the system becomes saturated and further increases in substrate have no significant effect.

Simple Assumptions: Microbial growth is directly proportional to substrate concentration when nutrients

are scarce. Growth slows and plateaus as the substrate concentration increases, mimicking saturation kinetics.

The Monod equation is:

$$\mu = \mu_{\max} \frac{S}{K_S + S}$$

Where:

μ is the specific growth rate of the microorganisms.

μ_{max} is the maximum specific growth rate.

S is the substrate concentration.

Ks is the half-saturation constant, the substrate concentration at which the growth rate is half of μ_{max}.

How It Works:

At Low Substrate Concentrations (S≪Ks):

The growth rate (μ) increases almost linearly with substrate concentration (S). Microbes are "starving," and their growth depends directly on the nutrient availability.

At Moderate Substrate Concentrations (S≈Ks):

The growth rate begins to slow as substrate availability starts to saturate. This marks the transition from nutrient-limited growth to saturation.

At High Substrate Concentrations (S≫Ks):

The growth rate approaches its maximum value (μmax). Increasing substrate further has minimal effect on microbial growth.

Applications:

Biotechnology:

Optimizing fermentation processes by controlling substrate concentrations to achieve the desired microbial growth rate.

Environmental Engineering:

Modeling the degradation of pollutants by microorganisms in wastewater treatment plants.

Medical Microbiology:

Understanding how pathogens grow in nutrient-limited environments, such as during infection.

EXAMPLE 4:

A hospital is testing the effectiveness of an antibiotic on a bacterial infection. The antibiotic works by reducing the availability of a key nutrient (substrate) required for bacterial growth. The goal is to determine the minimum antibiotic dosage needed to limit bacterial growth to a manageable level within a patient's body.

Problem:

Using the **Monod Model of Microbial Growth**, predict the bacterial growth rate under different substrate (nutrient) concentrations and identify the antibiotic dosage that reduces the growth rate to below a safe threshold.

Parameters:

- Maximum Growth Rate (μ_{max}): 0.8 h^{-1}.
- Half-Saturation Constant (Ks): 5 mg/L.
- Initial Substrate Concentration (S_0): 20 mg/L.
- Growth Threshold ($\mu_{threshold}$): 0.2 h^{-1}.
- Antibiotic Effect: The antibiotic reduces the substrate concentration linearly by 2 mg/L per unit of dosage.

Task:

1. Calculate the bacterial growth rate (μ) at the initial substrate concentration (S_0).
2. Determine the antibiotic dosage required to reduce the substrate concentration (S) so that the growth rate (μ) falls below the threshold ($\mu_{threshold}$=0.2).
3. Plot the growth rate (μ) as a function of substrate concentration (S) to visualize the impact of the antibiotic.

SOLUTION:

1. Initial Growth Rate:

At the substance concentration of S = 20mg/L, the bacterial growth rate is:

$$\mu = \mu_{\max} \cdot \frac{S}{K_S + S} = 0.8 \cdot \frac{20}{5+20} = 0.64 h^{-1}$$

2. Required Substrate Concentration:

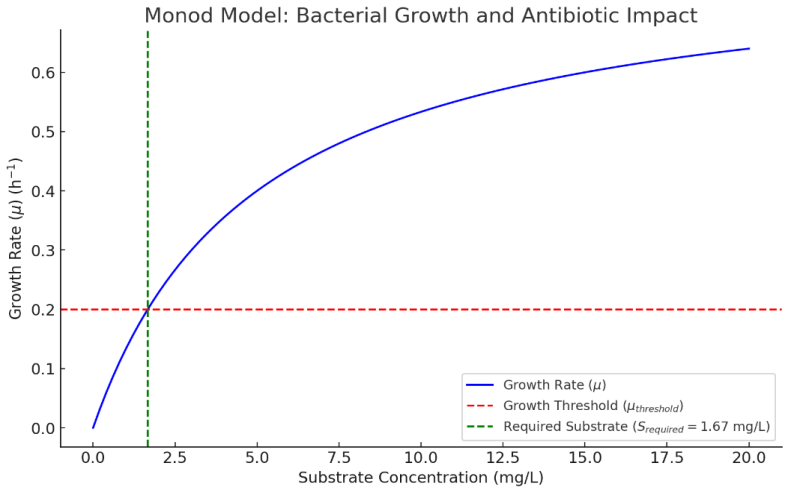
To reduce the bacterial growth rate to the threshold ($\mu_{threshold}$=0.2 h^{-1}), we solve the Monod equation for S:

$$S = \frac{\mu_{threshold} \cdot K_S}{\mu_{\max} - \mu_{threshold}} = \frac{0.2 \cdot 5}{0.8 - 0.2} = 1.67 mg/L$$

3. Antibiotic Dosage:

The antibiotic reduces substrate concentration by 2mg/L per unit dose. To lower S from 20mg/L to 1.67mg/L, the required dosage is:

$$Dosage = \frac{S_{initial} - S_{required}}{Antibiotic\ Effect} = \frac{20 - 1.67}{2} = 9.17 units$$



The graph shows how the bacterial growth rate (μ) decreases as substrate concentration (S) drops. The red dashed line represents the growth threshold ($\mu_{threshold}$). The green dashed line indicates the required substrate concentration (Srequired) for effective bacterial control. This analysis demonstrates how to use the Monod model to optimize antibiotic dosage for controlling bacterial growth effectively.

Mathematical modeling of the spread of infectious disease in the settlement

Mathematical models are crucial for understanding and predicting the spread of infectious diseases in a population. These models allow public health authorities to evaluate the potential impact of an outbreak and design effective intervention strategies.

Key Features:

Disease Dynamics: The models capture how a disease spreads over time through interactions between susceptible, infected, and recovered individuals.

Population Structure: The population is divided into compartments, such as **S** (**Susceptible**), **I** (**Infected**), and **R** (**Recovered**). Variants of the model may include compartments like **E** (**Exposed**) or **V** (**Vaccinated**).

Transmission Rate: The spread of the disease depends on the contact rate between susceptible and infected individuals and the probability of transmission.

Recovery and Immunity: Individuals in the infected group can recover, moving to the recovered group, potentially with immunity.

External Factors: Environmental and behavioral factors (e.g., vaccination, quarantine, or seasonal effects) can influence the spread.

The simplest model, the **SIR model**, consists of the following differential equations:
(**SIR: S**=Susceptible, **I**=Infected, and **R**=Recovered)

$$\begin{cases} \frac{dS}{dt} = -\beta SI \\ \frac{dI}{dt} = \beta SI - \gamma I \\ \frac{dR}{dt} = \gamma I \end{cases}$$

Where:
S(t): Number of susceptible individuals at time t
I(t): Number of infected individuals at time t
R(t): Number of recovered individuals at time t
β: Transmission rate (probability of infection per contact).
γ: Recovery rate (inverse of the average infectious period).

How It Works:
Initial Infection: The disease starts with a small number of infected individuals in a largely susceptible population.
Disease Spread: Susceptible individuals become infected at a rate proportional to their contact with infected individuals (**βSI**).
Recovery: Infected individuals recover at a rate **γI**, reducing the infected population and increasing the recovered population.
Epidemic Peak: The infected population grows rapidly at first, peaks, and then declines as fewer susceptible individuals remain.
Stabilization: Over time, the disease stabilizes as most of the population either recovers or avoids infection.

Applications:
Epidemiology: Predicting the course of an epidemic and estimating the peak infection rate and total number of cases.
Public Health Policy: Assessing the impact of interventions such as vaccination, social distancing, or quarantine.
Resource Allocation: Planning medical resources, such as hospital beds and vaccines, to manage the outbreak effectively.
Infectious Disease Research: Studying how factors like immunity, mutation rates, or climate conditions affect disease dynamics.

EXAMPLE 5:
A city of 100,000 people is experiencing the early stages of a COVID-19 outbreak. The local health department wants to assess how implementing social distancing affects the number of infections over time. They aim to compare two scenarios: no intervention and a 50% reduction in the transmission rate (β) due to social distancing.
Problem:
Using the SIR model, predict the number of susceptible, infected, and recovered individuals over 60 days under the following conditions:
Parameters:

- Initial Population (N): 100,000
- Initial Infected Individuals (I_0): 100
- Initial Recovered Individuals (R_0): 0
- Initial Susceptible Individuals ($S_0 = N - I_0 - R_0$): 99,900
- Transmission Rate (β):
    - Scenario 1 (No Social Distancing): 0.3 per day
    - Scenario 2 (Social Distancing): 0.15 per day
- Recovery Rate (γ): 0.1 per day (average recovery time = 10 days)

- Simulation Period: 60 days

Task:

1. Simulate the spread of COVID-19 for 60 days in both scenarios (with and without social distancing).
2. Compare the peak number of infections and the time it takes for infections to peak.
3. Calculate the total number of infected individuals by the end of the 60-day period in each scenario.

SOLUTION:

Setup Parameters:

- Total population (N): 100,000
- Initial Infected (I_0): 100
- Initial Recovered (R_0): 0
- Initial Susceptible ($S_0 = N - I_0 - R_0$): 99,900
- Transmission Rate (β):
  - Scenario 1 (No Social Distancing): 0.3 per day
  - Scenario 2 (Social Distancing): 0.15 per day
- Recovery Rate (γ): 0.1 per day (average recovery time = 10 days)
- Simulation Period: 60 days

Model Dynamics:

The SIR equations were used to calculate changes in the susceptible (S), infected (I), and recovered (R) populations over time for both scenarios.

Iterative calculations were done step-by-step for 60 days using small time steps (dt=0.1).

Key Metrics:

Peak Number of Infected Individuals:

Without social distancing: ~30,196 people infected at the peak.

With social distancing: ~1,725 people infected at the peak.

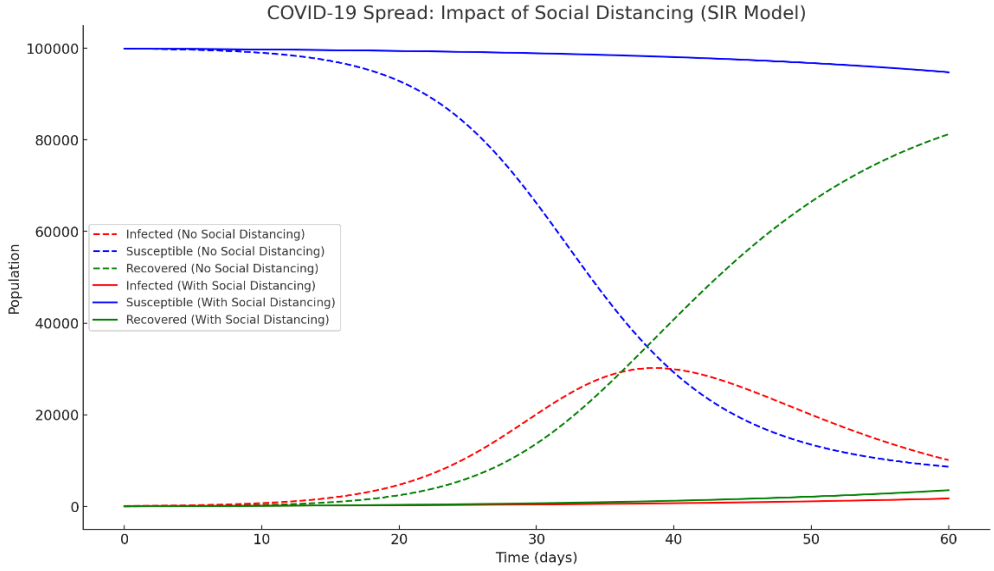
Total Infected Individuals by Day 60:

Without social distancing: ~91,334 people (over 91% of the population).

With social distancing: ~5,261 people (just over 5% of the population).

Impact of Social Distancing:

Social distancing dramatically reduced both the peak number of infections and the total number of infected individuals over 60 days. This highlights how reducing the transmission rate (β) flattens the infection curve, preventing healthcare systems from being overwhelmed.



The graph illustrates the dynamics for both scenarios, showing significantly fewer infections and a slower spread with social distancing in place.

EXAMPLE 6.

Wang, H., Miao, Z., Zhang, C., Wei, X., & Li, X. (2021). **K-SEIR-Sim: A simple customized software for simulating the spread of infectious diseases**. In *Computational and Structural Biotechnology Journal* (Vol. 19, pp. 1966–1975). Elsevier BV. https://doi.org/10.1016/j.csbj.2021.04.004

Computational and Structural Biotechnology Journal 19 (2021) 1966–1975

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journal homepage: www.elsevier.com/locate/csbj

K-SEIR-Sim: A simple customized software for simulating the spread of infectious diseases

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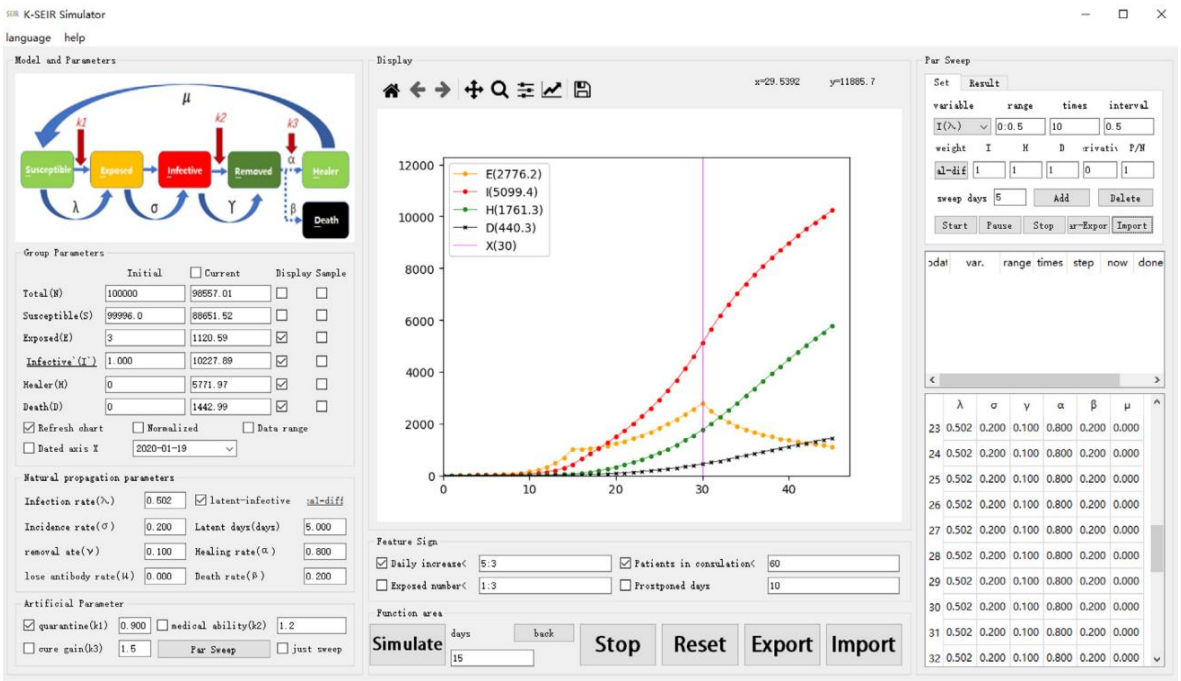
ABSTRACT

Infectious disease is a great enemy of humankind. The ravages of COVID-19 are leading to profound crises across the world. There is an urgent requirement for analyzing the current pandemic situation, predicting trends over time, and assessing the effectiveness of containment measures. Thus, numerous statistical models, primarily based on the susceptible–exposed–infected–recovered or removed (SEIR) model, have been established. However, these models are highly technical, which are difficult for the public and governing bodies to understand and use. To address this issue, we developed a simple operating software based on our improved K-SEIR model termed as the kernel SEIR simulator (K-SEIR-Sim). This software includes natural propagation parameters, containment measure parameters, and certain characteristic parameters that can deduce the effects of natural propagation and containment measures. Further, the applicability of the proposed software was demonstrated using the examples of the COVID-19 outbreak in the United States, Wuhan city of China, Diamond Princess, and France. Operating results verified the potency of the proposed software in evaluating the epidemic situation and human intervention during COVID-19. Importantly, no installation is required and the software can perform real-time, backward-looking, and forward-looking analysis by functioning in data-driven and model-driven ways. All of them have considerable practical values in their applications according to the actual needs of personal use. Conclusively, K-SEIR-Sim is the first simple customized operating software that is highly valuable for the global fight against COVID-19 and other infectious diseases.



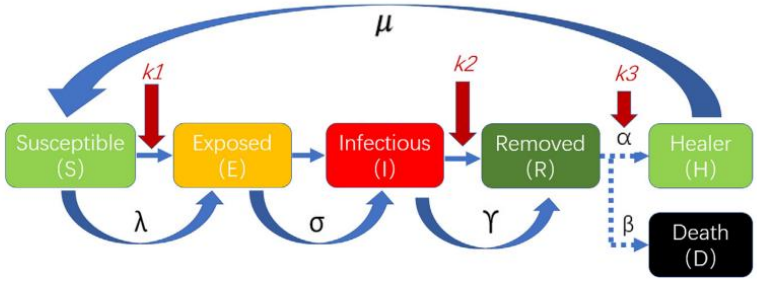


Fig. 1. Schematic of the logic structure of the K-SEIR-Sim model. The K-SEIR-Sim model consists of Susceptible (S), Exposed (E), Infectious (I), Removed (R), Healer (H), and Death (D). The parameter of human intervention measures is K, which includes three parameters: k_1 is a measure of physical isolation; k_2 is a measure of hospital admission capacity; and k_3 is a measure of the ability of medical treatment .

Table 1
Basic information for K-SEIR model.

Population	Formula	Parameter
Susceptible (S)	$\frac{ds}{dt} = -\lambda si/N + \mu h$	λ: average daily infection rate s: number of the population (S) at time t i : number of the population (I) at time t μ: average daily rate of reinfection h: number of the population (H) at time t *N*: number of total population in a certain region
Exposed (E)	$\frac{de}{dt} = \lambda si/N - \sigma e$	σ: incidence rate per day e: number of the population (E) at time t
Infectious (I)	$\frac{di}{dt} = \sigma e - \gamma i$	γ: average daily removal rate for infected patients
Removed (R)	$\frac{dr}{dt} = \gamma i$	It's the sum of the cured and the dead
Healer (H)	$h = \alpha r$	r: number of the population (R) at time t α: average daily cure rate
Death (D)	$d = \beta r$	β: average daily mortality rate
	$\alpha + \beta = \gamma$	
	$s_0 + e_0 + i_0 + r_0 = N$	0: time $t = 0$
	$\lambda_k = (1 - k_1)\lambda$	K: kernel for human intervention
	$\gamma_k = k_2\gamma$	k_1: physical isolation measure, the coefficient of λ
	$\alpha_k = k_3\alpha$	k_2: hospital admission capacity, the coefficient of γ
		k_3: the ability of medical treatment, the coefficient of α

Note: $\lambda = R_0/AIP$. R_0 stands for basic reproductive number, and AIP stands for average infectious period. $\sigma = 1/IP$. IP stands for incubation period.

* * * * * * * *

How to Choose an Experimental Design?

Selecting the right experimental design depends on your experiment's goals and the number of factors being studied. Here are common objectives and the designs suited for them [1]:

1. Comparative Design:

Use this if your main goal is to study the impact of one specific factor, even if other factors are present. The focus is on determining whether the key factor causes a significant change in the response.

2. Screening Design:

If the goal is to identify the most important factors from many possibilities, use a screening design. These designs help highlight the main effects while ignoring less significant ones.

3. Response Surface Design (RSM):

This design is useful when you want to estimate interactions or quadratic effects and understand the shape of the response surface. RSM designs can:

- Optimize process settings.
- Identify and fix process issues.
- Make a process or product more resistant to external or uncontrollable influences.

4. Mixture Design:

If your factors represent proportions of a mixture, and you want to determine the best proportions to maximize or minimize a response, choose a mixture design.

5. Regression Design:

If your goal is to model the response as a mathematical function of a few continuous factors and obtain precise parameter estimates, use a regression design. This is ideal for achieving unbiased results with minimal error.

Design Selection Guideline

Number of Factors	Comparative Objective	Screening Objective	Response Surface Objective
1	One-factor completely randomized design	-	-
2 – 4	Randomized block design	**Full or fractional factorial**	Central composite or Box-Behnken
5 or more	Randomized block design	Fractional factorial or Plackett-Burman	Screen first to reduce the number of factors

Full Factorial Designs with Two Levels

A full factorial design [1] is a method used in experiments to test multiple factors at the same time. It ensures that every combination of factors is tested together.

[from https://www.itl.nist.gov/div898/handbook/pri/section3/pri333.htm]

When each factor in the experiment is tested at only two levels, usually referred to as "high" and "low" (or "+1" and "-1"), it is called a **full factorial design with two levels**. This means that all possible combinations of these high and low settings for every factor are included in the experiment.

This type of design helps researchers understand how different factors and their combinations affect the outcome, providing a complete picture of the system being studied.

If there are k factors, each at 2 levels, a full factorial design has 2^k runs.

Number of Runs for a 2^k Full Factorial

Number of Factors	Number of Runs
2	4
3	8
4	16
5	32
6	64
7	128

Two-Level Full Factorial Designs

Consider the two-level, full factorial design for three factors, namely the 2^3 designs. This implies eight runs (not counting replications or center point runs).

The design matrix. In tabular form, this design is given by:

TABLE. A 2^3-two-level, full factorial design table showing runs in `Standard Order'

run	*X*1	*X*2	*X*3
1	-1	-1	-1
2	1	-1	-1
3	-1	1	-1
4	1	1	-1
5	-1	-1	1
6	1	-1	1
7	-1	1	1
8	1	1	1

The left-most column of Table, numbers 1 through 8, specifies a (non-randomized) run order called the

`Standard Order.' For example, run 1 is made at the `low' setting of all three factors.

How to Construct the Standard Order Matrix:

- The first column (X1) alternates between -1 and +1 for all runs.
- The second column (X2) has two consecutive -1s followed by two consecutive +1s, repeating until all runs are covered.
- The third column (X3) starts with four consecutive -1s, followed by four consecutive +1s, and so on.
- In general, for the i-th factor (Xi), the pattern begins with 2^{i-1} repeats of -1, followed by 2^{i-1} repeats of +1, continuing until all 2^k runs (where k is the number of factors) are filled.

This structure allows for a systematic exploration of all possible combinations of factor levels, ensuring that the experiment covers every potential interaction.

Preliminary Analysis of Experimental Data

Cochran's test is used for testing **homogeneity of variance** and calculating **variance of reproducibility.**

Cochran's test is calculated as follows: $g = \frac{s^2_{\max}}{\sum_{i=1}^{N} s_i^2}$,

where $s^2_{\max}$ is the maximum variance, $s_i^2 = \frac{\sum_{j=1}^{n} (y_{ij} - \bar{y}_i)^2}{n-1}$, n is the number of duplications of the experiment in a set.

If **g<g***, then it could be said that **variance is homogeneous**. Critical value g*=g (α; n; N-1) is taken from **Cochran's test** table.

The variance of reproducibility is calculated as follows:

$$s^2_{repr.} = \frac{\sum_{i=1}^{N} s_i^2}{N}.$$

Obtaining Regression Coefficients of Mathematical Model

The coefficients of the linear regression equation are calculated as follows:

$b_0 = \frac{\sum_{i=1}^{N} x_0 \bar{y}_i}{N}$, $b_q = \frac{\sum_{i=1}^{N} x_q \bar{y}_i}{N}$, $b_{qp} = \frac{\sum_{i=1}^{N} x_q x_p \bar{y}_i}{N}$, $\bar{y}_i = \frac{\sum_{j=1}^{n} \bar{y}_{ij}}{n}$, q = 1, ..., m and p = 1, ..., m.

Checking the significance of **coefficients of the mathematical model** is performed using **Student's t-test**, critical value t* = t(p=1-α;ν=N(n-1)) which is taken from the Student's distribution table.

The Interval of significance Δ is calculated as follows: $\Delta = t * \sqrt{\frac{s^2_{repr.}}{N}}$. If $|b_0| > \Delta$, $|b_q| > \Delta$, $|b_{qp}| > \Delta$, then respectively **coefficients b_0, b_q,** and **b_{qp}** are **significant**.

Practical tasks for students. Instructions for execution of practical work

1. Start a computer and wait for the loading of Windows OS**.**

2. Start **Microsoft Excel** program: **Start** → **ALL Programs** → **Microsoft Office** → **Microsoft Excel**.

3. *Save the document on Desktop* (select the **File** tab, then click **Save** or click the **Save** icon on the Quick Access toolbar**.** Type ***Mathematical models*** in the highlighted File name text box, click Desktop in the left part of the Save window, and click the Save button).

Attention: *Don't forget to click the icon* ***Save*** *on the* ***Quick Access toolbar*** *every few minutes during the lesson to avoid losing your work.*

4. Perform the following tasks:

****

Task №1. *Using **WolframAlpha** computational knowledge engine (https://www.wolframalpha.com/) perform the following tasks:*

A research team is studying how the immune system (predators) interacts with tumor cells (prey). A new drug is designed to enhance the immune system's ability to target and eliminate tumor cells. The team wants to compare tumor and immune cell populations over time with and without the drug.

Problem:

Using the Lotka-Volterra Model of Predation, simulate the interaction between tumor cells (prey) and immune cells (predators) under the following conditions:

Parameters:

- Initial Tumor Cells (P_0): 200,000 cells.
- Initial Immune Cells (Z_0): 50,000 cells.
- Tumor Growth Rate (**a**): 0.2/day.
- Immune Attack Rate (**b**):
  - Without the drug: 0.0001.
  - With the drug: 0.0004.
- Immune Death Rate (**c**): 0.1/day.
- Immune Reproduction Rate (**d**): 0.00005.
- Simulation Period: 30 days.

Task:

1. Simulate tumor and immune cell interactions over 30 days without the drug.
2. Repeat the simulation with the drug, which increases the immune system's attack rate (b).

Compare:

The peak tumor cell population.
The total reduction in tumor cells.
The stability of immune cell populations in both scenarios.

Write and implement a computer simulation using numerical integration of the **Lotka-Volterra predation model**. Set the following constants of the model:

Prey population growth parameter	a =
Predator population extinction parameter	c =
Species interaction parameter 1	b =
Species interaction parameter 2	d =
Initial prey population	
Initial predator population	

Start your simulation with **P0 = {200000 + your group number}** and **Z0 = {50000 – your number in the group list}**.

● When the task is done, take a screenshot of the *whole **WolframAlpha Widgets*** window, and insert the screenshot in the new slide of the **MS PowerPoint** document.

****

Task №2. *Using **Microsoft Excel**, identify the influence of factors on the reduction of patients' weight, build a mathematical model of full factorial design and assess its adequacy, considering that α = 0.05 and in the investigation following data were received:*

№	Reduction of patients' weight, kg		
	Y_1	Y_2	Y_3
1	7.8	6.3	6.9
2	5.45	5.9	6.1
3	-2.1	-1.7	-1.9
4	5.9	6.2	5.4
5	4.3	5.1	4.6
6	3.1	2.9	2.4
7	-1.5	-2.4	-1.9
8	1.3	2.4	0.7
Y_1, Y_2, Y_3 – results of repeated measurements			

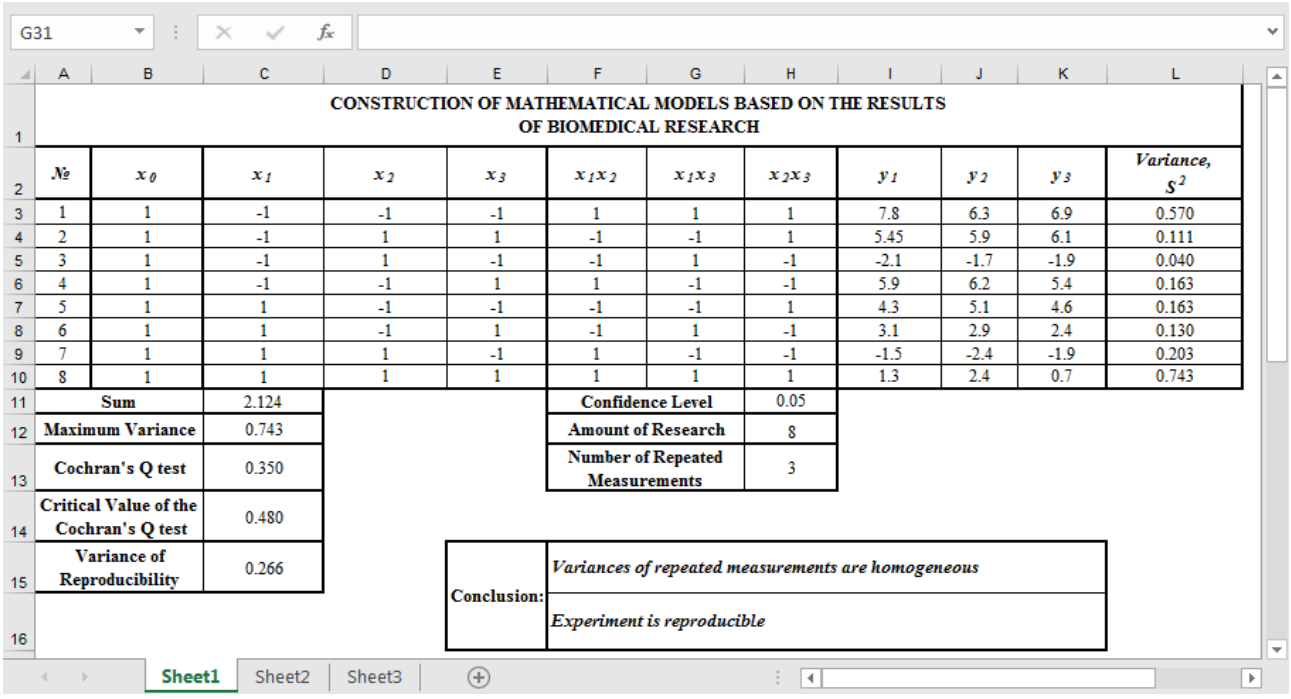
Experiment domain:

Factor	1	2	3
Denotation	X_1	X_2	X_3
Meaning	**Physical training**	**Diet**	**Size of food portion**
Units	**min**	**days**	**g**
Bottom level	30	5	150
Main level	45	10	250
Top-level	60	15	350
Variation interval	15	5	100

*Create a new table as shown in **Fig. 1***:
select cells **A1:L1** on the **Sheet1**, on the **Home** tab, in the **Alignment** group, click **Merge and Center** ;
in the same way merge cells **A11:B11**, **A12:B12**, **A13:B13**, **A14:B14**, **A15:B15**, **F11:G11**, **F12:G12**, **F13:G13**, **E15:E16**, **F15:K15** and **F16:K16**;
type text into cells **A1:L2, A3:E10, A11:A15, F11:F13, I3:K10** and **E15** according to **Fig.1**;
click the cell **H11** and type **0.05;**

Perform the calculations:
click the cell **F3** and enter the formula **=C3*D3 ®** press **Enter**;
click the cell **G3** and enter the formula **=C3*E3 ®** press **Enter**;
click the cell **H3** and enter the formula **=D3*E3 ®** press **Enter**;
copy the formulas from the cells **F3:H3** into the cells **F4:H10** using drag and drop method;
click the cell **L3** and enter the formula **=VAR.S(I3:K3)** (click the cell **L3**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **VAR.S** → **OK** → enter **I3:K3** → **OK)**;
copy the formula from the cell **L3** into the cells **L4:L10** using drag and drop method;
click the cell **H12** and enter the formula **=COUNT(A3:A10)** (click the cell **H12**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNT** → **OK** → enter **A3:A10** → **OK)**;
click the cell **H13** and enter the formula **=COUNT(I3:K3)** (click the cell **H13**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNT** → **OK** → enter **I3:K3** → **OK)**;

click the cell **C11** and enter the formula **=SUM(L3:L10)** (click the cell **C11**, click **Insert Function** button on the **Formula bar** → select **Math & Trig** from **select a category** box → select **SUM** → **OK** → enter **L3:L10** → **OK)**;
click the cell **C12** and enter the formula **=MAX(L3:L10)** (click the cell **C12**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **MAX** → **OK** → enter **L3:L10** → **OK)**;
click the cell **C13** and enter the formula **=C12/C11 ®** press **Enter**;
click the cell **C14** and enter the formula:
=F.INV.RT(H11/(H12-1),H13,H13*(H12-2))/(F.INV.RT(H11/(H12-1),H13,H13*(H12-2))+H12-2);
click the cell **C15** and enter the formula **=C11/H12 ®** press **Enter**;
click the cell **F15** and enter the formula **=IF(C13<C14,"Variances of repeated measurements are homogeneous","Variances of repeated measurements are not homogeneous")** (click the cell **F15,** click **Insert Function** button on the **Formula bar** → select **Logical** from **select a category** box → select **IF** → **OK** → enter **C13<C14** in **Logical_test** box → enter **Variances of repeated measurements are homogeneous** in **Value_if_true** box → enter **Variances of repeated measurements are not homogeneous** in **Value_if_false** box → **OK**);
click the cell **F16** and enter the formula **=IF(C13<C14,"Experiment is reproducible","Experiment is not reproducible")** (click the cell **F16,** click **Insert Function** button on the **Formula bar** → select **Logical** from **select a category** box → select **IF** → **OK** → enter **C13<C14** in **Logical_test** box → enter **Experiment is reproducible** in **Value_if_true** box → enter **Experiment is not reproducible** in **Value_if_false** box → **OK**);



CONSTRUCTION OF MATHEMATICAL MODELS BASED ON THE RESULTS OF BIOMEDICAL RESEARCH

№	x_0	x_1	x_2	x_3	x_1x_2	x_1x_3	x_2x_3	y_1	y_2	y_3	Variance, S^2
1	1	-1	-1	-1	1	1	1	7.8	6.3	6.9	0.570
2	1	-1	1	1	-1	-1	1	5.45	5.9	6.1	0.111
3	1	-1	1	-1	-1	1	-1	-2.1	-1.7	-1.9	0.040
4	1	-1	-1	1	1	-1	-1	5.9	6.2	5.4	0.163
5	1	1	-1	-1	-1	-1	1	4.3	5.1	4.6	0.163
6	1	1	-1	1	-1	1	-1	3.1	2.9	2.4	0.130
7	1	1	1	-1	1	-1	-1	-1.5	-2.4	-1.9	0.203
8	1	1	1	1	1	1	1	1.3	2.4	0.7	0.743

Sum	2.124	Confidence Level	0.05
Maximum Variance	0.743	Amount of Research	8
Cochran's Q test	0.350	Number of Repeated Measurements	3
Critical Value of the Cochran's Q test	0.480		
Variance of Reproducibility	0.266		

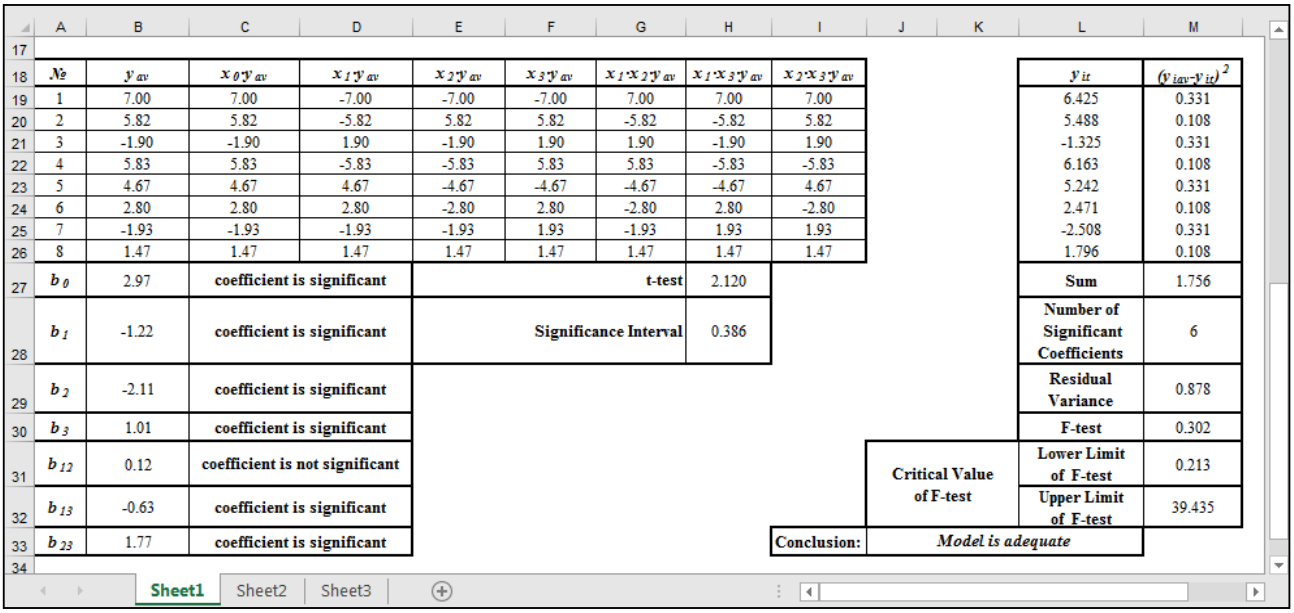
Conclusion:	*Variances of repeated measurements are homogeneous*
	Experiment is reproducible

Fig. 1

*On the same sheet create a table as shown in **Fig. 2***:
select cells **C27:D27** on the **Sheet1**, on the **Home** tab, in the **Alignment** group, click **Merge and Center**;
in the same way merge cells **C28:D28**, **C29:D29**, **C30:D30**, **C31:D31**, **C32:D32**, **C33:D33**, **E27:G27**, **E28:G28, J31:K32** and **J33:L33**;
type text into cells **A18:I18, A19:A33, E27:E28, L18:M18, L27:L32, J31** and **I33** according to **Fig.2**;

Perform the calculations:
click the cell **B19** and enter the formula **=AVERAGE(I3:K3)** (click the cell **B19**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** →

enter **I3:K3 → OK)**;
copy the formula from the cell **B19** into the cells **B20:B26** using drag and drop method;
click the cell **C19** and enter the formula **=B3*$B19 ®** press **Enter**;
copy the formula from the cell **C19** into the cells **C20: C26** using drag and drop method;
copy the formulas from the cells **C19:C26** into the cells **D19:I26** using drag and drop method;



№	y_{av}	x_0y_{av}	x_1y_{av}	x_2y_{av}	x_3y_{av}	$x_1x_2y_{av}$	$x_1x_3y_{av}$	$x_2x_3y_{av}$
1	7.00	7.00	-7.00	-7.00	-7.00	7.00	7.00	7.00
2	5.82	5.82	-5.82	5.82	5.82	-5.82	-5.82	5.82
3	-1.90	-1.90	1.90	-1.90	1.90	1.90	-1.90	1.90
4	5.83	5.83	-5.83	-5.83	5.83	5.83	-5.83	-5.83
5	4.67	4.67	4.67	-4.67	-4.67	-4.67	-4.67	4.67
6	2.80	2.80	2.80	-2.80	2.80	-2.80	2.80	-2.80
7	-1.93	-1.93	-1.93	-1.93	1.93	-1.93	1.93	1.93
8	1.47	1.47	1.47	1.47	1.47	1.47	1.47	1.47

b_0	2.97	coefficient is significant	t-test	2.120
b_1	-1.22	coefficient is significant	Significance Interval	0.386
b_2	-2.11	coefficient is significant		
b_3	1.01	coefficient is significant		
b_{12}	0.12	coefficient is not significant		
b_{13}	-0.63	coefficient is significant		
b_{23}	1.77	coefficient is significant		

y_{it}	$(y_{iav}-y_{it})^2$
6.425	0.331
5.488	0.108
-1.325	0.331
6.163	0.108
5.242	0.331
2.471	0.108
-2.508	0.331
1.796	0.108
Sum	1.756
Number of Significant Coefficients	6
Residual Variance	0.878
F-test	0.302
Lower Limit of F-test	0.213
Upper Limit of F-test	39.435

Critical Value of F-test	
Conclusion:	*Model is adequate*

Sheet1 Sheet2 Sheet3

Fig. 2.

click the cell **B27** and enter the formula **=AVERAGE(C19:C26)** (click the cell **B27**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → enter **C19:C26** → **OK)**;
click the cell **B28** and enter the formula **=AVERAGE(D19:D26)** (click the cell **B28**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → enter **D19:D26** → **OK)**;
click the cell **B29** and enter the formula **=AVERAGE(E19:E26)** (click the cell **B29**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → enter **E19:E26** → **OK)**;
click the cell **B30** and enter the formula **=AVERAGE(F19:F26)** (click the cell **B30**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → enter **F19:F26** → **OK)**;
click the cell **B31** and enter the formula **=AVERAGE(G19:G26)** (click the cell **B31**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → enter **G19:G26** → **OK)**;
click the cell **B32** and enter the formula **=AVERAGE(H19:H26)** (click the cell **B32**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → enter **H19:H26** → **OK)**;
click the cell **B33** and enter the formula **=AVERAGE(I19:I26)** (click the cell **B33**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **AVERAGE** → **OK** → enter **I19:I26** → **OK)**;
click the cell **H27** and enter the formula **=T.INV.2T(H11,H12*(H13-1))** (click the cell **H27**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **T.INV.2T** → **OK** → enter **H11** in **Probability** box → enter **H12*(H13-1)** in **Deg_freedom** box → **OK)**;
click the cell **H28** and enter the formula **=H27*SQRT(C15/H12) ®** press **Enter**;
click the cell **C27** and enter the formula **=IF(ABS(B27)>$H$28,"coefficient is significant","coefficient is not significant")** (click the cell **C27,** click **Insert Function** button f_x on the **Formula bar** → select

Logical from **select a category** box → select **IF** → **OK** → enter **ABS(B27)>$H$28** in **Logical_test** box → enter **coefficient is significant** in **Value_if_true** box → enter **coefficient is not significant** in **Value_if_false** box → **OK**);
copy the formula from the cell **C27** into the cells **C28:C33** using drag and drop method;
click the cell **L19** and enter the formula:
=$B$27*B3+$B$28*C3+$B$29*D3+$B$30*E3+$B$32*G3+$B$33*H3 ® press **Enter**;
copy the formula from the cell **L19** into the cells **L20:L26** using drag and drop method;
click the cell **M19** and enter the formula **=(B19-L19)^2 ®** press **Enter**;
copy the formula from the cell **M19** into the cells **M20:M26** using drag and drop method;
click the cell **M27** and enter the formula **=SUM(M19:M26)** (click the cell **M27**, click **Insert Function** button on the **Formula bar** → select **Math & Trig** from **select a category** box → select **SUM** → **OK** → enter **M19:M26** → **OK)**;
click the cell **M28** and enter the formula **=COUNT(B27:B33)-1 ®** press **Enter**;
click the cell **M29** and enter the formula **=M27/(H12-M28) ®** press **Enter**;
click the cell **M30** and enter the formula **=C15/M29 ®** press **Enter**;
click the cell **M31** and enter the formula **=F.INV.RT(1-H11/2,H12*(H13-1),H12-M28)** (click the cell **M31**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **F.INV.RT** → **OK** → enter **1-H11/2** in **Probability** box → enter **H12*(H13-1)** in **Deg_freedom1** box → enter **H12-M28** in **Deg_freedom2** box → **OK)**;
click the cell **M32** and enter the formula **=FINV(H11/2,H12*(H13-1),H12-M28)** (click the cell **M32**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **F.INV.RT** → **OK** → enter **H11/2** in **Probability** box → enter **H12*(H13-1)** in **Deg_freedom1** box → enter **H12-M28** in **Deg_freedom2** box → **OK)**;
click the cell **J33** and enter the formula **=IF(AND(M31<M30,M30<M32),"Model is adequate","Model is not adequate")** (click the cell **J33,** click **Insert Function** button on the **Formula bar** → select **Logical** from **select a category** box → select **IF** → **OK** → enter **Model is adequate** in **Value_if_true** box → enter **Model is not adequate** in **Value_if_false** box → click **Logical_test** box and click **triangle** button next to **Formula Bar** → click **More Funktions…** → select **Logical** from **select a category** box → select **AND** → **OK** → enter **M31<M30** in **Logical1** box → enter **M30<M32** in **Logical2** box → **OK**);

*Format the tables according to **Fig. 1** and **Fig. 2**.*
Formatting instructions:
Font: **Times New Roman**;
Size: **12;**
Style: cells **A2:L2, F15:F16, A18:I18, L18:M18, A27:A33, C27:C33** and **J33 – Bold Italic**; **A1:L2, A11:A15, F11:F13, E15, E27:E28, L27:L32, J31,** and **I33** – **Bold**; other cells – **Regular**;
Horizontal alignment: cells **F15:F16** – **Left**, **E27:E28** – **Right**, other cells – **Center**;
Vertical alignment: **Center**;
*Apply cell borders to the table according to **Fig. 1** and **Fig. 2**.*
*Click **Save** .*

****

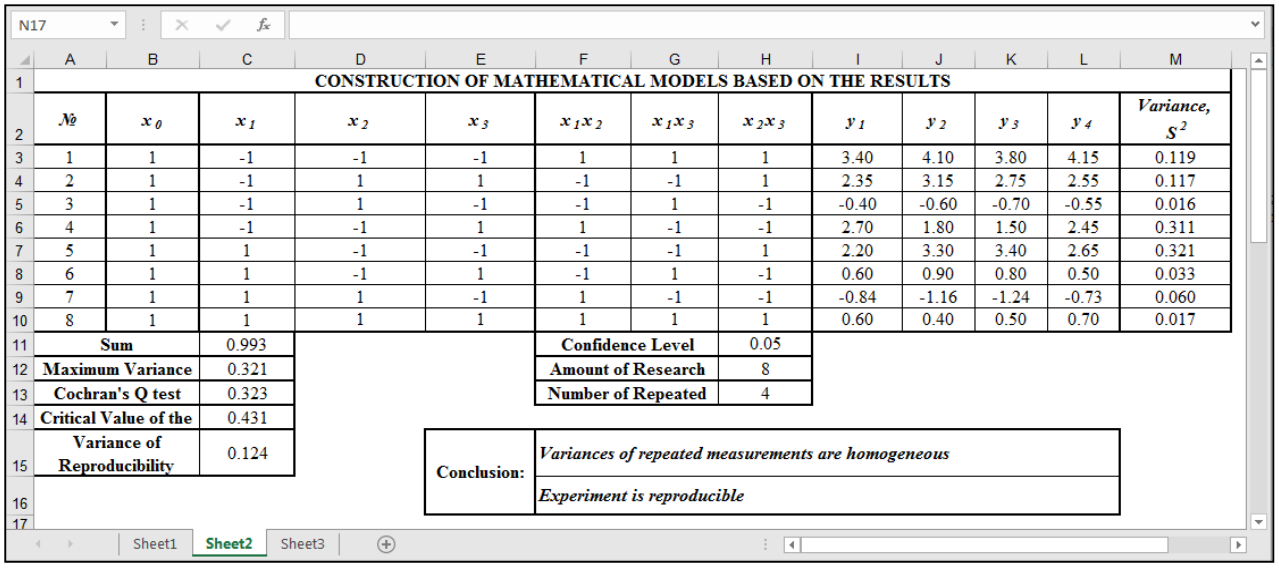
Task №3. *Using **Microsoft Excel**, identify the influence of factors on the value of the output of the main substance in the chemical reaction, build a mathematical model of full factorial design and assess its adequacy, considering that **α = 0.05** and in the investigation following data were received:*

№	The output of the main substance, g			
	Y_1	Y_2	Y_3	Y_4
1	3.40	4.10	3.80	4.15
2	2.35	3.15	2.75	2.55
3	-0.40	-0.60	-0.70	-0.55
4	2.70	1.80	1.50	2.45
5	2.20	3.30	3.40	2.65
6	0.60	0.90	0.80	0.50
7	-0.84	-1.16	-1.24	-0.73
8	0.60	0.40	0.50	0.70
Y_1, Y_2, Y_3, Y_4 – results of repeated measurements				

Experiment domain:

Factor	1	2	3
Denotation	X_1	X_2	X_3
Meaning	**Temperature**	**Time**	**Radiation dose**
Units	**°C**	**s**	**mR**
Bottom level	30	30	0.4
Main level	45	55	0.7
Top-level	60	80	1.0
Variation interval	15	25	0.3

*Create a new table as shown in **Fig. 3** and **Fig. 4**:*



CONSTRUCTION OF MATHEMATICAL MODELS BASED ON THE RESULTS

№	x_0	x_1	x_2	x_3	x_1x_2	x_1x_3	x_2x_3	y_1	y_2	y_3	y_4	Variance, S^2
1	1	-1	-1	-1	1	1	1	3.40	4.10	3.80	4.15	0.119
2	1	-1	1	1	-1	-1	1	2.35	3.15	2.75	2.55	0.117
3	1	-1	1	-1	-1	1	-1	-0.40	-0.60	-0.70	-0.55	0.016
4	1	-1	-1	1	1	-1	-1	2.70	1.80	1.50	2.45	0.311
5	1	1	-1	-1	-1	-1	1	2.20	3.30	3.40	2.65	0.321
6	1	1	-1	1	-1	1	-1	0.60	0.90	0.80	0.50	0.033
7	1	1	1	-1	1	-1	-1	-0.84	-1.16	-1.24	-0.73	0.060
8	1	1	1	1	1	1	1	0.60	0.40	0.50	0.70	0.017

Sum	0.993	Confidence Level	0.05
Maximum Variance	0.321	Amount of Research	8
Cochran's Q test	0.323	Number of Repeated	4
Critical Value of the	0.431		
Variance of Reproducibility	0.124		

Conclusion:	*Variances of repeated measurements are homogeneous*
	Experiment is reproducible

Fig. 3

click **Sheet1** → select cells **A1:M33** → on the **Home** tab click **Copy** → click **Sheet2** → select cell **A1** → on the **Home** tab click **Paste**;
solve the problem by corrections of data according to **Task 2** (see. **Fig.3, Fig. 4**) and using instructions on **Fig.5, Fig.6,** and **Fig.7**;

*Format the table according to **Fig. 3** and **Fig. 4**.*

*Apply cell borders to the table according to **Fig. 3** and **Fig. 4**.*

*Click **Save** .*

№	y_{av}	$x_0 y_{av}$	$x_1 y_{av}$	$x_2 y_{av}$	$x_3 y_{av}$	$x_1 x_2 y_{av}$	$x_1 x_3 y_{av}$	$x_2 x_3 y_{av}$
1	3.86	3.86	-3.86	-3.86	-3.86	3.86	3.86	3.86
2	2.70	2.70	-2.70	2.70	2.70	-2.70	-2.70	2.70
3	-0.56	-0.56	0.56	-0.56	0.56	0.56	-0.56	0.56
4	2.11	2.11	-2.11	-2.11	2.11	2.11	-2.11	-2.11
5	2.89	2.89	2.89	-2.89	-2.89	-2.89	-2.89	2.89
6	0.70	0.70	0.70	-0.70	0.70	-0.70	0.70	-0.70
7	-0.99	-0.99	-0.99	-0.99	0.99	-0.99	0.99	0.99
8	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55

b_0	1.41	coefficient is significant	t-test	2.064
b_1	-0.62	coefficient is significant	Significance Interval	0.257
b_2	-0.98	coefficient is significant		
b_3	0.11	coefficient is not significant		
b_{12}	-0.02	coefficient is not significant		
b_{13}	-0.27	coefficient is significant		
b_{23}	1.09	coefficient is significant		

y_{it}	$(y_{iav}-y_{it})^2$
3.726	0.019
2.516	0.034
-0.426	0.019
2.297	0.034
3.024	0.019
0.516	0.034
-1.129	0.019
0.734	0.034
Sum	0.210
Number of Significant Coefficients	5
Residual Variance	0.070
F-test	1.771
Lower Limit of F-test	0.269
Upper Limit of F-test	14.124

Critical Value of F-test	
Conclusion:	*Model is adequate*

Sheet1 Sheet2 Sheet3

Fig. 4

№	x_0	x_1	x_2
1	1	-1	-1
2	1	-1	1
3	1	-1	1
4	1	-1	-1
5	1	1	-1
6	1	1	-1
7	1	1	1
8	1	1	1

Sum	=SUM(M3:M10)
Maximum Variance	=MAX(M3:M10)
Cochran's Q test	=C12/C11
Critical Value of the	=F.INV.RT(H11/(H12-1),H13,H13*(H12-2))/(F.INV.RT(H11/(H12-1),H13,H13*(H12-2))+H12-2)
Variance of Reproducibility	=C11/H12

№	y_{av}	$x_0 y_{av}$	$x_1 y_{av}$
1	=AVERAGE(I3:L3)	=B3*$B19	=C3*$B19
2	=AVERAGE(I4:L4)	=B4*$B20	=C4*$B20
3	=AVERAGE(I5:L5)	=B5*$B21	=C5*$B21
4	=AVERAGE(I6:L6)	=B6*$B22	=C6*$B22
5	=AVERAGE(I7:L7)	=B7*$B23	=C7*$B23
6	=AVERAGE(I8:L8)	=B8*$B24	=C8*$B24
7	=AVERAGE(I9:L9)	=B9*$B25	=C9*$B25
8	=AVERAGE(I10:L10)	=B10*$B26	=C10*$B26

b_0	=AVERAGE(C19:C26)	=IF(ABS(B27)>$H$28,"coefficient is significant","coefficient is not significant")
b_1	=AVERAGE(D19:D26)	=IF(ABS(B28)>$H$28,"coefficient is significant","coefficient is not significant")
b_2	=AVERAGE(E19:E26)	=IF(ABS(B29)>$H$28,"coefficient is significant","coefficient is not significant")
b_3	=AVERAGE(F19:F26)	=IF(ABS(B30)>$H$28,"coefficient is significant","coefficient is not significant")
b_{12}	=AVERAGE(G19:G26)	=IF(ABS(B31)>$H$28,"coefficient is significant","coefficient is not significant")
b_{13}	=AVERAGE(H19:H26)	=IF(ABS(B32)>$H$28,"coefficient is significant","coefficient is not significant")
b_{23}	=AVERAGE(I19:I26)	=IF(ABS(B33)>$H$28,"coefficient is significant","coefficient is not significant")

Fig. 5

	E	F	G	H	I	J	K	L
2	x_3	x_1x_2	x_1x_3	x_2x_3	y_1	y_2	y_3	y_4
3	-1	=C3*D3	=C3*E3	=D3*E3	3.4	4.1	3.8	4.15
4	1	=C4*D4	=C4*E4	=D4*E4	2.35	3.15	2.75	2.55
5	-1	=C5*D5	=C5*E5	=D5*E5	-0.4	-0.6	-0.7	-0.55
6	1	=C6*D6	=C6*E6	=D6*E6	2.7	1.8	1.5	2.45
7	-1	=C7*D7	=C7*E7	=D7*E7	2.2	3.3	3.4	2.65
8	1	=C8*D8	=C8*E8	=D8*E8	0.6	0.9	0.8	0.5
9	-1	=C9*D9	=C9*E9	=D9*E9	-0.84	-1.16	-1.24	-0.73
10	1	=C10*D10	=C10*E10	=D10*E10	0.6	0.4	0.5	0.7
11		**Confidence Level**		0.05				
12		**Amount of Research**		=COUNT(A3:A10)				
13		**Number of Repeated**		=COUNT(I3:L3)				
14								
15	**Conclusion:**	*=IF(C13<C14,"Variances of repeated measurements are homogeneous","Variances of repeated measurements are not homogeneous")*						
16		*=IF(C13<C14,"Experiment is reproducible","Experiment is not reproducible")*						
17								
18	$x_2 \cdot y_{av}$	$x_3 \cdot y_{av}$	$x_1 \cdot x_2 \cdot y_{av}$	$x_1 \cdot x_3 \cdot y_{av}$	$x_2 \cdot x_3 \cdot y_{av}$			
19	=D3*$B19	=E3*$B19	=F3*$B19	=G3*$B19	=H3*$B19			
20	=D4*$B20	=E4*$B20	=F4*$B20	=G4*$B20	=H4*$B20			
21	=D5*$B21	=E5*$B21	=F5*$B21	=G5*$B21	=H5*$B21			
22	=D6*$B22	=E6*$B22	=F6*$B22	=G6*$B22	=H6*$B22			
23	=D7*$B23	=E7*$B23	=F7*$B23	=G7*$B23	=H7*$B23			
24	=D8*$B24	=E8*$B24	=F8*$B24	=G8*$B24	=H8*$B24			
25	=D9*$B25	=E9*$B25	=F9*$B25	=G9*$B25	=H9*$B25			
26	=D10*$B26	=E10*$B26	=F10*$B26	=G10*$B26	=H10*$B26			
27				**t-test**	=T.INV.2T(H11,H12*(H13-1))			
28				**Significance Interval**	=H27*$QRT(C15/H12)			
29								
30								
31						**Critical Value of F-test**		
32								
33					**Conclusion:**	*=IF(AND(N31<N30,N30<N32),"Model is adequate","Model is not adequate")*		

Fig. 6

	M	N
2	*Variance, S^2*	
3	=VAR.S(I3:L3)	
4	=VAR.S(I4:L4)	
5	=VAR.S(I5:L5)	
6	=VAR.S(I6:L6)	
7	=VAR.S(I7:L7)	
8	=VAR.S(I8:L8)	
9	=VAR.S(I9:L9)	
10	=VAR.S(I10:L10)	
18	y_{ie}	$(y_{iav}-y_{ie})^2$
19	=$B$27*B3+$B$28*C3+$B$29*D3+$B$30*E3+$B$32*G3+$B$33*H3	=(B19-M19)^2
20	=$B$27*B4+$B$28*C4+$B$29*D4+$B$30*E4+$B$32*G4+$B$33*H4	=(B20-M20)^2
21	=$B$27*B5+$B$28*C5+$B$29*D5+$B$30*E5+$B$32*G5+$B$33*H5	=(B21-M21)^2
22	=$B$27*B6+$B$28*C6+$B$29*D6+$B$30*E6+$B$32*G6+$B$33*H6	=(B22-M22)^2
23	=$B$27*B7+$B$28*C7+$B$29*D7+$B$30*E7+$B$32*G7+$B$33*H7	=(B23-M23)^2
24	=$B$27*B8+$B$28*C8+$B$29*D8+$B$30*E8+$B$32*G8+$B$33*H8	=(B24-M24)^2
25	=$B$27*B9+$B$28*C9+$B$29*D9+$B$30*E9+$B$32*G9+$B$33*H9	=(B25-M25)^2
26	=$B$27*B10+$B$28*C10+$B$29*D10+$B$30*E10+$B$32*G10+$B$33*H10	=(B26-M26)^2
27	**Sum**	=SUM(N19:N26)
28	**Number of Significant Coefficients**	=COUNT(B27:B33)-2
29	**Residual Variance**	=N27/(H12-N28)
30	**F-test**	=C15/N29
31	**Lower Limit of F-test**	=F.INV.RT(1-H11/2,H12*(H13-1),H12-N28)
32	**Upper Limit of F-test**	=FINV(H11/2,H12*(H13-1),H12-N28)

Sheet1 | Sheet2 | Sheet3

Fig. 7

5. Show the teacher the results of your work.
6. Close the **MS Excel** document.

Attention*: After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:
Excel help & learning. Microsoft.com. from https://support.microsoft.com/en-us/excel
1) 5.3.3. How do you select an experimental design? Nist.gov. [cited 2024 Nov 20]. Available from: https://www.itl.nist.gov/div898/handbook/pri/section3/pri33.htm
2) Van Belle, G., & Kerr, K. F. (2012). *Design and analysis of experiments in the health sciences: Van belle/design and analysis health*. Wiley-Blackwell.
3) Roy, S., Goyal, L. M., Balas, V. E., Agarwal, B., & Mittal, M. (2022). *Predictive modeling in Biomedical Data Mining and analysis*. Academic Press.
4) Najarian, K., & Splinter, R. (2012). *Biomedical Signal and Image Processing* (2nd ed.). CRC Press.
Additional
1) Subasi, A. (2019). *Practical guide for biomedical signals analysis using machine learning techniques*: A MATLAB based approach. Academic Press.
2) Hoffman, J. I. E. (2019). *Biostatistics for medical and biomedical practitioners* (2nd ed.). Academic Press.

Topic 14: MODELING AND SOLVING MARKETING PROBLEMS IN MEDICINE.

Actuality: Healthcare patients have more options than ever before. With so much information available online, these patients no longer feel the need to visit the closest hospital, a medical practice nearest to their location, or even healthcare practices with multiple locations in the community. That's why it's so important to have a planned, budgeted healthcare marketing plan to reach new and returning patients in your area at the right moment.

Educational aims of the lesson:

To know:

1. basis of algorithmization of medical tasks;
2. verification of statistical hypotheses.

To be able to:

1. solve marketing problems using MS Excel;

The list of questions for the survey:

1. Bases of algorithmization of medical tasks.
2. Types of algorithms.
3. Verification of statistical hypotheses about the equality of variances of two normally distributed populations.
4. Verification of statistical hypotheses about the equality of centers of distribution of two independent normally distributed populations when their variances are unknown and it is assumed that they are equal (small samples).
5. Determination of connection between variables. Contingency tables.

The list of required practical skills:

1. solving marketing problems using MS Excel.

Brief theoretical information

What is healthcare marketing? [https://webmdignite.com/faq/what-is-healthcare-marketing]

Healthcare marketing is a strategy for doctors, hospitals, healthcare networks, health practitioners, caregivers, healthcare providers, and healthcare marketing executives.

It is a process of strategic outreach and communications built to bring in new healthcare consumers, shepherd them through their healthcare journey, and keep them engaged with the healthcare system.

The best healthcare marketing plans integrate omnichannel, highly-segmented, and specific online and offline efforts to drive engagement and growth, all focused on certain market-specific key performance indicators and return on investment.

Marketing in Medical Practice

As the demand for medical care increases due to an aging population, new treatments, and innovative insurance plans, competition among healthcare providers—such as hospitals, urgent care centers, and private practices—is also growing. To attract patients, medical providers are relying more on advanced marketing strategies.

Patients naturally want the best and most qualified doctors, but most people (except those in the medical field) lack the expertise to assess a provider's skills or knowledge. Instead, patients use other factors to decide where to seek care. This is why being recognized as a thought leader in a specific medical field is a powerful way for healthcare professionals to attract and retain patients.

Several factors influence where patients choose to get care, including their financial situation, health insurance coverage, location, lifestyle, and the severity of their condition. However, when patients have multiple options, effective marketing often becomes the deciding factor in their choice, whether for routine care or major procedures. In these situations, marketing efforts, particularly those that highlight expertise and thought leadership, can make a significant impact.

Many healthcare providers are using thought leadership strategies to stand out. They share their expertise and showcase their standard of care through educational websites, newsletters, webinars, seminars, and even books. This approach has proven highly effective in building trust and attracting new patients.

Determination of the Existence of Influence

To determine the presence of the connection between advertising and the value of sales of medication by a pharmacy it is appropriate to use the Student's t-test, provided that the studied populations are normally distributed and their variance are equal.

Verification of Statistical Hypotheses About the Equality of Variances of Two Normal Distributed Populations

Let μ_X and σ_X^2 – mean and variance of the first normally distributed population (control), μ_Y and σ_Y^2 – mean and variance of the second normally distributed population (investigated).

It is assumed the formation of a sample with volume n_X from the first population and a sample with volume n_Y from the second population.

Null and alternative hypothesis:

H0: $\sigma_Y^2 = \sigma_X^2$ – variances of populations are equal;

H1: $\sigma_Y^2 > \sigma_X^2$ – variance of the investigated population is bigger (right-tailed critical region).

α – confidence interval.

Checking criterion:

$$f = \frac{s_y^2}{s_x^2},$$

$s_x^2 = \frac{1}{n_x - 1}\sum_{i=1}^{n_x}(x_i - \bar{x})^2$ – point estimation of the variance of the control population,

$s_y^2 = \frac{1}{n_y - 1}\sum_{i=1}^{n_y}(y_i - \bar{y})^2$ – point estimation of the variance of an investigated population,

$\bar{x}$, $\bar{y}$ – sample average values of quantities X and Y.

Criterion *f* obeys a Fisher distribution with $\nu_1 = \nu_y = n_y - 1$ and $\nu_2 = \nu_x = n_x - 1$ degree of freedom.

If $f < f^*$, then the null hypothesis should be rejected. The critical value $f^* = f(p = 1-\alpha; \nu_1 = \nu_y; \nu_2 = \nu_x)$ is determined by the F-distribution table.

In the case of the left-tailed critical region ($\sigma_X^2 > \sigma_Y^2$ and $f = \frac{s_x^2}{s_y^2}$) null hypothesis should be rejected, if $f > f^*$, where $f^* = f(p = 1-\alpha; \nu_1 = \nu_x; \nu_2 = \nu_y)$.

In the case of the two-tailed critical region ($\sigma_Y^2 \neq \sigma_X^2$ and $f = \frac{s_y^2}{s_x^2}$) null hypothesis should be rejected, if $f < f_1^*$, $f > f_2^*$, where $f_1^* = f(p = 1-\alpha; \nu_1 = \nu_y; \nu_2 = \nu_x)$ and $f_2^* = f(p = 1-\alpha; \nu_1 = \nu_y; \nu_2 = \nu_x)$.

Verification of Statistical Hypotheses About the Equality of Centers of Distribution of Two Independent Normally Distributed Populations When Their Variances Are Unknown and It Is Assumed That They Are Equal (Small Samples)

Null and alternative hypothesis:

H0: $\mu_X = \mu_Y$ – centers of distribution are not shifted;

H1: $\mu_X \neq \mu_Y$ – centers of distribution are shifted (two-tailed critical region).

α – confidence interval.

Checking criterion:

$$t = \frac{\bar{y} - \bar{x}}{s_{\bar{y}-\bar{x}}},$$

where $s_{\bar{y}-\bar{x}} = \sqrt{\left(\frac{1}{n_x} + \frac{1}{n_y}\right) \cdot \frac{(n_x - 1)s_x^2 + (n_y - 1)s_y^2}{n_x + n_x - 2}}$.

If $n_x = n_y$:

$$s_{\bar{y}-\bar{x}} = \sqrt{\frac{s_x^2}{n_x} + \frac{s_y^2}{n_y}}.$$

t-score obeys a Student distribution with $\nu = n_x + n_y - 2$ degrees of freedom.

If $|t| > t^*$, then the null hypothesis should be rejected and it means that centers of distribution are shifted.

Critical value $t_2^* = -t_1^* = t(p = 1-\alpha/2; \nu = n_x + n_y - 2)$ is determined by the Student distribution table.

Determination of Connection Between Variables

Contingency Tables

To determine the presence of the connection between advertising and the number of services rendered to the patients, for example, by a private clinic, it is advisable to use the χ^2 criterion.

Let:

n₁ – the number of rendered **Services 1,** $n_1 = n_1^+ + n_1^-$, where n_1^+ – the number of rendered **Services 1** after familiarization the patient with advertising, n_1^- – the number of rendered **Services 1** before familiarization the patient with advertising;

n₂ – the number of rendered **Services 2,** $n_2 = n_2^+ + n_2^-$, where n_2^+ – the number of rendered **Services 2** after familiarization the patient with advertising, n_2^- – the number of rendered **Services 2** before familiarization the patient with advertising;

Contingency Table:

n_1^+	n_1^-	n_1
n_2^+	n_2^-	n_2
$n_1^+ + n_2^+$	$n_1^- + n_2^-$	$n_1 + n_2$

The checking criterion is determined by the formula:

$$\chi^2 = \frac{(n_1 + n_2)\left(\left|n_1^+ n_2^+ - n_1^- n_2^+\right| - \frac{1}{2}(n_1 + n_2)\right)^2}{(n_1^+ + n_2^+)(n_1^- + n_2^-)n_1 n_2}$$

If $\chi^2 > \chi^{2*}$, then the hypothesis about the presence of the connection between advertising and the number of services rendered to the patients should be accepted with probability $P = 1 - \alpha$.

Critical value $\chi^{2*} = \chi^2(p = 1-\alpha; \nu = 1)$ is determined by the χ^2-distribution table.

Solver Add-in in Excel

What is Excel Solver?

Excel Solver is a tool in Microsoft Excel used for optimization [1].

[from: https://support.microsoft.com/en-us/office/define-and-solve-a-problem-by-using-solver-5d1a388f-079d-43ac-a7eb-f63e45925040]

It helps you find the best solution to a problem by adjusting certain variables in your model. This is a type of "what-if analysis" that is especially useful when you want to determine the optimal result based on multiple assumptions.

How to Use Excel Solver – Example

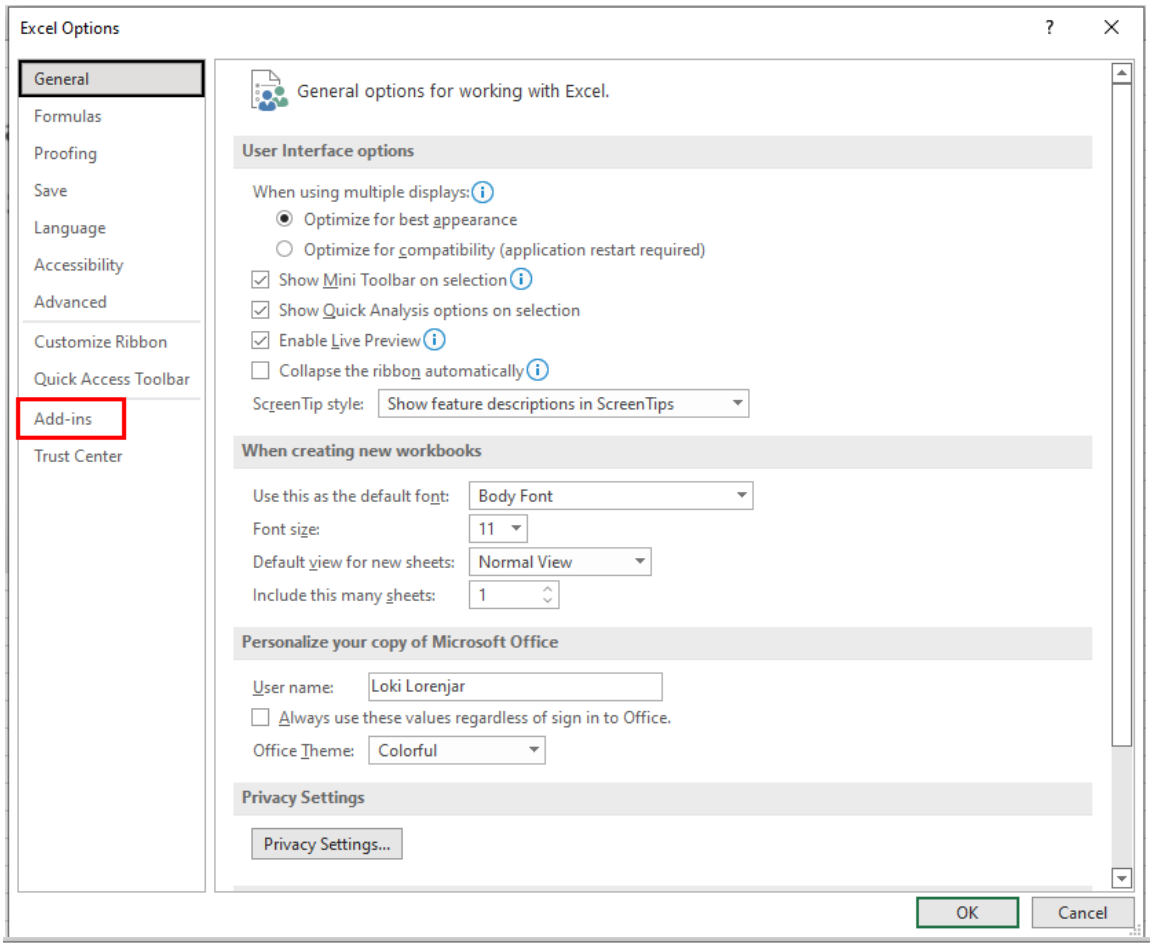
Imagine a company wants to figure out the ideal number of salespeople to hire to maximize profit. As more salespeople are added, profit increases, but at a slower rate due to diminishing returns. Using Excel Solver, you can determine the number of salespeople that will generate the highest profit. Solver does this by changing the number of salespeople in the model while analyzing the profit relationship to find the best possible outcome.

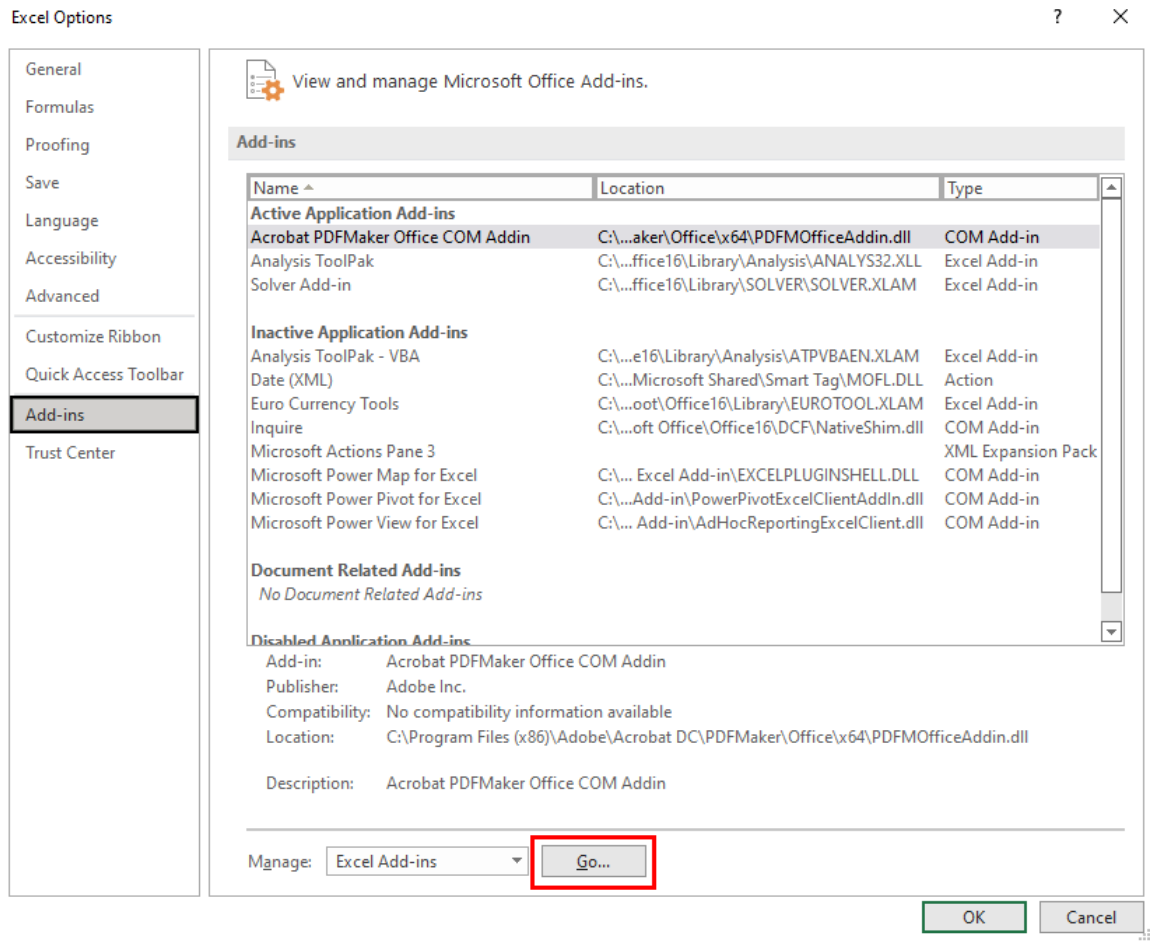
Excel Solver. https://corporatefinanceinstitute.com/resources/excel/excel-solver/

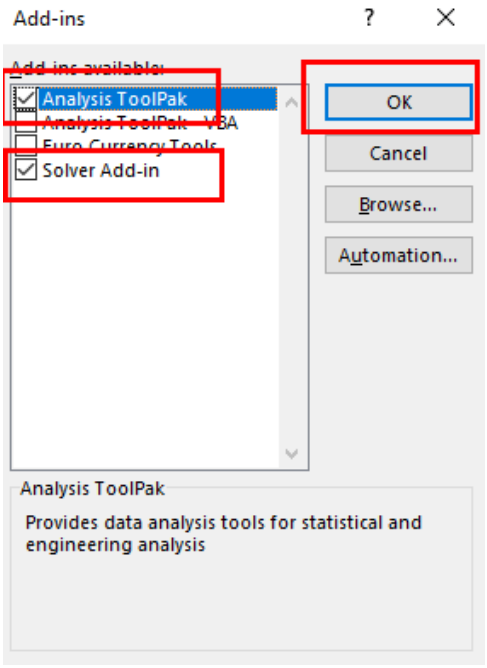
Step 1: Ensure the Solver Add-In is Installed

The first step is to make sure you have Solver installed in your Excel file. To do this, go to **File -> Options -> Add-Ins -> Manage Excel Add-Ins.**

When the dialogue box appears, make sure the box is ticked, as shown below.


Excel Options
General
Formulas
Proofing
Save
Language
Accessibility
Advanced
Customize Ribbon
Quick Access Toolbar
Add-ins
Trust Center
General options for working with Excel.
User Interface options
When using multiple displays:
Optimize for best appearance
Optimize for compatibility (application restart required)
Show Mini Toolbar on selection
Show Quick Analysis options on selection
Enable Live Preview
Collapse the ribbon automatically
ScreenTip style: Show feature descriptions in ScreenTips
When creating new workbooks
Use this as the default font: Body Font
Font size: 11
Default view for new sheets: Normal View
Include this many sheets: 1
Personalize your copy of Microsoft Office
User name: Loki Lorenjar
Always use these values regardless of sign in to Office.
Office Theme: Colorful
Privacy Settings
Privacy Settings...
OK
Cancel


Excel Options
General
Formulas
Proofing
Save
Language
Accessibility
Advanced
Customize Ribbon
Quick Access Toolbar
Add-ins
Trust Center
View and manage Microsoft Office Add-ins.
Add-ins
Name
Location
Type
Active Application Add-ins
Acrobat PDFMaker Office COM Addin C:\...aker\Office\x64\PDFMOfficeAddin.dll COM Add-in
Analysis ToolPak C:\...ffice16\Library\Analysis\ANALYS32.XLL Excel Add-in
Solver Add-in C:\...ffice16\Library\SOLVER\SOLVER.XLAM Excel Add-in
Inactive Application Add-ins
Analysis ToolPak - VBA C:\...e16\Library\Analysis\ATPVBAEN.XLAM Excel Add-in
Date (XML) C:\...Microsoft Shared\Smart Tag\MOFL.DLL Action
Euro Currency Tools C:\...oot\Office16\Library\EUROTOOL.XLAM Excel Add-in
Inquire C:\...oft Office\Office16\DCF\NativeShim.dll COM Add-in
Microsoft Actions Pane 3 XML Expansion Pack
Microsoft Power Map for Excel C:\... Excel Add-in\EXCELPLUGINSHELL.DLL COM Add-in
Microsoft Power Pivot for Excel C:\...Add-in\PowerPivotExcelClientAddIn.dll COM Add-in
Microsoft Power View for Excel C:\... Add-in\AdHocReportingExcelClient.dll COM Add-in
Document Related Add-ins
No Document Related Add-ins
Disabled Application Add-ins
Add-in: Acrobat PDFMaker Office COM Addin
Publisher: Adobe Inc.
Compatibility: No compatibility information available
Location: C:\Program Files (x86)\Adobe\Acrobat DC\PDFMaker\Office\x64\PDFMOfficeAddin.dll
Description: Acrobat PDFMaker Office COM Addin
Manage: Excel Add-ins
Go...
OK
Cancel



Step 2: Build a Model
It is necessary to formulate a problem in the form of mathematical equations.

Step 3: Use the Ribbon to Launch Excel Solver
The Excel Solver function is located on the Data Ribbon and the keyboard shortcut on Windows is Alt, A, Y21. Once the dialog box appears you will notice several options you can work with.

Set the "Objective" cell.
Set it "To" something (Max, Min, or a specific value)
Select the Cell(s) you want to change to find the solution.
Add constraints.
Click "Solve."
Decide if you want to keep the solution in the cells or restore the original values.

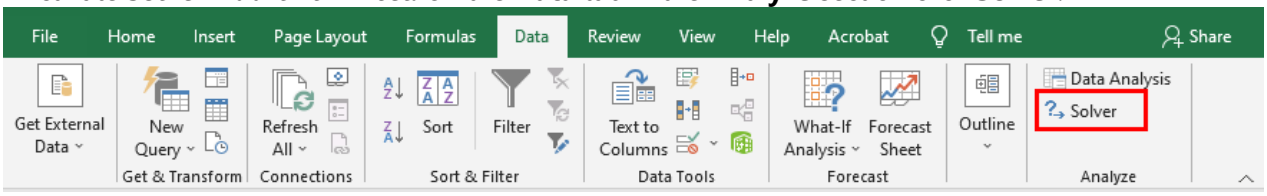
EXAMPLE 1 *Using* ***Solver Add-in in Excel*** *solve the following task:*
Maximize $P = 3x_1 + 2x_2 - x_3$
Subject to the constraints:

$$\begin{cases} x_1 + 3x_2 + x_3 \le 9 \\ 2x_1 + 3x_2 - x_3 \ge 2 \\ 3x_1 - 2x_2 + x_3 \ge 5 \\ x_1 \ge 0; x_2 \ge 0; x_3 \ge 0; \end{cases}$$

SOLUTION:
● Create a table according to the example given. Set variables x1, x2, x3. Specify objective. Specify constraints.

	A	B	C	D	E
1	Variables				
2	x1	0			
3	x2	0			
4	x3	0			
5					
6	Objective				
7					
8	*Maximize*	=3*B2+2*B3-B4			
9					
10	Constraints				
11			ineqality		
12	1	=B2+3*B3+B4	<=	9	
13	2	=2*B2+3*B3-B4	>=	2	
14	3	=3*B2-2*B3+B4	>=	5	
15	4	=B2	>=	0	
16	5	=B3	>=	0	
17	6	=B4	>=	0	
18					
19					

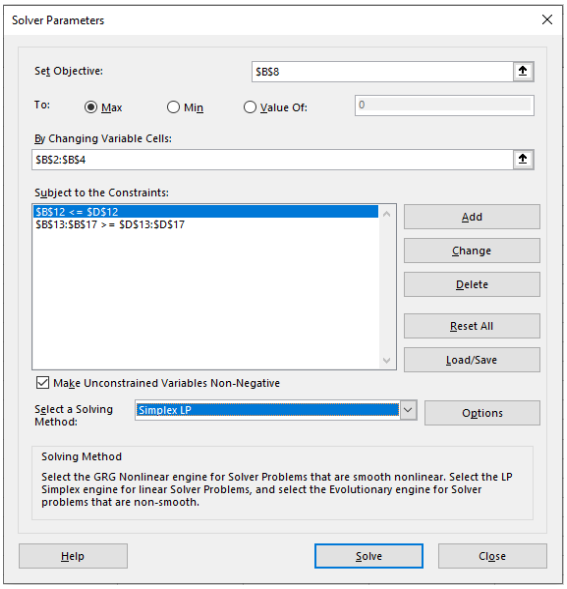
- Activate ***Solver Add-in in Excel:*** on the **Data** tab in the **Analyze** section click **Solver**.



- Fill **Solve Parameters** Window

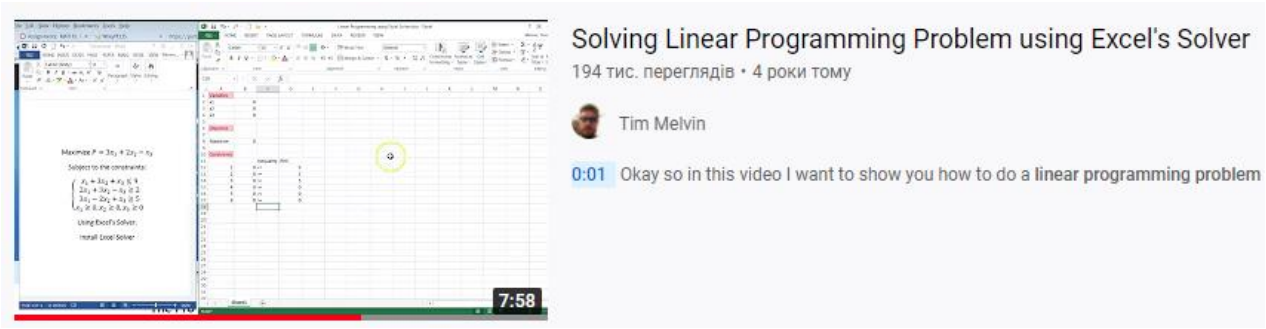
Set Objective:	**$B$8**
To:	**Max**
By Changing Variable Cells:	**$B$2:$B$4**
Subject to the Constraints:	**$B$12 <= $D$4** **$B$13:$B$17 => $D$13:$D$17**
Make Unconstrained Variables Non-Negative:	☑
Select a Solving Method:	**Simplex LP**

Click **Solve.**



	A	B	C	D	E
1	Variables				
2	x1	9			
3	x2	0			
4	x3	0			
5					
6	Objective				
7					
8	*Maximize*	27			
9					
10	Constraints				
11			ineqality		
12	1	9	<=	9	
13	2	18	>=	2	
14	3	27	>=	5	
15	4	9	>=	0	
16	5	0	>=	0	
17	6	0	>=	0	
18					
19					

● **For more detailed instructions watch the following video:**
https://youtu.be/rQt_SWrOktg



EXAMPLE 2 *Using* ***Solver Add-in in Excel*** *solve the following task:*
Nurse scheduling *is a known problem. Consider a hospital that is open seven days a week. Based on experience, the number of nurses needed on a particular day is given as follows:*

	x1	x2	x3	x4	x5	x6	x7
Day	Mon	Tue	Wed	Thu	Fri	Sat	Sun
No. of Nurses	200	150	250	90	160	300	100

Every Nurse works five consecutive days, and then takes two days off, repeating this pattern indefinitely. How can we ***minimize*** *the number of nurses that staff the hospital?*

SOLUTION:

● Create a table according to the example given. Set variables. Specify objective. Specify constraints.

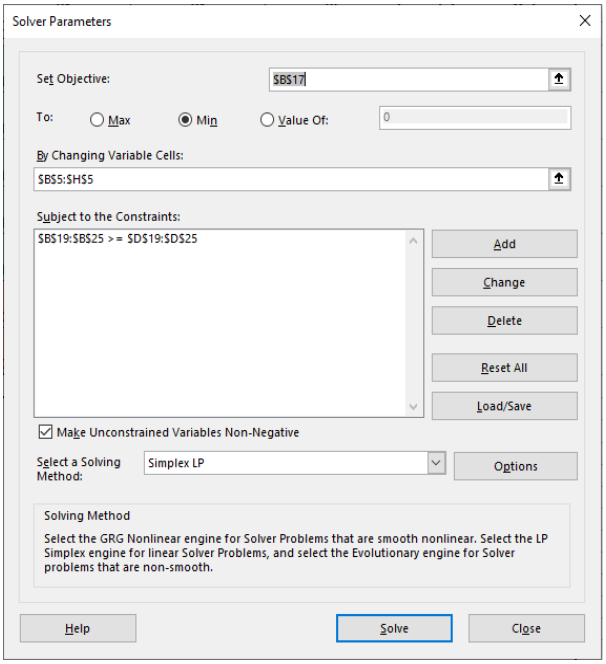
	x1	x2	x3	x4	x5	x6	x7
Monday shift	*	*	*	*	*	-	-
Tuesday shift	-	*	*	*	*	*	-
Wednesday shift	-	-	*	*	*	*	*
Thursday shift	*	-	-	*	*	*	*
Friday shift	*	*	-	-	*	*	*
Saturday shift	*	*	*	-	-	*	*
Sunday shift	*	*	*	*	-	-	*

A natural first attempt at this problem is to let x_i be the number of people working on the day i.
Let x1 be the number of nurses starting duty on Monday (Monday shift), x2, x3, x4, … x7 – the number of nurses starting duty on other days of the week.
Our ***objective*** *is minimal value of Z=x1+x2+x3+x4+x5+x6+x7.*
Constraints:
x1+x4+x5+x6+x7>=200
x1+x2+ x5+x6+x7>=150
x1+x2+x3+x6+x7>=250
x1+x2+x3+x4+ x7>=90
x1+x2+x3+x4+x5 >=160
x2+x3+x4+x5+x6 >=300
x3+x4+x5+x6+x7>=100
x1+x2+x3+x4+x5+x6+x7>=0, all x_i>=0.

	x1	x2	x3	x4	x5	x6	x7	Minimum Staff size
	0	0	0	0	0	0	0	
Monday shift	1	1	1	1	1	0	0	200
Tuesday shift	0	1	1	1	1	1	0	150
Wednesday shift	0	0	1	1	1	1	1	250
Thursday shift	1	0	0	1	1	1	1	90
Friday shift	1	1	0	0	1	1	1	160
Saturday shift	1	1	1	0	0	1	1	300
Sunday shift	1	1	1	1	0	0	1	100

Nurse Scheduling Scenario

Objective function	Z=x1+x2+x3+x4+x5+x6+x7		
Minimize	=B5+C5+D5+E5+F5+G5+H5		
Constraints			
1	=B5+E5+F5+G5+H5	>=	200
2	=B5+C5+F5+G5+H5	>=	150
3	=B5+C5+D5+G5+H5	>=	250
4	=B5+C5+D5+E5+H5	>=	90
5	=B5+C5+D5+E5+F5	>=	160
6	=C5+D5+E5+F5+G5	>=	300
7	=D5+E5+F5+G5+H5	>=	100



Nurse Scheduling Scenario

	x1	x2	x3	x4	x5	x6	x7	Minimum Staff size
	3.333333	3.333333	100	53.33333	0	143.3333	0	
Monday shift	1	1	1	1	1	0	0	200
Tuesday shift	0	1	1	1	1	1	0	150
Wednesday shift	0	0	1	1	1	1	1	250
Thursday shift	1	0	0	1	1	1	1	90
Friday shift	1	1	0	0	1	1	1	160
Saturday shift	1	1	1	0	0	1	1	300
Sunday shift	1	1	1	1	0	0	1	100

Objective	Z=x1+x2+x3+x4+x5+x		
Minimize	303.3333333		
Constraints			
1	200	>=	200
2	150	>=	150
3	250	>=	250
4	160	>=	90
5	160	>=	160
6	300	>=	300
7	296.6667	>=	100

Practical tasks for students. Instructions for execution of practical work

1. Start a computer and wait for the loading of Windows OS**.**
2. Start **Microsoft Excel** program: **Start** → **ALL Programs** → **Microsoft Office** → **Microsoft Excel**.
3. *Save the document on Desktop*.

Attention: *Don't forget to click the icon* ***Save*** *on the* ***Quick Access toolbar*** *every few minutes during the lesson to avoid losing your work.*

4. Perform the following tasks:

Task №1. *Using* **MS Excel** *to investigate whether or not advertising using the newest diagnostic equipment that was held during the month in hospital departments led to an increase in the number of examinations in the department of functional diagnostics if economists estimated that the average increase in the number of examinations should be 280 examinations per month (20 examinations in each department). The number of examinations before and after advertising in each of the departments was as follows:*

Department	***Number of Examinations Before Advertising***	***Number of Examinations After Advertising***
Surgery	62	91
Traumatology	78	104
Gastroenterology	54	48
Nephrology	82	76
Urology	67	62
Otolaryngology	49	65
Ophthalmology	45	41
Dentistry	32	37
Neurology	32	69
Allergology	52	87
Hematology	64	71
Cardiology	44	62
Traumatology	31	28
Neurosurgery	48	73

Create a new table as shown in ***Fig. 1***:
type text into cells **A2:E2, A3:D16, B18:B23** according to **Fig. 1**;

	A	B	C	D	E	F	G	H	I	J
1										
2	*No*	*Department*	*Number of Examinations Before Advertising, n_0*	*Number of Examinations After Advertising, n*	*n-20*		**t-Test: Two-Sample Assuming Equal Variances**			
3	1	*Surgery*	62	91	71					
4	2	*Traumatology*	78	104	84			*Variable 1*	*Variable 2*	
5	3	*Gastroenterology*	54	48	28		**Mean**	52.857	45.286	
6	4	*Nephrology*	82	76	56		**Variance**	262.901	457.912	
7	5	*Urology*	67	62	42		**Observations**	14	14	
8	6	*Otolaryngology*	49	65	45		**Pooled Variance**	360.407		
9	7	*Ophthalmology*	45	41	21		**Hypothesized Mean Difference**	0		
10	8	*Dentistry*	32	37	17		**df**	26		
11	9	*Neurology*	32	69	49		**t Stat**	1.055		
12	10	*Allergology*	52	87	67		**P(T<=t) one-tail**	0.151		
13	11	*Hematology*	64	71	51		**t Critical one-tail**	1.706		
14	12	*Cardiology*	44	62	42		**P(T<=t) two-tail**	0.301		
15	13	*Traumatology*	31	28	8		**t Critical two-tail**	2.056		
16	14	*Neurosurgery*	48	73	53					
17							***Conclusion:***	***Distribution centers coincide***		
18		*Sample Size*	14							
19		*Variance*	262.901		457.912					
20		*F-Statistic*	1.742							
21		*Critical Value of F-Statistic*	2.577							
22										
23		*Conclusion:*	*Variances are equal*							

Sheet1 Sheet2 Sheet3

Fig. 1

Perform the calculations:
click the cell **E3** and enter the formula **=D3-20** → press **Enter**;
copy the formula from the cell **E3** into the cells **E4:E16** using drag and drop method;
click the cell **C18** and enter the formula **=COUNT(C3:C16)** (click the cell **C18**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNT** → **OK** → enter **C3:C16** → **OK)**;

click the cell **C19** and enter the formula **=VAR.S(C3:C16)** (click the cell **C19**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **VAR.S** → **OK** → enter **C3:C16** → **OK)**;
click the cell **E19** and enter the formula **=VAR.S(E3:E16)** (click the cell **E19**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **VAR.S** → **OK** → enter **E3:E16** → **OK)**;
click the cell **C20** and enter the formula **E19/C19** → press **Enter**;

click the cell **C21** and enter the formula **=F.INV.RT(0.05,C18-1,C18-1)** (click the cell **C21**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **F.INV.RT** → **OK** → enter **0.05** in **Probability** box → enter **C18-1** in **Deg_freedom1** box → enter **C18-1** in **Deg_freedom2** box → **OK)**;
click the cell **C23** and enter the formula **=IF(C20<C21,"Variances are equal","Variance of investigated sample is bigger")** (click the cell **C23,** click **Insert** → **Function…** → select **Logical** from **select a category** box → select **IF** → **OK** → enter **C20<C21** in **Logical_test** box → enter **Variances are equal** in **Value_if_true** box → enter **Variance of investigated sample is bigger** in **Value_if_false** box → **OK**);
click the **Data** tab → in the **Analysis** group, select the **Data Analysis** category (if there is no option **Data Analysis** in the **Data** tab, click the **File** tab → click **Options** → click **Add-Ins** → click the **Go** button → check the **Data Analysis Toolpak** check box) → click **t-Test: Two-Sample Assuming Equal Variances** → click **OK** → enter the data according to the **Fig. 2** → click **OK**;

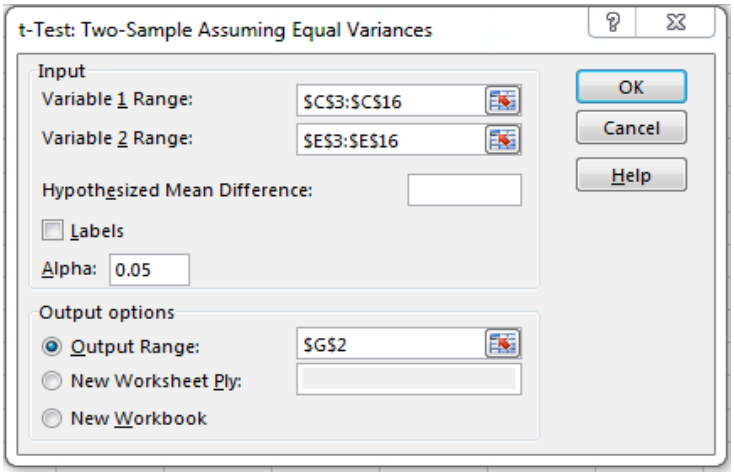


Fig. 2

type **Conclusion:** in the cell **G17**;
click the cell **H17** and enter the formula **=IF(H11<H15,"Distribution centers coincide","Distribution centers do not coincide")** (click the cell **C23,** click **Insert** → **Function…** → select **Logical** from **select a category** box → select **IF** → **OK** → enter **H11<H15** in **Logical_test** box → enter **Distribution centers coincide** in **Value_if_true** box → enter **Distribution centers do not coincide** in **Value_if_false** box → **OK**);

Conclude the effectiveness of the advertising.

*Format the table according to **Fig. 1**.*
Formatting instructions:
Font: **Times New Roman**;
Size: cells **A2:E2 – 12;** other cells – **11**;
Style: cells **A2:E2, A3:B23, C23** and **G17:H17 – Bold Italic**; **G2 and G5:G15** – **Bold**; other cells – **Regular**;
Horizontal alignment: cells **A2:E2** – **Center,** other cells – **by default** (don't change);
Vertical alignment: cells **A2:E2** – **Center,** other cells – **by default** (don't change);
*Apply cell borders to the table according to **Fig. 1**.*

Click ***Save*** .

Task №2. *Using* **MS Excel** *investigate whether or not advertising in one of the periodicals led to an increase in the number of services rendered to people by a private clinic if the clinic rendered the following number of services:*

Services	***Patients read periodical***	***Patients do not read periodical***
Service 1	98	12
Service 2	92	27

Create a new table as shown in ***Fig. 3***:
click **Sheet2**, type text into cells **B2:E2**, **B3:D4**, **D7:D8, C10, B5** according to **Fig. 3**;

Perform the calculations:
click the cell **E3** and enter the formula **=SUM(C3:D3)** (click the cell **E3**, click **Insert Function** button on the **Formula bar** → select **Math & Trig** from **select a category** box → select **SUM** → **OK** → enter **C3:D3** → **OK)**;
copy the formula from the cell **E3** into the cell **E4** using the drag and drop method;

click the cell **C5** and enter the formula **=SUM(C3:C4)** (click the cell **C5**, click **Insert Function** button on the **Formula bar** → select **Math & Trig** from **select a category** box → select **SUM** → **OK** → enter **C3:C4** → **OK)**;
copy the formula from the cell **C5** into the cell **D5:E5** using the drag and drop method;

	A	B	C	D	E	F	G	H
1								
2		Services	Patients, That Read the Periodical	Patients, That Did Not Read the Periodical	Total			
3		Service 1	98	12	110			
4		Service 2	92	27	119			
5		Total	190	39	229			
6								
7				Chi-Square Score, χ^2	4.811			
8				Critical Value of Chi-Square Score, χ^{2*}	3.841			
9								
10			Conclusion:	*The difference in number of rendered services is significant*				
11								

Sheet1 Sheet2 Sheet3

Fig. 3

click the cell **E7** and enter the formula **=E5*(ABS(C3*D4-C4*D3)-E5/2)^2/(C5*D5*E3*E4)** ® press **Enter**;
click the cell **E8** and enter the formula **=CHISQ.INV.RT(0.05,1)** (click the cell **E8**, click **Insert Function** button on the **Formula bar** → select **Statistical** from **select a category** box → select **CHISQ.INV.RT** → **OK** → enter **0.05** in **Probability** box → enter **1** in **Deg_freedom** box → **OK)**;
click the cell **D10** and enter the formula **=IF(E7>E8,"The difference in the number of rendered services is significant","The difference in the number of rendered services is not significant")** (click the cell **D10,** click **Insert** → **Function…** → select **Logical** from **select a category** box → select **IF** → **OK** → enter **E7>E8** in **Logical_test** box → enter **The difference in the number of rendered services is significant** in **Value_if_true** box → enter **The difference in the number of rendered services is not significant** in **Value_if_false** box → **OK**);

Conclude the influence of the advertising in one of the periodicals on the number of services rendered to people by a private clinic.
Format the table according to ***Fig. 3***.
Formatting instructions:
Font: **Times New Roman**;
Size: **12**;
Style: cells **B2:E2, B3:B5, D7:D8** and **C10 – Bold**; **D10** – **Bold Italic**; other cells – **Regular**;
Horizontal alignment: cells **B2:E2** – **Center,** other cells – **by default** (don't change);
Vertical alignment: cells **B2:E2** – **Center,** other cells – **by default** (don't change);
Apply cell borders to the table according to ***Fig. 3***.
Click ***Save*** .

Task №3. *Using* **MS Excel** *investigate whether there is a significant difference between the sales of medications by three pharmacies during six months depending on their location if they sold medications in the following amounts:*

Month	***Number of Pharmacy***		
	1	***2***	***3***
	Sales Revenue, UAH		
1	25200	22800	25200
2	24000	23100	24300
3	22800	23700	23700
4	23100	24000	23350
5	24300	24150	23600
6	24900	19200	18300

Create a new table as shown in ***Fig. 4***:
click **Sheet3**, select cells **B1:B3**, on the **Home** tab, in the **Alignment** group, click **Merge and Center**
in the same way, merge cells **C1:E1 and C2:E2;**
type text into cells **B1:E9** and **G8:G10** according to the **Fig. 4**;
click the cell **H10** and type **0.05;**

	A	B	C	D	E	F	G	H
1			Sales Revenue					
2		Month	Number of Pharmacy					
3			1	2	3			
4		1	25200	22800	25200			
5		2	24000	23100	24300			
6		3	22800	23700	23700			
7		4	23100	24000	23350			
8		5	24300	24150	23600		Sample Size	18
9		6	24900	19200	18300		Number of Levels	3
10							Confidence Level	0.05
11								
12		Anova: Single Factor						
13								
14		SUMMARY						
15		*Groups*	*Count*	*Sum*	*Average*	*Variance*		
16		Column 1	6	144300	24050	915000		
17		Column 2	6	136950	22825	3423750		
18		Column 3	6	138450	23075	5911750		
19								
20								
21		ANOVA						
22		*Source of Variation*	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
23		Between Groups	5027500	2	2513750	0.7357	0.495686672	3.68232
24		Within Groups	51252500	15	3416833.333			
25								
26		Total	56280000	17				
27								
28								
29								
30		The Lower Limit of F-Statistic	0.0254		Conclusion:	*Difference is not significant*		
31		The Upper Limit of F-Statistic	4.7650					
32								

Sheet1 Sheet2 Sheet3

Fig. 4

Perform the calculations:
click the cell **H8** and enter the formula **=COUNT(C4:E9)** (click the cell **H8**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNT** → **OK** → enter **C4:E9** → **OK)**;
click the cell **H9** and enter the formula **=COUNT(C3:E3)** (click the cell **H9**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **COUNT** → **OK** → enter **C3:E3** → **OK)**;
click the **Data** tab → in the **Analysis** group, select **Data Analysis** category → click **Anova:Single Factor** → click **OK** → enter the data according to the **Fig. 5** → click **OK**;
type text into cells **B30:B31** and **E30** according to the **Fig. 4**;
click the cell **C30** and enter the formula **=F.INV.RT(1-H10/2,H9-1,H8-H9)** (click the cell **C30**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **F.INV.RT** → **OK** → enter **1-H10/2** in **Probability** box → enter **H9-1** in **Deg_freedom1** box → enter **H8-H9** in **Deg_freedom2** box → **OK)**;
click the cell **C31** and enter the formula **=F.INV.RT(H10/2,H9-1,H8-H9)** (click the cell **C31**, click **Insert Function** button f_x on the **Formula bar** → select **Statistical** from **select a category** box → select **F.INV.RT** → **OK** → enter **H10/2** in **Probability** box → enter **H9-1** in **Deg_freedom1** box → enter **H8-H9** in **Deg_freedom2** box → **OK)**;
click the cell **F30** and enter the formula **=IF(F23<C30,"Difference is significant",IF(F23<C31;"Difference is not significant","Difference is significant"))** (click the cell **F30,** click **Insert Function** button f_x on the **Formula bar** → select **Logical** from **select a category** box → select **IF** → **OK** → enter **F23<C30** in **Logical_test** box → enter **Difference is significant** in **Value_if_true** box → click **Value_if_false** box and click **IF** button next to **Formula Bar** → enter **F23<C31** in **Logical_test** box → enter **Difference is not significant** in **Value_if_true** box → enter **Difference is significant** in **Value_if_false** box → **OK**);

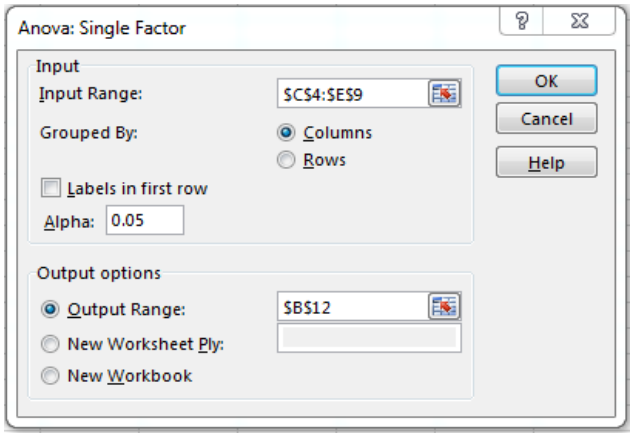


Fig. 5

Conclude the influence of the location of the pharmacies on the sales of medications by them.

*Format the table according to **Fig. 4**.*

Formatting instructions:

Font: **Times New Roman**;
Size: **12**;
Style: cells **B15:F15, B22:H22** and **F30 – Bold Italic**; **A1:E3, G8:G10, A12:F12, B14, B21, B23:B26, B31:B31, E30** – **Bold**; other cells – **Regular**;
Horizontal alignment: cells **B1:E3, B4:B9, B12:F12, B15:F15, B22:F22** – **Center,** other cells – **by default** (don't change);

Vertical alignment: cells **B1:E3, E30:F30, B30:C31** – **Center,** other cells – **by default** (don't change);
Click ***Save***  .
5. Show the teacher results of your work.
6. Close the **MS Excel** document.

Task №4. *Using* ***Solver Add-in in Excel*** *solve the following task.*

Choose ONE variant according to your number in the list

Variant 1. *Consider a hospital that is open seven days a week. Based on experience, the number of nurses needed on a particular day is given as follows:*

	x1	x2	x3	x4	x5	x6	x7
Day	Mon	Tue	Wed	Thu	Fri	Sat	Sun
No. of Nurses	140	200	185	190	160	150	70

Every Nurse works five consecutive days, and then takes two days off, repeating this pattern indefinitely. How can we ***minimize*** *the number of nurses that staff the hospital?*

Variant 2. *Consider a hospital that is open seven days a week. Based on experience, the number of nurses needed on a particular day is given as follows:*

	x1	x2	x3	x4	x5	x6	x7
Day	Mon	Tue	Wed	Thu	Fri	Sat	Sun
No. of Nurses	130	200	195	197	1150	70	65

Every Nurse works five consecutive days, and then takes two days off, repeating this pattern indefinitely. How can we ***minimize*** *the number of nurses that staff the hospital?*

Attention*: After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:
Excel help & learning. Microsoft.com. from https://support.microsoft.com/en-us/excel
1) Define and solve a problem by using Solver. Microsoft.com. Retrieved December 1, 2024, from https://support.microsoft.com/en-us/office/define-and-solve-a-problem-by-using-solver-5d1a388f-079d-43ac-a7eb-f63e45925040
2) Excel Solver. Corporate Finance Institute. Retrieved December 1, 2024, from https://corporatefinanceinstitute.com/resources/excel/excel-solver/
3) Baum, N., & Kahn, M. J. (2019). *The Business Basics of Building and Managing a Healthcare Practice*. Springer Nature.
4) Djakeli, K. (2023). *Modern Healthcare Marketing in the Digital Era*. Medical Information Science Reference.
5) Prasad, A. (2018, August 6). *Healthcare Marketing – A Guide for Doctors & Practice Managers*. Gmrwebteam.com; GMR Web Team. https://www.gmrwebteam.com/blog/healthcare-marketing
6) Hora, S. (2021, September 21). *Understanding hypothesis testing. Towards Data Science*. https://towardsdatascience.com/understanding-hypothesis-testing-65f9b3e9ab1f
Additional
1) Thomas, R. K. (2007). *Health Services Marketing: A Practitioner's Guide* (2008th ed.). Springer.
2) Fortenberry, J. L., Jr. (2010). *Health care marketing: Tools and techniques* (3rd ed.). Jones and Bartlett.

Topic 15: CLINICAL DECISION SUPPORT SYSTEMS, PREDICTION TOOLS, AND DECISION SUPPORT SYSTEM MODELING.

Actuality: Recent advances in the field of artificial intelligence have led to the emergence of expert systems, and computational tools designed to capture and make available the knowledge of experts in a field. Intelligent systems, particularly expert systems for diagnosis and treatment, have been developed for use in a range of medical contexts: medical practitioners - hospital doctors, nurses, consultants, operating theatre, but also nursing home staff, sometimes parents, patients themselves; basic tasks - diagnosis, prognosis, treatment, monitoring. That is why the ability to work with expert systems is important for future medical workers.

Educational aims of the lesson:

To know:

1. types of expert systems;
2. basics of work with an expert system;

To be able to:

1. create an expert system database;
2. edit expert system database;
3. conduct a dialogue with an expert system.

The list of questions for the survey:

1. What is an expert system?
2. Types of expert systems.
3. Architecture of an ideal expert system.
4. Knowledge Base; Reasoning Machine; Communication Interface; Interpreter; and Blackboard.
5. Advantages of Expert System.
6. Cons of Expert System.

The list of required practical skills:

1. Creating an expert system database.
2. Editing expert system database.
3. Conducting a dialogue with an expert system.

Brief theoretical information

What Are Expert Systems?

Expert systems are intelligent computer programs designed using artificial intelligence (AI) techniques to assist human experts, often in a consultative role. These systems are built with a vast knowledge base, typically containing thousands of rules, and can explain the reasoning behind their conclusions. They are particularly useful in fields like medicine, where they store detailed information about diseases and treatment options.

How Medical Expert Systems Work:

Built on Expertise: Medical expert systems are developed and constantly updated by teams of medical professionals to ensure they stay relevant and accurate.

Modes of Operation:

1. **Consultation Mode:** Used for diagnosing and suggesting treatments when the cause of a condition is unclear. Users input symptoms, and the system suggests possible diagnoses and further tests.
2. **Simulation Mode:** Creates virtual patients, enabling medical students and professionals to practice diagnosing and managing conditions in a simulated environment.

Definitions of Expert Systems (ES):

1. Expert systems solve complex real-world problems by mimicking the reasoning of human experts to arrive at similar conclusions.
2. An expert system is an intelligent program that uses stored knowledge and logical inference methods to tackle problems that typically require significant human expertise.

An expert system is a smart computer program that can perform challenging and specialized tasks in a specific field, achieving results comparable to those of a human expert.

Types of Expert Systems [1]:

Category	Problem Addressed
Interpretation	Inferring situation descriptions from sensor data
Prediction	Inferring likely consequences of a given situation
Diagnosis	Inferring system malfunction from observation
Design	Configuring objects under constraints
Planning	Designing actions
Monitoring	Comparing observation to plan vulnerabilities
Debugging	Prescribing remedies for malfunction
Repair	Executing a plan to administer a prescribed remedy
Instruction	Diagnosing, debugging, and repairing student behavior
Control	Interpreting, predicting, repairing, and monitoring system behavior

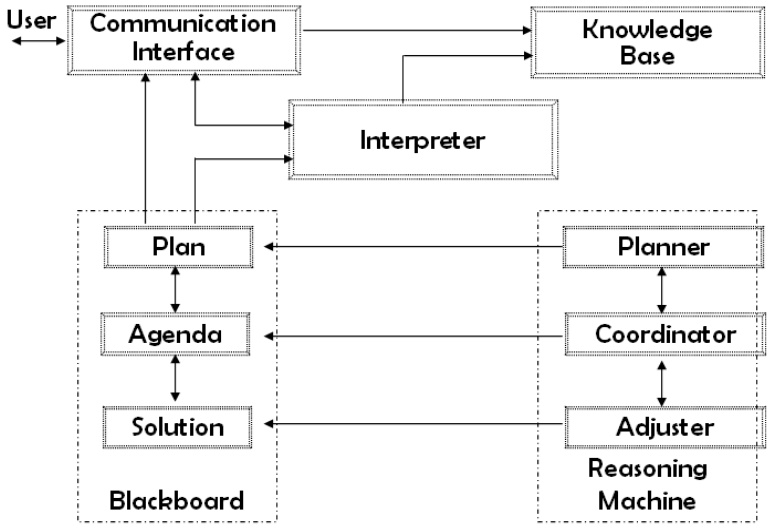


Fig. 1. The architecture of an ideal expert system.

An ideal expert system (Fig. 1) is composed of 5 parts: Knowledge Base; Reasoning Machine; Communication Interface; Interpreter; and Blackboard.

Knowledge Base stores knowledge from the experts of special field(s). It contains facts and feasible operators or rules for heuristic planning and problem-solving.

The reasoning Machine memorizes the reasoning rules and the control strategies applied. According to the information from the knowledge base, the reasoning machine can logically coordinate the whole system, draw inferences and make a decision.

The user interface helps to communicate between the user and the expert system.

The user interacts with the expert system in a problem-oriented language such as in restricted English, graphics, or a structure editor. The interface mediates information exchanges between the expert system and the human user.

Interpreter. Through the user interface, the interpreter explains user questions, commands, and other information generated by the expert system, including answers to questions, explanations and justifications for its behavior, and requests for data.

Blackboard records intermediate hypotheses and decisions that the expert system manipulates.

Note:

Almost no exiting expert system contains all the components shown above, but some components, especially the knowledge base and reasoning machine, occur in almost all expert systems.

Advantages of Expert Systems

Permanent Memory: Expert systems do not forget information, unlike human experts.

Easy Duplication: Multiple copies of an expert system can be created, while training new human experts takes time and money.

Thorough Analysis: Expert systems can review all transactions, while humans can usually analyze only a sample.

Broad Knowledge: They combine the expertise of multiple experts, offering more comprehensive knowledge than a single person.
Faster Results: Expert systems can detect errors or fraud quickly, providing timely information for decision-making.
Higher Efficiency: They increase productivity and reduce staffing costs.
Cost Savings: They eliminate the need for large clerical teams.

Limitations of Expert Systems

Lack of Common Sense: Unlike humans, expert systems lack common sense and practical judgment.
No Creativity: They cannot handle unusual situations creatively.
Limited Scope: They struggle with problems outside their expertise or when no solution exists.
No Sensory Input: They rely on symbolic input and cannot use sensory experiences like humans.
No Automatic Learning: Unlike humans, expert systems must be manually updated to adapt to changes.

When to Use Expert Systems

Expert systems are useful when they can:
- Offer significant benefits or reduce risks.
- Capture and preserve critical human expertise.
- Solve problems that traditional programming cannot handle easily.
- Deliver more consistent results than human experts.
- Provide expertise in multiple locations or unsafe environments.
- Offer rare or expensive expertise.
- Deliver faster solutions than human experts.
- Share expert knowledge widely for training and education.

Epilexia

Epilexia is an expert system conceived for an early and quick diagnostic arrangement of the epileptic pathology, founded almost exclusively on parameters of clinical kind. The diagnosis suggested by the system is express like hypothesis and in consequence is connected to a per cent data of probability; only the mediation of a physician can to agree a right interpretation of the supplied conclusions. The system is founded on the clean distinction between occasional epileptic seizure and real epileptic syndromes; every single branch of the system is articulated in a collection in sequence of data of various kind (anamnesticals, objectives, of laboratory) and on their subsequent processing. The system make use, in this step of data analysis, of neural networks of back-propagation kind, previously trained with a proper number of examples. It's essential to enable an effective approximation to the real case, to supply the maximum number of informations in the initial data collection:

...few informations produce a poor knowledge

DXplain

http://www.mghlcs.org/projects/dxplain
https://dxplain.net/

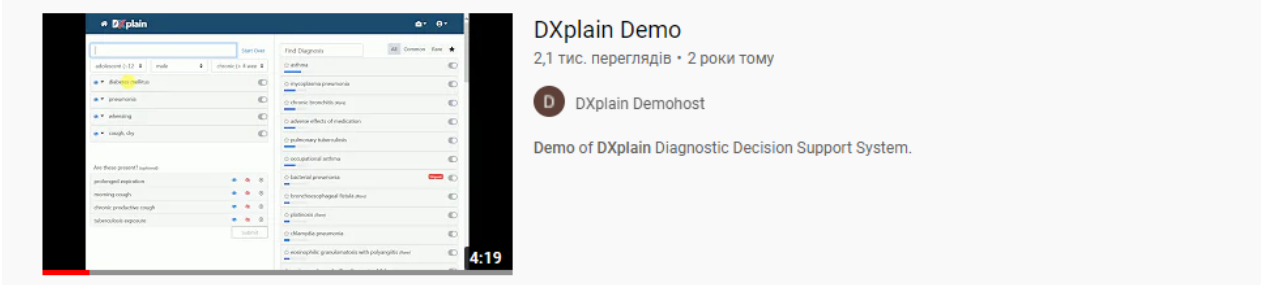
DXplain is a Clinical Decision Support System (CDSS) developed at Massachusetts General Hospital's Laboratory of Computer Science [from http://www.mghlcs.org/projects/dxplain]. It functions as both a medical reference tool and an electronic medical textbook. Accessible via the internet, DXplain helps clinicians by generating a list of possible diagnoses based on patient data, including symptoms, lab results, and other clinical findings. For each diagnosis, the system provides evidence to support it and suggests follow-up actions to guide the clinician toward a more accurate diagnosis. Additionally, DXplain serves as a reference tool with a searchable database of diseases and their clinical manifestations.

DXplain Knowledge Base

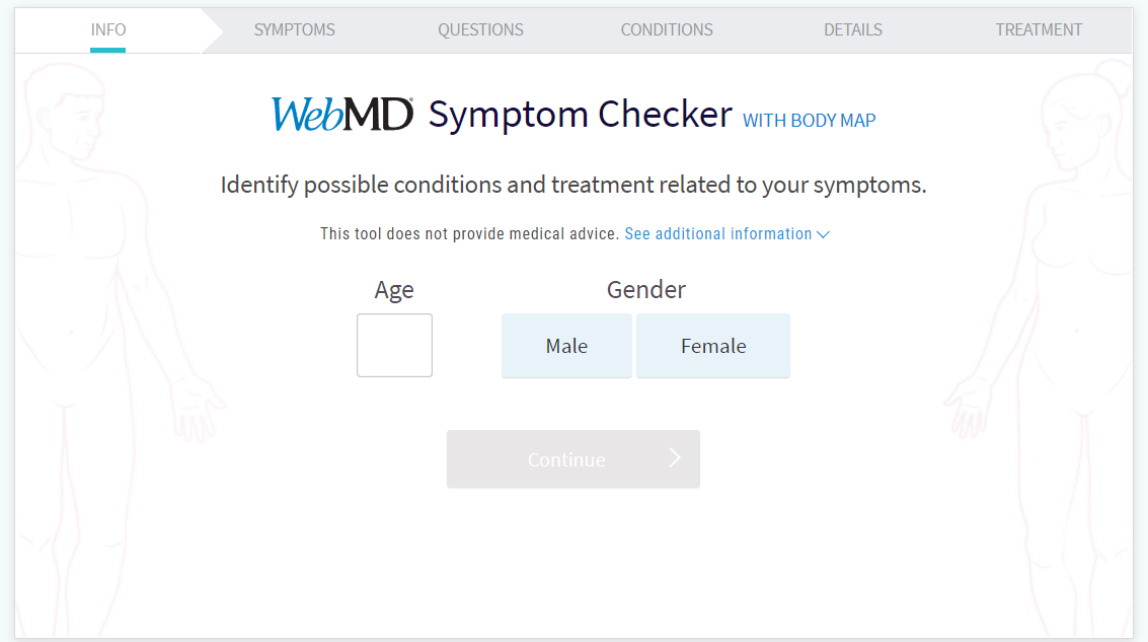
The DXplain knowledge base includes:
- **Over 2,600 diseases** and **5,700 clinical findings**, such as symptoms, signs, epidemiologic details, and test results.
- Each disease description includes an average of 53 findings, ranging from 10 to over 100.
- Over **300,000 data points** connect diseases to findings, with two key attributes for each connection:
- **Frequency**: How often does the finding occur with the disease.
- **Suggestiveness**: How strongly the finding suggests the disease.
- Findings also have an independent importance score, reflecting how significant it is to explain the finding's presence.
- Diseases are assigned two additional attributes:
- **Prevalence**: Categorized as very common, common, rare, or very rare.
- **Importance**: Indicates the potential consequences of overlooking the disease.

How DXplain Works

DXplain collects clinical information through an interactive format and uses a modified version of Bayesian logic to interpret the data. Since its release, it has been widely used by tens of thousands of doctors and medical students, initially as a standalone system (now discontinued) and currently via the internet.
The system and its database are continuously updated based on user feedback to improve its functionality. DXplain is regularly used in hospitals and medical schools as a teaching tool for clinical education and to help with clinical problem-solving.
A demonstration video is available to showcase and explain the features of the latest version of DXplain.
https://youtu.be/M0vf27T839c



WebMD Symptom Checker with Body Map
https://symptoms.webmd.com/



FAQ for Symptom Checker with Body Map [from https://symptoms.webmd.com/]**:**

1) How many body sections are there?

• There are 11 primary body regions and 41 sub-regions from which you can choose. For example, the arm is a primary region, and your elbow is a more specific sub-region. The ability to choose sub-regions allows you to more precisely specify your symptoms.

2) What should I do if I'm not sure which body area to choose?

• Since all symptoms in a sub-region (example "elbow") are also listed in the primary body region (example "arm"), it is best to start with the primary body region if you are unsure exactly where the symptom is on your body.

3) What if my symptom isn't associated with a specific body location (for example, "chills")?

• If you are not sure what body area your symptom falls under, you can type your symptom in the main search box or select the "General Symptoms" category.

• There is also a separate section for skin symptoms only.

4) What if I don't see my symptom on the list?

• When a body location is selected, the "most common symptoms" are displayed first, but you can also switch tabs to see "All" symptoms.

• You can also use the category-specific search box to search for all symptoms in that category.

• The search box on the main page includes ALL symptoms in all categories.

5) What if I can't find my condition or my medication on the "Questions" page?

•If your condition or medication is not displayed in the type-ahead list, we don't have enough information about it to factor it into the results. If you don't see it, skip that field.

• All questions are optional; you can always skip directly to results.

6) Are there any other tips for using this symptom checker?

• If you need to go back to a previous page, please use the "back" or "previous" buttons within the tool. Do not use the back button on your browser or phone. You could lose the symptoms you entered.

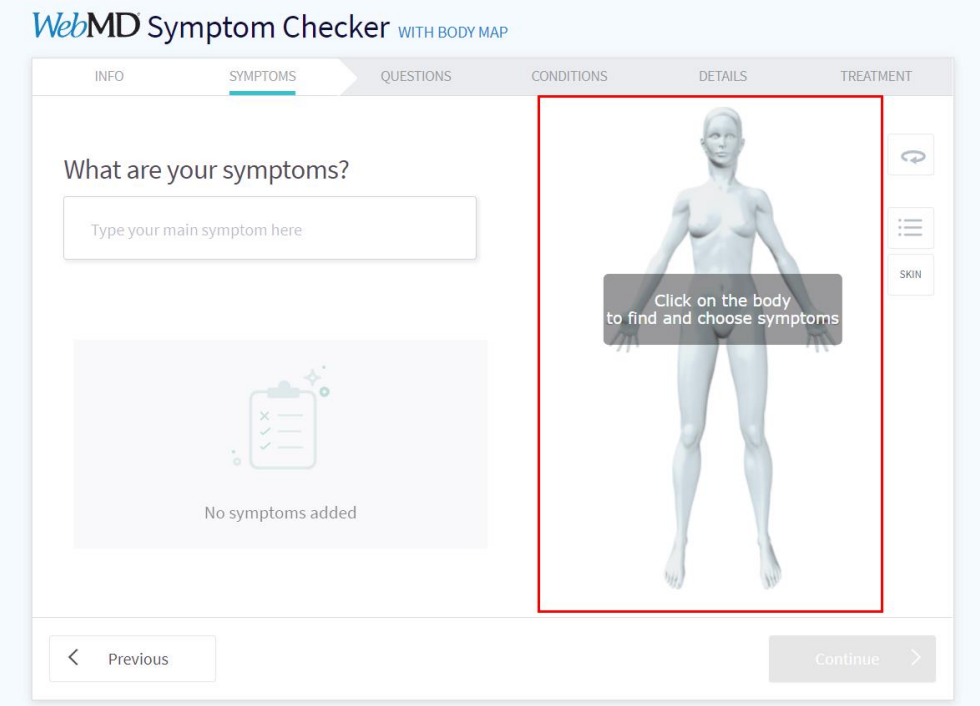
• Results are ordered by how closely your symptoms match a condition AND how common it is (in the United States). Extremely rare conditions may not surface in this tool. You should always consult a doctor for specific concerns.

• We strongly suggest entering more than 1 symptom. It will likely improve your results.

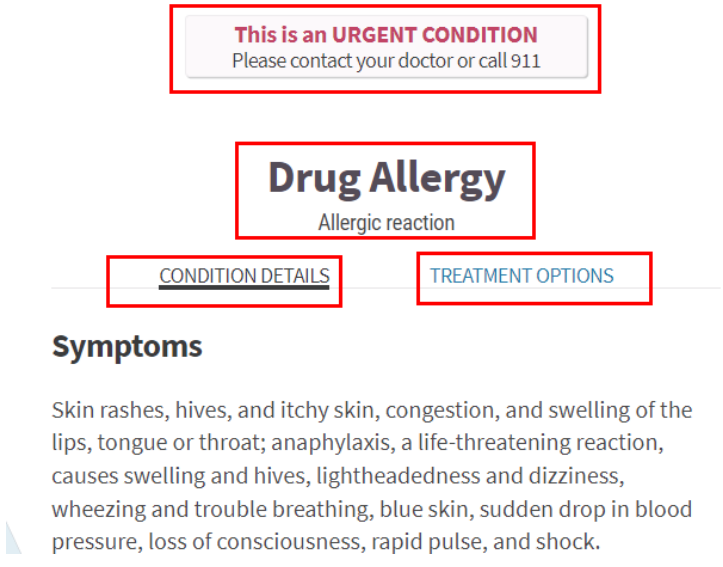
Practical tasks for students. Instructions for execution of practical work

1. Start a computer and wait for the loading of Windows OS**.**
2. Perform the following tasks:

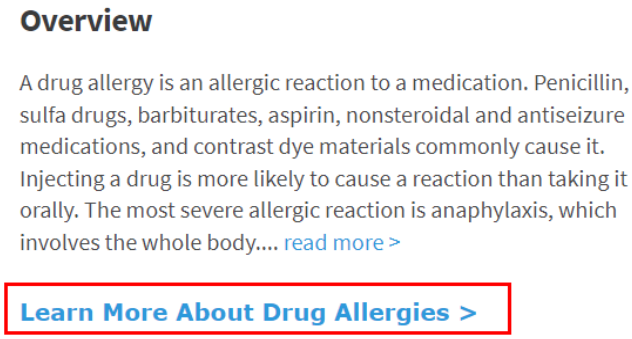
Task №1. *Using **WebMD** expert system (https://symptoms.webmd.com/) find the most likely health condition.*
*You can use textual input or visual, **using 3D body map**.*



Check **Condition Details** and proposed **Treatment Options**



In **Overview** section Click **Learn More About** link



Understanding Your Results
Match strength shows how well the symptoms you entered match the symptoms of each condition. It's not the likelihood of having the condition
Just because a condition is listed here, doesn't mean that you have it. Some of the conditions on this list are less frequently diagnosed.
Talk to your doctor to understand what your symptoms may mean.

● When the task is done, take the screenshot of *whole* ***WebMD*** expert system window, insert the screenshot in the new slide of **MS PowerPoint** document.

*Choose **ONE** variant according to your number in the group list.*

** Try to guess what medical specialty this case belongs to: Infectious Diseases / Internal Medicine; Pulmonology; Gastroenterology; Dermatology; Neurology; Rheumatology; Hematology; Urology; Cardiology.*

1. **Scenario:** "I've had a sore throat and fever for two days, and now it's painful to swallow. My neck feels swollen."
Gender: Female
Age: 24
Symptoms: Sore throat, fever (102°F), difficulty swallowing, swollen lymph nodes, fatigue, mild headache

2. **Scenario:** "I'm coughing up yellow mucus, and my chest feels heavy. I also have chills."
Gender: Male
Age: 62
Symptoms: Productive cough, yellow mucus, chest heaviness, chills, fever (101.5°F), shortness of breath

3. **Scenario:** "I've been coughing a lot, and it's hard to breathe deeply. I also feel a tightness in my chest."
Gender: Male
Age: 45
Symptoms: Persistent cough, shortness of breath, chest tightness, wheezing, fatigue, mild fever (100°F)

4. **Scenario:** "I have trouble breathing, and my lips sometimes turn blue after activity."
Gender: Female
Age: 40
Symptoms: Shortness of breath, cyanosis (blue lips), fatigue, chest tightness, wheezing

5. **Scenario:** "I have sharp stomach pain after eating, and my stools are dark and tarry."
Gender: Male
Age: 52
Symptoms: Stomach pain, bloating, nausea, dark tarry stools, fatigue, loss of appetite

6. **Scenario:** "I've been feeling nauseous all day, and now I'm vomiting and have a fever."
Gender: Female
Age: 38
Symptoms: Nausea, vomiting, fever (101°F), stomach cramps, diarrhea, loss of appetite

7. **Scenario:** "My skin is very itchy, and there's a rash on my arms and legs that's spreading."
Gender: Female
Age: 31
Symptoms: Itchy skin, red rash on arms and legs, dry patches, mild swelling, fatigue

8. **Scenario:** "I have a fever, and my joints hurt. I've also noticed a butterfly-shaped rash on my face."
Gender: Female
Age: 34
Symptoms: Fever (101°F), joint pain, butterfly-shaped facial rash, fatigue, sensitivity to sunlight

9. **Scenario:** "I have a pounding headache, and my neck feels stiff. Bright lights make it worse."
Gender: Male
Age: 35
Symptoms: Severe headache, stiff neck, sensitivity to light, nausea, fever (102°F)

10. **Scenario:** "I feel dizzy when I stand up, and my heart races. I'm also unusually tired."
Gender: Male
Age: 28
Symptoms: Dizziness, rapid heartbeat, fatigue, lightheadedness, occasional chest discomfort

11. **Scenario:** "I have constant joint pain that's worse in the morning. My fingers are stiff and swollen."
Gender: Female
Age: 55
Symptoms: Joint pain, stiffness in fingers, swollen joints, fatigue, mild fever

12. **Scenario:** "I feel extremely tired and weak. I also have unusual bruising on my arms and legs."
Gender: Male
Age: 50
Symptoms: Fatigue, weakness, easy bruising, pale skin, dizziness, mild fever

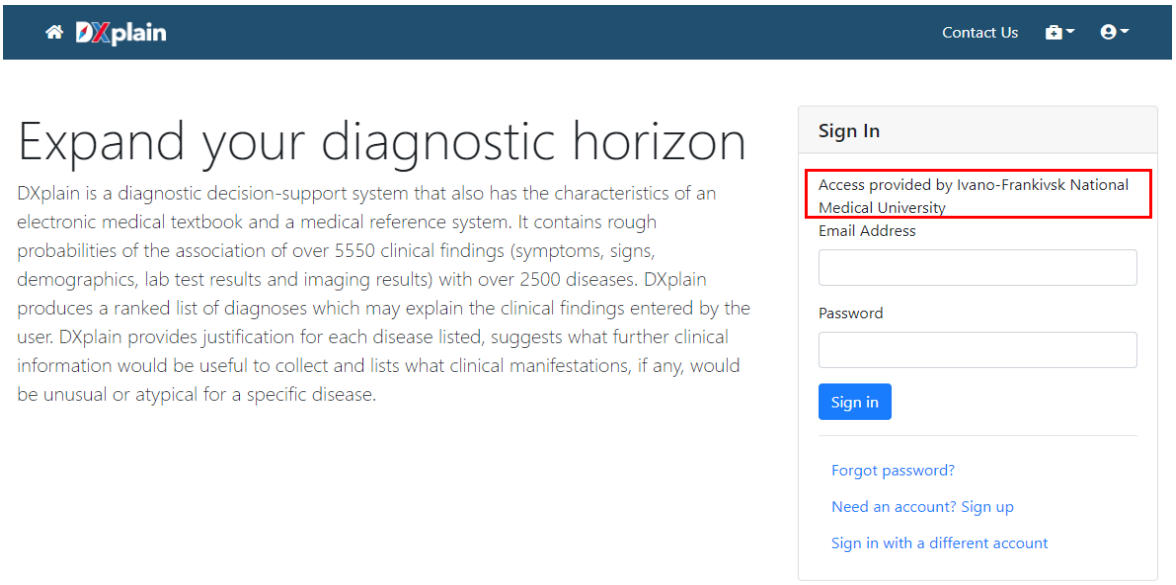
13. **Scenario:** "I've been having frequent urination and a burning sensation when I pee."
Gender: Female
Age: 29
Symptoms: Frequent urination, burning during urination, lower abdominal pain, cloudy urine, mild fever (99.5°F)

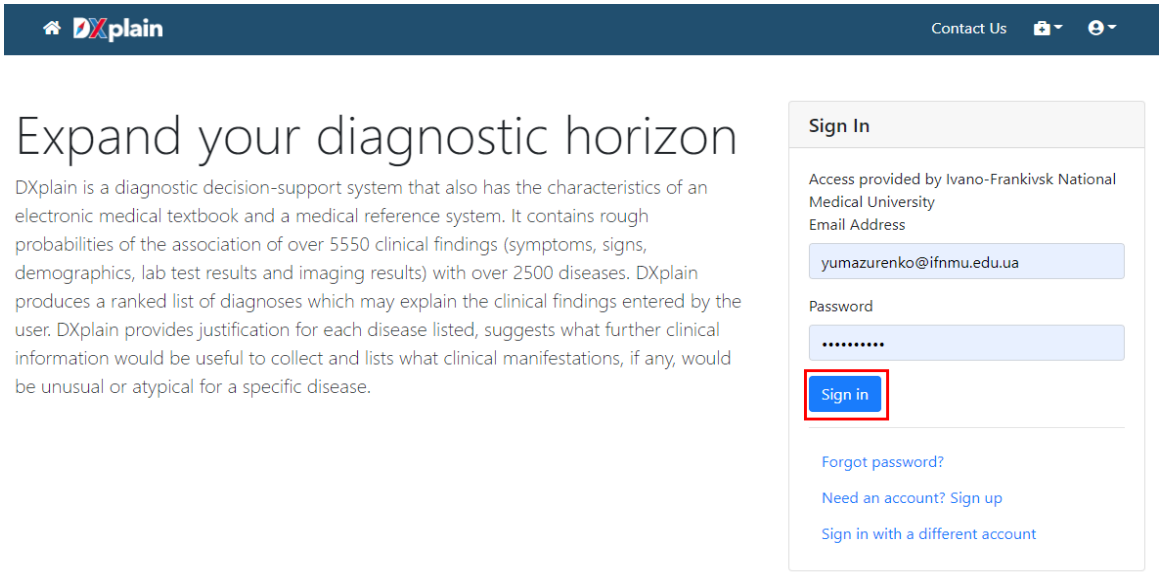
14. **Scenario:** "My heart feels like it's racing, and I'm sweating a lot even when I'm not active."
Gender: Male
Age: 33
Symptoms: Rapid heartbeat, excessive sweating, anxiety, trembling hands, fatigue

Answer: Infectious Diseases / Internal Medicine (1, 2); Pulmonology (3, 4); Gastroenterology (5, 6); Dermatology (7, 8); Neurology (9, 10); Rheumatology (11); Hematology (12); Urology (13); Cardiology (14).

****

Task №2. *Using **Dxplain** expert system (https://dxplain.net/) find the most likely health condition.*





*Choose **ONE** variant according to your number in the group list.*

1. **Scenario:** "I feel very weak, my skin is pale, and I'm bruising easily. I also have shortness of breath and chest discomfort."
Gender: Male
Age: 55
Symptoms: Fatigue, pale skin, easy bruising, shortness of breath, chest discomfort
Basic Labs:
Hemoglobin: 8.5 g/dL (low)
Platelet Count: 90,000/µL (low)
WBC Count: 3,000/µL (low)

2. **Scenario:** "I have abdominal pain, my skin looks yellow, and my urine is dark."
Gender: Female
Age: 45

Symptoms: Abdominal pain, jaundice, dark urine, nausea, fatigue
Basic Labs:

Bilirubin: 3.2 mg/dL (high)
ALT: 150 U/L (high)
AST: 170 U/L (high)

3. **Scenario:** "I have a severe headache, blurred vision, and my blood pressure is high."
Gender: Male
Age: 60
Symptoms: Severe headache, blurred vision, dizziness, nausea
Basic Labs:
Blood Pressure: 200/110 mmHg (high)
Creatinine: 2.3 mg/dL (high)
Potassium: 5.5 mmol/L (high)

4. **Scenario:** "I've been vomiting for two days, my stomach hurts, and I feel dizzy and weak."
Gender: Female
Age: 32
Symptoms: Vomiting, abdominal pain, dizziness, weakness
Basic Labs:
Sodium: 128 mmol/L (low)
Potassium: 3.0 mmol/L (low)
Blood Glucose: 70 mg/dL (low)

5. **Scenario:** "My legs are swollen, and I feel very tired. I also get breathless when lying down."
Gender: Male
Age: 65
Symptoms: Leg swelling, fatigue, breathlessness while lying flat, weight gain
Basic Labs:
BNP: 500 pg/mL (high)
Serum Creatinine: 1.8 mg/dL (high)
Potassium: 4.8 mmol/L (normal)

6. **Scenario:** "I have joint pain, especially in the mornings, and my hands are swollen and red."
Gender: Female
Age: 48
Symptoms: Morning stiffness, joint pain, swollen and red hands
Basic Labs:
Rheumatoid Factor: Positive
ESR: 40 mm/hr (high)
CRP: 20 mg/L (high)

7. **Scenario:** "I feel shaky, my heart is racing, and I've been sweating a lot."
Gender: Female
Age: 38
Symptoms: Palpitations, excessive sweating, tremors, weight loss
Basic Labs:
TSH: 0.01 mIU/L (low)
Free T4: 3.5 ng/dL (high)
Glucose: 85 mg/dL (normal)

8. **Scenario:** "I have a severe burning sensation when I pee, and I feel feverish."

Gender: Male
Age: 40
Symptoms: Painful urination, fever, lower abdominal discomfort, chills
Basic Labs:
Urinalysis: Positive for leukocytes and nitrites
WBC Count: 12,000/µL (high)
CRP: 15 mg/L (high)

9. **Scenario:** "I've been feeling thirsty all the time and going to the bathroom a lot."
Gender: Male
Age: 50
Symptoms: Increased thirst, frequent urination, weight loss, fatigue
Basic Labs:
Blood Glucose: 280 mg/dL (high)
HbA1c: 10.2% (high)
Sodium: 145 mmol/L (normal)

10. **Scenario:** "I feel lightheaded, my skin is itchy, and I've noticed unusual bruising."
Gender: Female
Age: 55
Symptoms: Dizziness, pruritus (itching), easy bruising, fatigue
Basic Labs:
Platelets: 70,000/µL (low)
Bilirubin: 2.5 mg/dL (high)
Alkaline Phosphatase: 150 U/L (high)

11. **Scenario:** "I've been losing weight, my stool is greasy, and I feel bloated all the time."
Gender: Female
Age: 46
Symptoms: Weight loss, greasy stools, bloating, fatigue
Basic Labs:
Fecal Fat: Positive
Serum Albumin: 2.8 g/dL (low)
Vitamin D: 15 ng/mL (low)

12. **Scenario:** "I have chest pain that gets worse when I take a deep breath or lie down."
Gender: Male
Age: 29
Symptoms: Sharp chest pain, shortness of breath, fever
Basic Labs:
D-dimer: Normal
CRP: 25 mg/L (high)
ECG: Diffuse ST elevation

13. **Scenario:** "My legs hurt, and I've noticed red streaks along my veins."
Gender: Female
Age: 30
Symptoms: Leg pain, redness along veins, mild fever, swelling
Basic Labs:
WBC Count: 11,000/µL (high)
ESR: 30 mm/hr (high)
CRP: 12 mg/L (high)

14. **Scenario:** "I've been feeling very weak, and my skin looks bronze-colored."
Gender: Male
Age: 42
Symptoms: Fatigue, bronze skin discoloration, joint pain, weight loss
Basic Labs:
Ferritin: 1,000 ng/mL (high)
AST: 85 U/L (high)
ALT: 90 U/L (high)

15. **Scenario:** "I've had a persistent cough and night sweats, and I've lost some weight."
Gender: Male
Age: 34
Symptoms: Persistent cough, weight loss, night sweats, fatigue
Basic Labs:
Chest X-Ray: Infiltrates in upper lobe
TB Test: Positive
ESR: 50 mm/hr (high)

****

Task №3. *Knowing if a person is having a seizure and diagnosing the type of seizure or epilepsy syndrome can be difficult. Many other disorders can cause changes in behavior and can be confused with epilepsy. Since the treatment of seizures depends on an accurate diagnosis, making sure that a person has epilepsy and knowing what kind is a critical first step.* ***Epilexia*** *is a medical-decision-making program, particularly an expert system to aid in the clinical diagnosis of epileptic pathology.*
Using ***Epilexia*** *expert system to determine what type of seizures patients are having.*

start **Epilexia** program.

Patient 1
click **Epileptic syndromes**;
in the **Anamnestical data** window put the check marks next to **Epilepsy familiarity**, **Previous cerebral damages (pre-, peri- and post-birth)**, **Sex:** *Male*, **Age of beginning:** *from 2 to 5 years*, **Clinical context:** *normality* (***Fig. 4***) → click **Forward**;
in **Seizure's kind** window put the check marks next to **Clonic seizures:** *generalized*, **Tonic seizures (or hypertonic):** *generalized*, **Atonic seizures:** *global: sudden downfall*, **Tonic-clonic seizures:** *generalized* (***Fig. 5***) → click **Forward**;

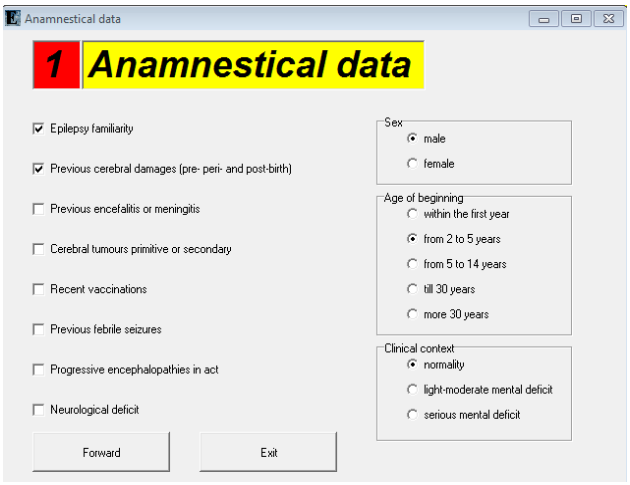


Fig. 4

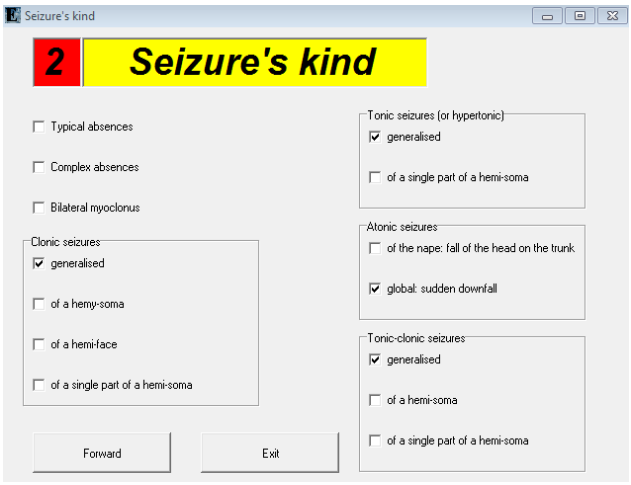


Fig. 5

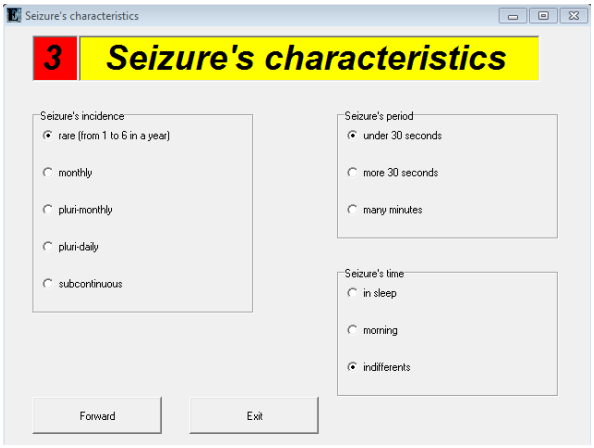


Fig. 6

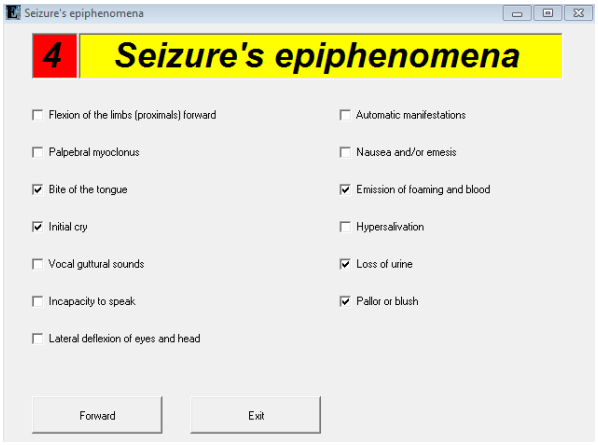


Fig. 7

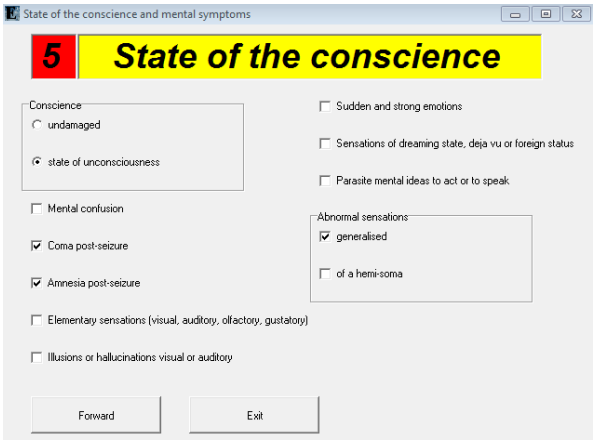


Fig. 8

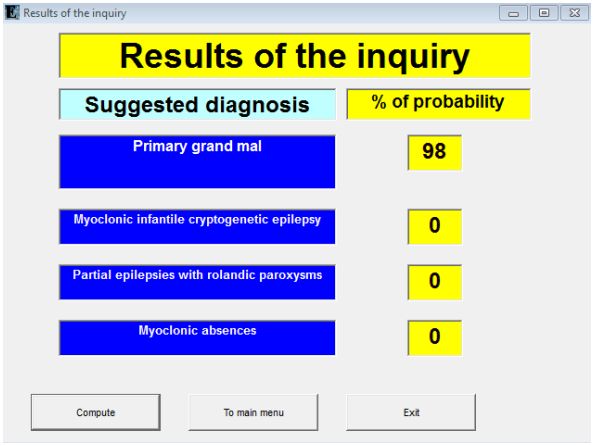


Fig. 9

in the **Seizure's characteristics** window put the check marks next to **Seizure's incidence:** *rare (from 1 to 6 in a year)*, **Seizure's period:** *under 30 seconds*, **Seizure's time:** *indifferents* (***Fig. 6***) → click **Forward**;
in the **Seizure's epiphenomena** window put the check marks next to **Bite of the tongue**, **Initial cry**, **Emission of foaming and blood**, **Loss of urine**, **Pallor or blush** (***Fig. 7***) → click **Forward**;

Patient 2
in the **State of the conscience,** window put the check marks next to **Conscience:** *state of unconsciousness*, **Coma post-seizure**, **Amnesia post-seizure**, **Abnormal sensations:** *generalized* (***Fig. 8***) → click **Forward**;
in **Results of the inquiry** window click **Compute** (***Fig. 9***);
type *1) Suggested diagnosis: Primary grand mal* in the **REPORT** document;
click **To main menu** → click **Forms of the epileptic syndromes** → select **Primary grand mal** → click **OK** → read information → type *Therapy. First choice: phenobarbital or primidone or dipropilacetate* in the **REPORT** document;
click **To main menu**;
click **Epileptic occasional seizures**;
in the **Anamnestical data** window put the check marks next to **Epileptic familiarity**, **Beginning age:** *within the first 5 years*, **Previous cerebral damages:** *pre- or peri-birth damages* (***Fig. 10***) → click **Forward**;
in **Pathologies of base or** window put the check mark next to **Neurological deficit** (***Fig. 11***) → click **Forward**;

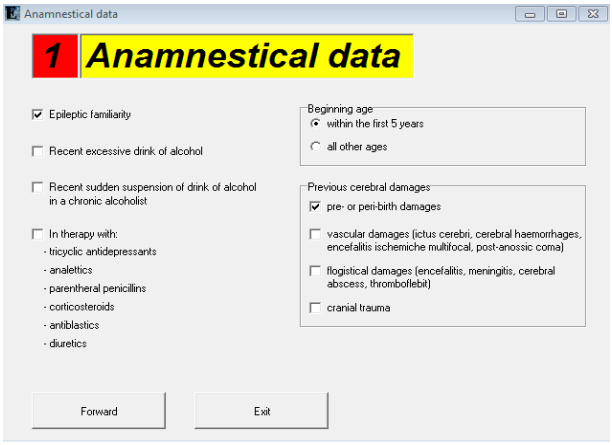


Fig. 10

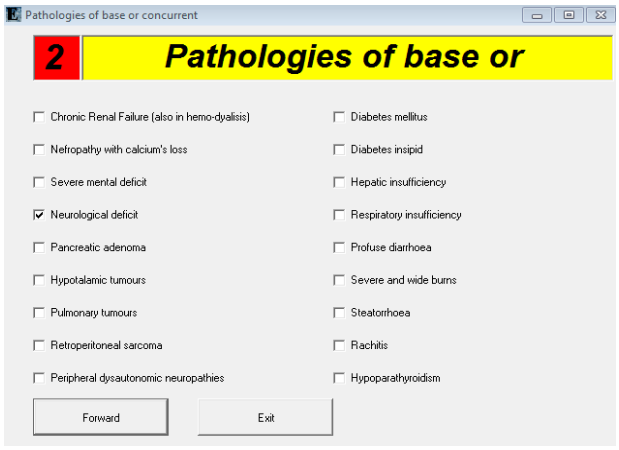


Fig. 11

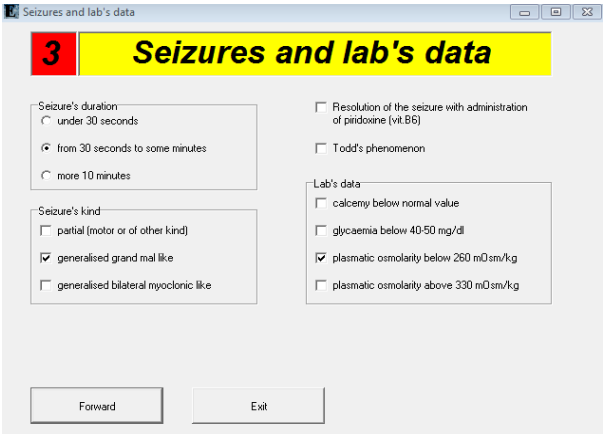


Fig. 12

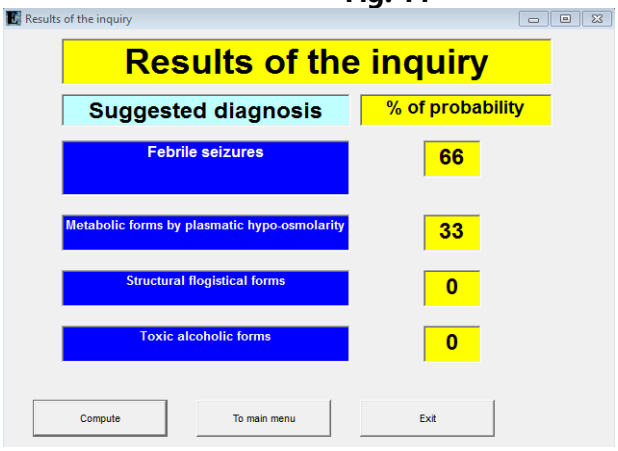


Fig. 13

in **Seizures and lab's data** window put the check marks next to **Seizure's duration:** *from 30 seconds to some minutes*, **Seizure's kind:** *generalized grand mal like*, **Lab's data:** *plasmatic osmolarity below 260 mOsm/kg* (***Fig. 12***) → click **Forward**;
in **Results of the inquiry** window click **Compute** (***Fig. 13***);
type *2) Suggested diagnosis: Febrile seizures (66%), Metabolic forms by plasmatic hypo-osmolarity (33%)* in the **REPORT** document;
click **To main menu** → click **Forms of the epilept.occas.seizures** → select **Febrile seizures** → click **OK** → read information → type *Therapy. Seizures: diazepam or clonazepam. Prophylaxis of the relapses: antipyretics (during the hyperpyrexia with chronicity phenobarbital or dipropilacetate (only in the cases with high risk)* in the **REPORT** document.
click **Forms** → select **Metabolic forms by plasmatic hypo-osmolarity** → click **OK** → read information → type *Conditions of plasmatic hypo-osmolarity. Hyper-secretion primary or secondary of ADH (cranial trauma, hypothalamic tumors, pulmonary tumor secreting ADH, peripheral dysautonomia neuropathies). Latrogenous cause: too fast hemodialysis or excessive use of diuretics. Dipsomania: mental patient with episodes of compulsive thirst.* in the **REPORT** document;
click **To main menu**;
change the data few times and after any change click **Compute**;
make a conclusion about different types of epilepsy.

****

Task №4. *Using the Cardiac Risk expert system compute the absolute risk of developing a cardiovascular event in the next 10 years, in patients who have never had a previous cardiac event (the risk is regarded as high when greater of 20%).*

start **Cardiac Risk** program;
click **Sex:** *Male*, **Age:** *50-59*, **Diabetus mellitus:** *Yes*, **Systolic blood pressure (mmHg):** *130-150*, **Smoking:** *Yes*, **Total Cholesterol (mg/dl):** *168-206*, click **Compute the risk** (***Fig. 14***);

type *Evaluation of the cardiovascular risk in the normal patient: patient 1,* rewrite the conditions and calculated risk value in the **REPORT** document;
change following data: **Diabetus mellitus:** *No,* **Smoking:** *No,* click **Compute the risk**;
type *patient 2,* rewrite the conditions and calculated risk value in the **REPORT** document;
change the data few more times and after any change click **Compute the risk**;
make a conclusion about dependence of risk of developing a cardiovascular event in the next 10 years on the different conditions of patients' health.

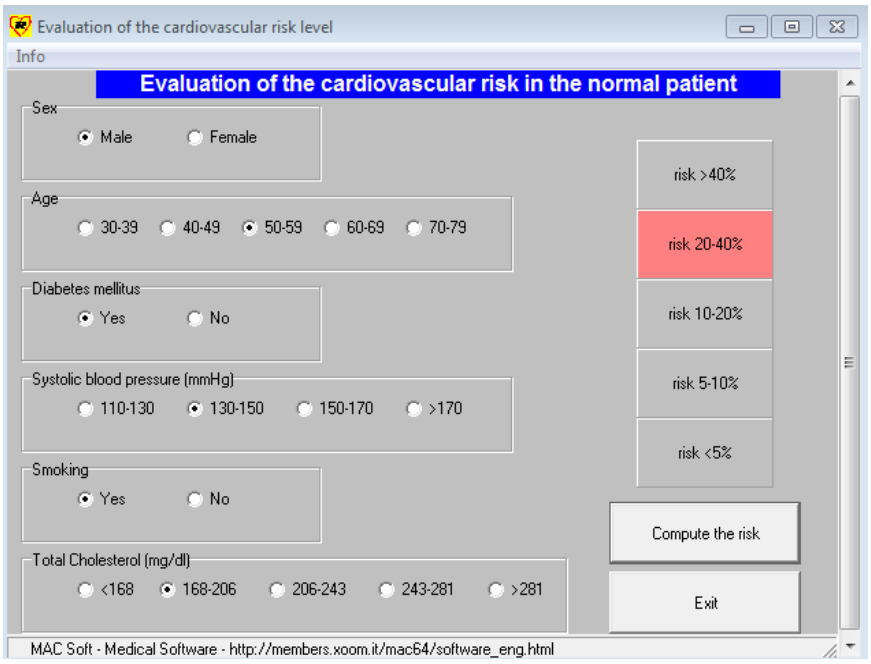


Fig. 14

Attention*: After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:

1) Expert systems directors: Prof. Zixing Cai &miss WenSha. Slideplayer.com. Retrieved December 1, 2024, from https://slideplayer.com/slide/12860973/

2) Symptom checker with body from WebMD - check your medical symptoms. WebMD. Retrieved December 1, 2024, from https://symptoms.webmd.com/

3) Sabry, F. (2023). *Clinical decision support system: Fundamentals and applications*. One Billion Knowledgeable.

4) Bhadula, S., Sharma, S., & Johri, A. (2023). *Innovations and applications of Clinical Decision Support Systems in healthcare*. Medical Information Science Reference.

5) Information Resources Management Association (Ed.). (2021). *Research anthology on decision support systems and decision management in healthcare, business, and engineering*. Business Science Reference. https://doi.org/10.4018/978-1-7998-9023-2

Additional

1) Belciug, S., & Gorunescu, F. (2020). *Intelligent Decision Support Systems: A journey to smarter healthcare*. Springer International Publishing.

2) Berner, E. S. (Ed.). (2016). *Clinical decision support systems: Theory and practice (3rd ed.)*. Springer International Publishing.

3) Tan, J. (2008). *Healthcare information systems and informatics: Research and practices* (J. Tan, Ed.). Medical Information Science Reference.

Topic 16: INFORMATION RESOURCES IN HEALTHCARE, EVIDENCE-BASED MEDICINE, AND FUNDAMENTALS OF TELEMEDICINE.

Actuality: Medical performance is based on quality, and quality is based on the best available evidence. Clinicians should seek and apply the highest level of evidence available. Information technology has the potential to improve decision-making through online medical resources, electronic clinical practice guidelines, electronic health records (EHRs) with decision support, online literature searches, statistical analysis, and online continuing medical education (CME). That is why students of medical specialties have to know the basis of evidence-based medicine and should have the skills to search for information, appraise that information, and apply the valid information to solve clinical problems (EBM practice).

Educational aims of the lesson:

To know:

1. main principles of evidence-based medicine;
2. steps in the evidence-based process;
3. levels of evidence;
4. pyramid of evidence.

To be able to:

1. search, appraise, and apply valid information to solve clinical problems.

The list of questions for the survey:

2. What is Evidence-Based Medicine?
3. Main principles of evidence-based medicine.
4. Steps in the evidence-based process.
5. Levels of evidence.
6. Pyramid of evidence.

The list of required practical skills:

1. Searching, appraising, and applying valid information to solve clinical problems.

Brief theoretical information

What Is a Clinical Study?

A clinical study is research involving human volunteers (called participants) to improve medical knowledge. There are two main types of clinical studies: **clinical trials** (interventional studies) and **observational studies** [1].

Clinical Trials

In **clinical trials**, participants receive specific treatments or interventions based on a detailed research plan or protocol. These interventions might include:

- Medical products like drugs or devices.
- Procedures or changes in behavior, such as diet adjustments.

Clinical trials often compare:

- A new treatment with a standard one, a placebo (inactive treatment), or no treatment.
- Two or more existing treatments to see which works better.

When studying a new approach, it's usually unknown if it will help, harm, or have no effect compared to alternatives. Researchers measure specific outcomes to determine the safety and effectiveness of the intervention. For example, a trial might test a drug on people with high blood pressure to see if it lowers their blood pressure.

Clinical trials for drug development are divided into phases, as defined by the Food and Drug Administration (FDA). People who cannot join a trial might access experimental treatments through expanded access programs.

Observational Studies

In **observational studies**, researchers study health outcomes in participants but do not assign specific treatments. Instead, participants may receive treatment as part of their usual medical care.

For example, researchers might observe older adults to understand how different lifestyles affect heart health. Unlike clinical trials, participants in observational studies are not given treatments specifically for the study.

Both clinical trials and observational studies play a vital role in advancing medical knowledge and improving patient care.

Who Conducts Clinical Studies?

A clinical study is led by a principal investigator, usually a medical doctor. The research team may include other professionals like doctors, nurses, social workers, and healthcare specialists.

Studies are funded by various organizations, such as pharmaceutical companies, academic medical centers, voluntary groups, or government agencies like the National Institutes of Health or the Department of Defense. Sometimes, individual doctors or healthcare providers sponsor research as well.

Where Are Clinical Studies Conducted?

Clinical studies can take place in hospitals, universities, doctors' offices, or community clinics. The location depends on the study and its sponsors.

How Long Do Clinical Studies Last?

The duration of a clinical study varies based on its goals. Participants are informed about the expected length before joining.

Why Are Clinical Studies Conducted?

Clinical studies aim to improve medical knowledge about treating, diagnosing, or preventing diseases. Common reasons include:

- Testing new treatments like drugs, devices, or surgical methods for diseases or conditions.
- Finding ways to prevent diseases, including vaccines, medications, or lifestyle changes.
- Studying interventions to diagnose or identify diseases and their risk factors.
- Exploring ways to improve comfort and quality of life for people with chronic illnesses.

Participating in Clinical Studies

Clinical studies follow a detailed research plan called a protocol. The protocol ensures the study answers research questions while protecting participants' health. It includes:

- The purpose of the study.
- Eligibility criteria for participants.
- The number of participants needed.
- The schedule of tests, procedures, or treatments.
- The length of the study.
- The type of data collected about participants.

Who Can Join a Clinical Study?

Clinical studies have specific rules, called eligibility criteria, that determine who can participate. These rules are outlined in the study protocol. Some studies require participants with specific conditions being studied, while others look for healthy volunteers. In some cases, researchers invite specific groups of people to join.

- Inclusion Criteria: Factors that allow someone to participate, like age, gender, or the type and stage of a disease.

- Exclusion Criteria: Factors that disqualify someone from participating, such as certain medical conditions or past treatments.

Randomized Controlled Trials (RCTs)

RCTs are a common type of clinical study designed to reduce bias when testing new treatments. Participants are randomly assigned to one of **two groups**:

1. A group receiving the new treatment being tested.

2. A control group receiving standard treatment or a placebo (an inactive substance).

Randomization ensures fairness and reduces the risk of bias, allowing researchers to better assess the treatment's effectiveness compared to the control group. RCTs are often considered the "gold standard" for clinical trials and help determine both the benefits and potential side effects of treatments.

Blinding in Clinical Trials

Single-Blind Trials: In these trials, **participants don't know which treatment they are receiving**—whether it's the new treatment, standard treatment, or a placebo. This prevents bias, as knowing the treatment could influence how participants feel or report results. For example, someone might feel better simply because they believe they are getting the new treatment.

Double-Blind Trials: In these trials, **neither the participant nor the doctor knows which treatment the participant is receiving**. A computer assigns code numbers to treatments, and this information is kept secret until the trial is finished. This ensures the results are unbiased.

- Patients are told about the possibility of receiving a placebo, especially if no standard treatment exists.
- If there is a medical emergency, researchers can access the treatment assignment.

Participants are "**unblinded**" (told which group they were in) only if it becomes medically necessary before the trial ends.

Types of Clinical Trials

Clinical trials can be classified by how researchers conduct the study [2]:

- **Observational Studies:** Researchers watch participants and record their outcomes without directly intervening or providing treatments.
- **Interventional Studies:** Researchers actively give participants specific treatment, such as a drug or therapy, and compare their outcomes to those receiving no treatment or standard care.

The National Institutes of Health (NIH) divides clinical trials into **five categories**:

1. Treatment Trials: Test experimental treatments, new drug combinations, or innovative approaches to surgery and radiation therapy.

2. Prevention Trials: Explore ways to prevent diseases in healthy individuals or prevent recurrence in those who have had a condition.

3. Diagnostic Trials: Focus on improving tests or procedures for identifying diseases or conditions.

4. Screening Trials: Investigate the best methods for early detection of diseases or health conditions.

5. Quality of Life Trials: Study ways to improve comfort and overall quality of life for people with chronic illnesses.

Phases of Clinical Trials

New drugs, medical devices, or interventions go through multiple stages of testing before approval:

1. Preclinical Stage: Safety and biological activity are assessed in the lab using animal models.

- Toxicity Testing: Includes acute, subacute, chronic, and special toxicity studies (e.g., reproductive effects, carcinogenicity, mutagenicity).

- Pharmacokinetics/Pharmacodynamics (PK/PD): Studies absorption, distribution, metabolism, and excretion (ADME) in animals like rats, dogs, and monkeys. Also evaluates bioavailability (how much of a drug reaches the bloodstream).

- Pharmacological Effects: Examines the therapeutic index (ratio of effective dose to toxic dose) and measures such as ED50 (effective dose for 50% of participants) and LD50 (lethal dose for 50%).

2. Phase 0: First human trials, involves 10–15 participants, often with very small doses, to assess how the body responds.

3. Phase I: Test safety, dosage range, and initial side effects. Compare animal results to human responses. Trials are open label (not blinded).

Types of Phase I trials:

1. SAD (Single Ascending Dose):

- Small groups (3 participants) receive a single dose.
- If no issues occur, the dose increases for another group of 3 participants.
- If toxicity occurs, the same dose is tested on 3 more participants to confirm the maximum tolerated dose (MTD).

2. MAD (Multiple Ascending Dose):

- Participants receive repeated low doses to study how the drug is processed over time (pharmacokinetics and pharmacodynamics).
- Blood and other samples are analyzed.

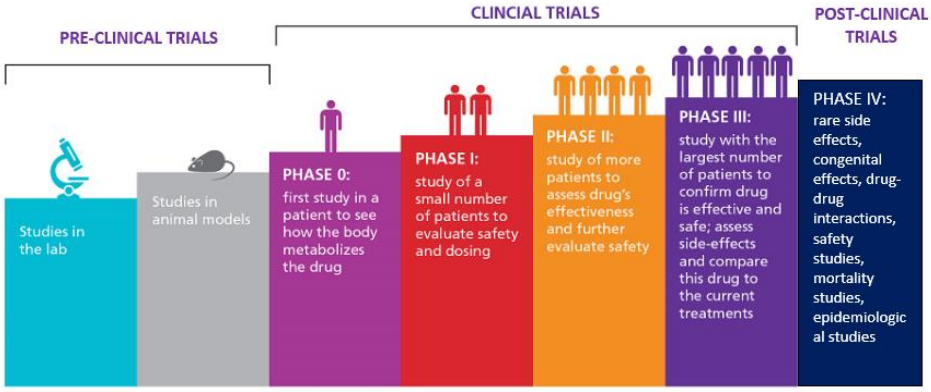
3. Food Effect:
- Tests on how eating before taking the drug affects its absorption.

3. Phase II: Test if the treatment works (efficacy) and monitor side effects, lasts from several months to two years.
Trials are often randomized and divided into two stages:
- **Early Phase (single-blind):** Around 200 patients participate.
- **Late Phase (double-blind, controlled):** 200–400 patients.

Focus on:
- Indications for use.
- Patient type and disease severity.
- Dosage, schedule, and increments.
- Side effects and their severity.
- Effects on specific patient groups.

4. Phase III: Determine if the new treatment is better than the current standard. Involves large-scale, multi-center trials to confirm effectiveness and monitor for adverse effects.
- Includes 1,500–3,500 patients.
- Trials are randomized and double-blinded.

5. Phase IV (Post-Marketing): Study long-term effects after approval, including rare side effects, congenital effects, and interactions with other drugs.
Includes safety studies, mortality studies, and epidemiological research to monitor ongoing use in larger populations.



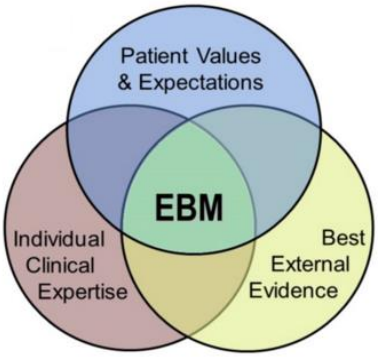
ClinicalTrials.gov is a resource provided by the U.S. National Library of Medicine. It hosts a large collection of clinical studies from around the world

What is Evidence-Based Medicine (EBM)?

Evidence-Based Medicine (EBM) is the careful and thoughtful use of the best available evidence to make decisions about the care of individual patients.
Another way to define EBM is:
a process of systematically reviewing, evaluating, and applying clinical research findings to provide the best possible care for patients.

What is Evidence-Based Practice (EBP)?

Evidence-Based Practice (EBP) involves making clinical decisions based on reliable research that minimizes bias and focuses on improving patient outcomes, including their quality of life and survival.



EBP combines three key components:

1. **Clinical Expertise:** The skills, education, and experience of the healthcare provider.
2. **Patient Values:** The patient's preferences, concerns, and expectations.
3. **Best Research Evidence:** High-quality, clinically relevant research conducted using strong methodologies.

These elements work together to guide decision-making and enhance care quality. While evidence does not directly make decisions, it provides strong support for better outcomes.

How EBP Works

EBP often starts with a patient's situation, which raises questions about:

- Treatment options.
- Diagnostic tests.
- Disease prognosis.
- Causes of disorders.

To practice EBP effectively, clinicians need skills in:

- Searching medical literature efficiently.
- Applying evidence-based rules to assess the reliability and usefulness of research findings.

Steps in the Evidence-Based Practice (EBP) Process

1. Assess the Patient: Identify a clinical problem or question from the patient's care.
2. Ask the Question: Create a clear and focused clinical question based on the patient's case.
3. Acquire the Evidence: Search for reliable information using appropriate resources.
4. Appraise the Evidence: Check the evidence for accuracy (validity) and relevance (usefulness in practice).
5. Apply the Evidence: Discuss the findings with the patient, combining the evidence with your clinical expertise and the patient's preferences to make decisions.
6. Evaluate Your Performance: Reflect on how well you handled the process with this patient and identify areas for improvement.

Types of Questions and Studies

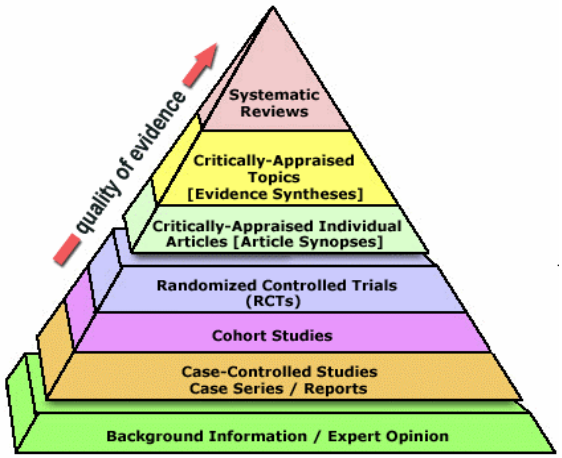
When building a clinical question, consider:

- **Type of Question:** Helps determine what information you need.
- **Type of Study:** Guides you to the best research design for answering the question.

The most common type of questions:	**Type of study:**
Diagnosis how to select and interpret diagnostic tests	Prospective, blinded comparison with a gold standard or cross-sectional study.
Therapy How to select treatments that provide more benefits than risks and are worth the cost and effort.	Randomized controlled trial (RCT) or cohort study.
Prognosis How to predict a patient's clinical course over time and identify possible complications of a disease.	Cohort study, case-control study, or case series.
Harm/Etiology How to identify the causes of a disease, including those caused by medical interventions (iatrogenic).	Cohort study, case-control study, or case series.

Levels of Evidence: Pyramid of Evidence

The pyramid of evidence shows how study designs become more reliable and less prone to bias as you move up the levels.



1. Case Series and Case Reports

- These are collections of reports about the treatment of individual patients or a single patient.
- They do not include control groups for comparison, so their statistical reliability is low.

2. Case-Control Studies

- These studies compare patients with a specific condition to those without it, looking back to identify potential causes or risk factors.
- Data often comes from medical records or patient recall.
- These studies are less reliable than cohort studies or randomized controlled trials because a statistical link does not always mean causation.

3. Cohort Studies

- These follow a group of people with a specific treatment or exposure over time and compare their outcomes to a similar group without that treatment or exposure.
- While more reliable than case-control studies, they are observational and not as strong as randomized controlled trials, since differences between groups may influence the results.

4. Randomized Controlled Trials (RCTs)

- Carefully designed experiments that test the effects of a treatment or exposure on patients.
- Use methods like randomization and blinding to minimize bias.
- Compare outcomes between intervention groups (those receiving treatment) and control groups (no treatment).
- Provide strong evidence for cause-and-effect relationships.

5. Systematic Reviews

- Focus on answering a specific clinical question by reviewing multiple studies.
- Use strict criteria to select studies with reliable methods.
- Summarize findings from selected studies to provide a clear answer to the question.

6. Meta-Analysis

- Combines results from multiple valid studies using statistical methods.
- Treats the combined data as if it were from one large study, offering stronger conclusions.

7. Cross-Sectional Studies

- Examine the relationship between diseases and other factors at a single point in time within a population.
- Do not provide information about the timing of cause and effect.
- Often used to compare diagnostic tests or assess the effectiveness of a new test against a "gold standard."

8. Qualitative Research

- Explores and explains human responses to health problems.
- Aims to describe and understand health-related behaviors, experiences, and phenomena.

9. Retrospective Cohort Studies

- Similar to cohort studies but use previously collected data.
- Patients are identified based on past exposure or risk factors, and outcomes are tracked forward in time.
- Useful for studying historical data to identify relationships between exposure and outcomes.

Cochrane: Advancing Evidence-Based Healthcare

Cochrane, formerly known as the Cochrane Collaboration, is an independent, non-profit organization made up of over 37,000 volunteers from more than 130 countries. Its mission is to organize and share medical research information to help healthcare professionals, patients, policymakers, and others make

informed decisions about health interventions based on evidence-based medicine principles.

What Cochrane Does

- **Systematic Reviews:** Cochrane conducts and publishes systematic reviews of randomized controlled trials (RCTs) to assess healthcare interventions. Some reviews also include findings from non-randomized observational studies, such as those in occupational health.
- **Collaborative Network:** Contributors join through specialized Cochrane groups, including those focused on specific healthcare topics, systematic review methods, and regional centers.

Cochrane Database of Systematic Reviews (CDSR)

The CDSR is a leading resource for systematic reviews in healthcare. It contains:

- **Cochrane Reviews:** Comprehensive, regularly updated systematic reviews.
- **Protocols:** Plans for upcoming reviews.
- **Editorials:** Articles designed to spark discussion and advance evidence synthesis for better clinical care and health policy decisions.
- **Supplements:** Occasional additions to the database.

The CDSR is updated continuously, with new reviews published as they are completed, forming monthly issues to ensure timely access to the latest evidence.

Links:

Cochrane: http://www.cochrane.org/

Cochrane Library: http://www.cochranelibrary.com/

What Are Critically Appraised Topics (CATs)?

A **Critically Appraised Topic (CAT)** is a brief summary of evidence on a specific clinical question. It is less detailed than a systematic review but still highlights the best available research on the topic. CATs often include findings from multiple studies. When a single study is summarized, it is called a Critically Appraised Paper (CAP). CATs and CAPs help busy clinicians quickly access and share important evidence.

Parts of a CAT typically include:

- **The clinical question (PICO):** Defines the problem, population, intervention, comparison, and outcome.
- **Search strategy:** Explains how the evidence was gathered.
- **Description of included studies:** Summarizes the research used.
- **Methodological limitations:** Lists the weaknesses of the studies, often presented in an evidence table.
- **Clinical bottom line:** Provides the key takeaway for practice.
- **Short reference list:** Cites of the sources used.

A 3-Part Question

The 3-part question is designed using the PICO format. Structuring research and clinical questions in this way means you can be very clear about the clinical conundrum you are interested in. PICO stands for:

P: the patient group, problem, or population of interest;

I: the intervention or factor of interest being considered (e.g. treatment, diagnostic test, risk factor);

C: the comparator or most likely alternative if appropriate;

O: the clinical outcome of interest.

PICO Example for Treatment

"For a 60-year-old male with bilateral osteoarthritis of the knees, is a physical therapy program of manual therapy plus guided exercises more effective than placebo in reducing pain, improving function, and reducing the likelihood of surgery?" LCDR Jessica Feda, DPT, OCS, October 2006

PICO Example for Prognosis

"For a 46-year-old male with a venous stasis ulcer of 16.5 cm2 in size which has remained open for 2.5 years, what is the likelihood of the wound closing with compression therapy by the time that the patient is released from prison in 4 months?" CDR Eric Payne, DPT, January 2007

PICO Example for Diagnosis

"For a 22-year-old male runner is there a clinical test that is valid for determining patellofemoral pain syndrome?" Heather Khan, DPT, January 2007

PICO Example for Harm

For a 54-year-old man taking a non-FDA-approved drug for male pattern balding what is the prevalence of permanent disfigurement as related to drug side effects?

CATmaker

The ***CATmaker software***, developed by *Douglas Badenoch* from the *Centre for Evidence-Based Medicine in Oxford*, is a tool that helps you create *Critically Appraised Topics*, or CATs, for the key articles you encounter about therapy, and diagnosis, prognosis, etiology/harm, and systematic reviews of therapy.

It carries out the following functions:

• prompts you for your clinical question, your search strategy, and key information about the study you found;
• provides online critical appraisal guides for assessing the validity and usefulness of the study;
• automates the calculation of clinically useful measures (and their 95% confidence intervals);
• helps you formulate clinical "Bottom Lines" from what you've read;
• creates 1-page summaries (CATs) that are easy to store, print, retrieve, and share (as both text and HTML files);
• helps you remember when to update each CAT you create.

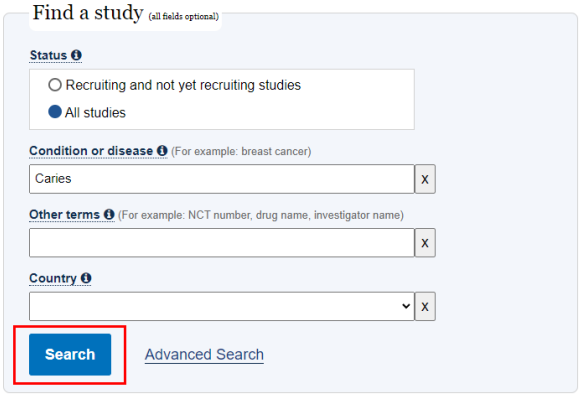
Practical tasks for students.
Instructions for execution of practical work

1. Start a computer and wait for the loading of **Windows OS.**
2. Perform the following tasks:

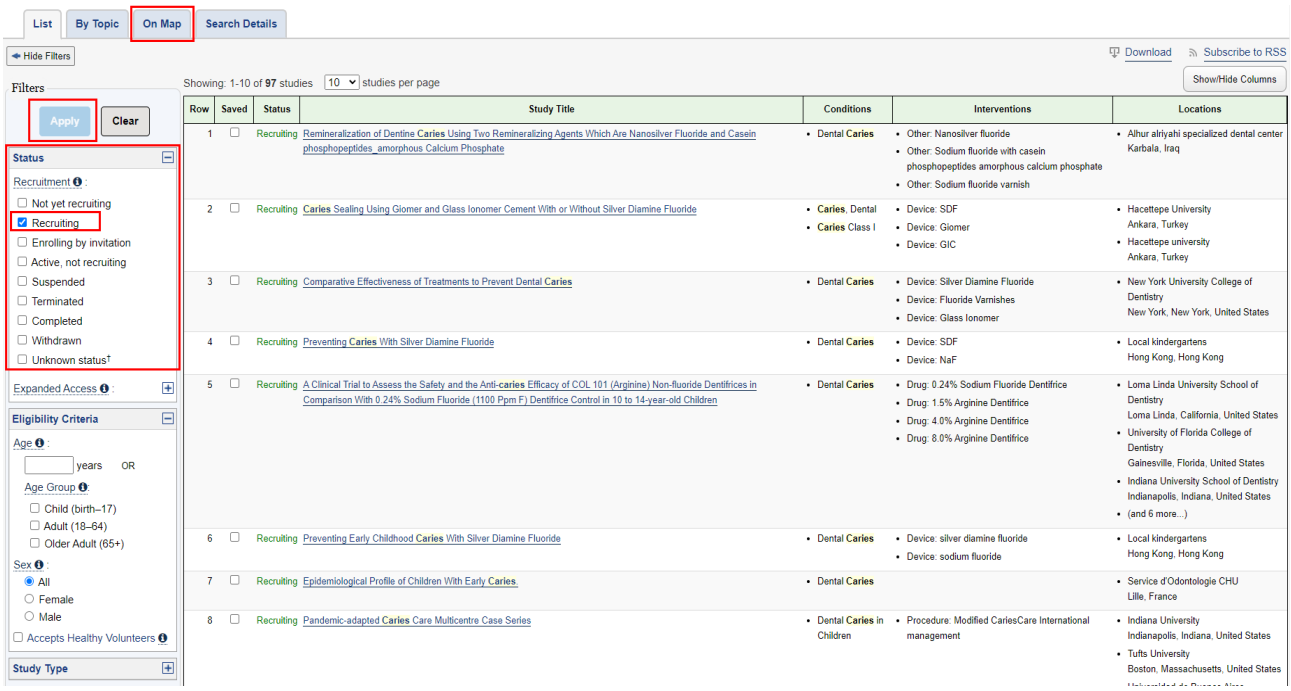
****

Task 1. *Visit the website* ***https://www.clinicaltrials.gov/***.
ClinicalTrials.gov hosts a large collection of clinical studies from around the world. You can search for clinical studies by a condition or disease name or other terms such as a drug name. You can find a study close to home by entering an address, city, or state. You can also narrow your search by selecting from a long list of other fields such as participation criteria or study results.

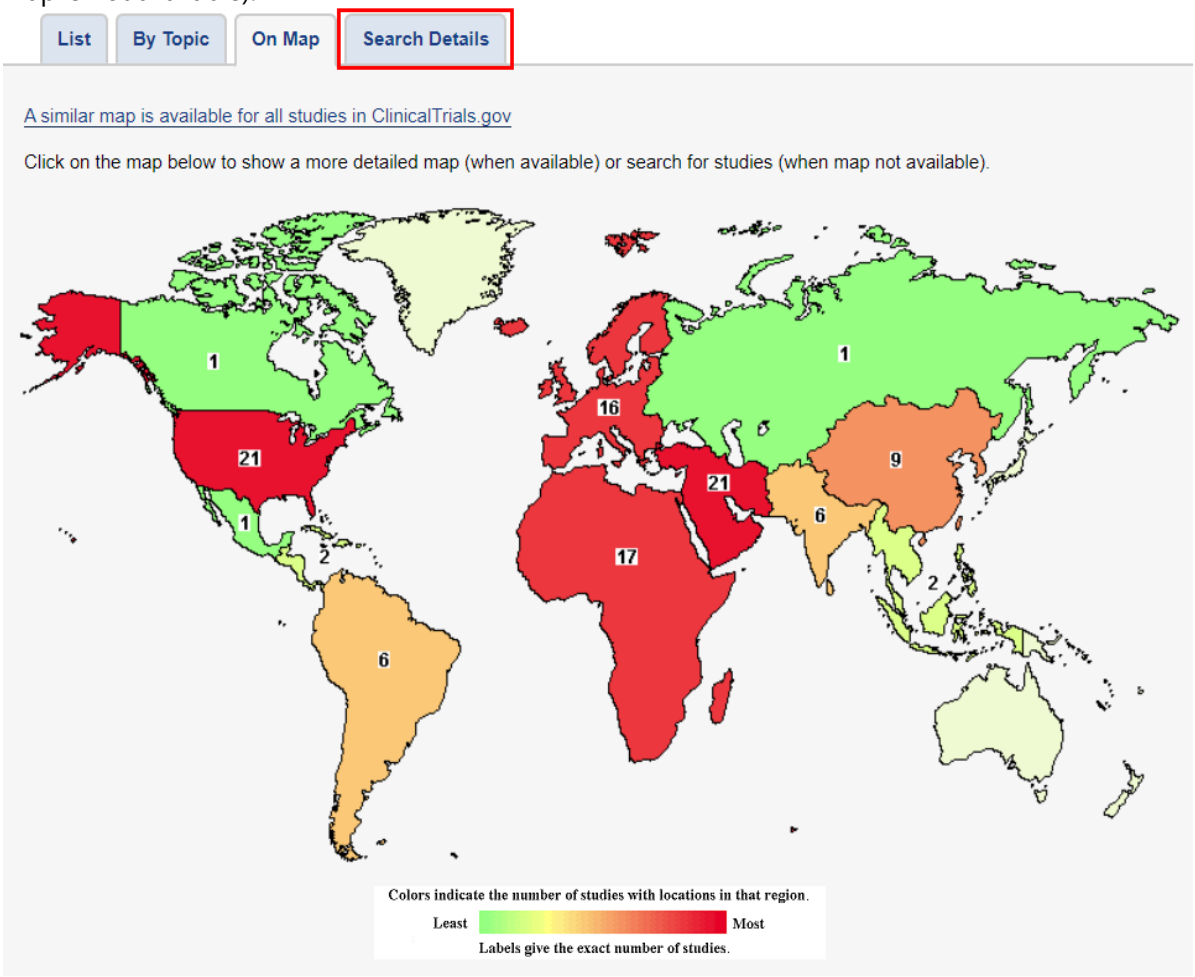
In the box **Find a study** and fill in the field **Condition or disease** as given in the screenshot. Click the **Search** button.



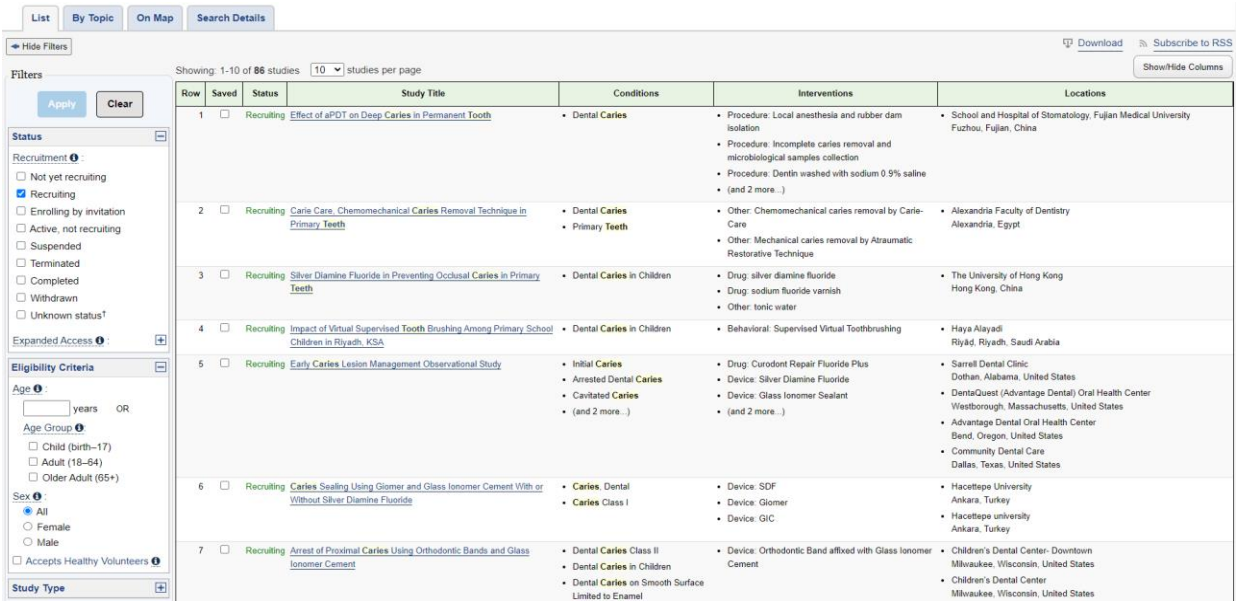
In the **Status** section use **Recruiting**; Click the **Apply** button.



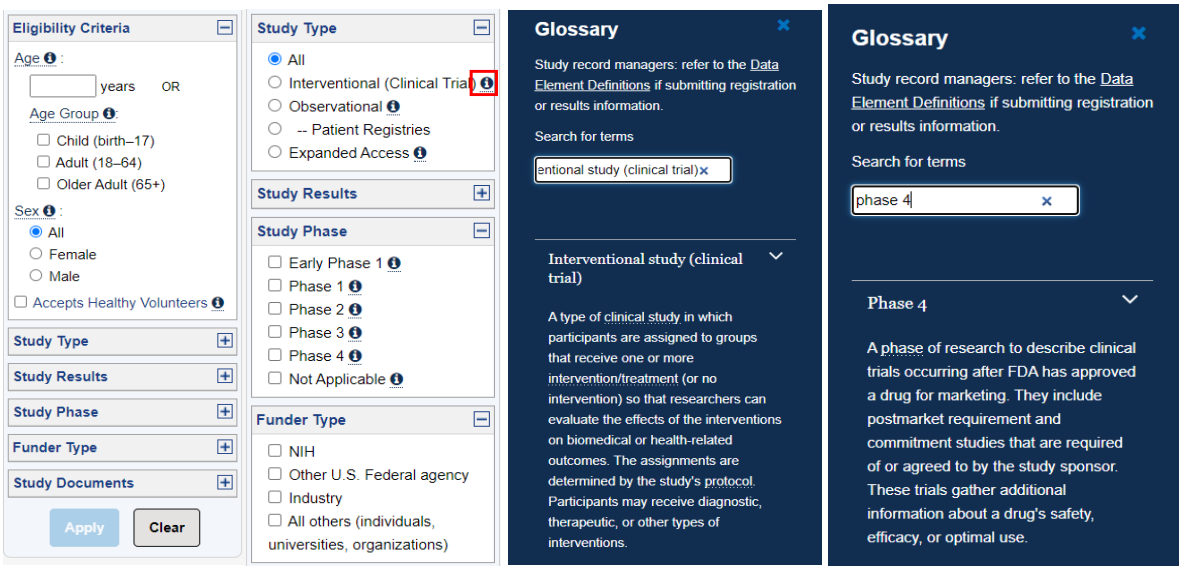
Click the tab **On map**, to see where the majority of researchers are carried.
Click on the map below to show a more detailed map (when available) or search for studies (when the map is not available).



Click the tab **Search details**, and overview related terms.
Find in the list the letter **T** and click on the word **tooth**.
Overview of the list obtained.



Overview of other filters, such as **Study Type**, **Study Results**, **Study Phase**, **Funder Type**, etc.
By clicking on the ***i*** icon, you can activate the **Glossary** and find more information.



close the tabs.

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Task 2. *Overview critically appraised topics online libraries, make conclusions about CATs structure and purpose of their creation.*
Start **browser** (**Google Chrome**, **Mozilla Firefox**, **Opera**, **Microsoft Internet Explorer,** or other).
type *https://cats.uthscsa.edu/*;
click **Public Health** in **Browse by Dental Specialty/Topic** region;
type *Allergy* in the **Search** field;
click the **CATs Search** button;
click any of the topics on the search results page;
overview the CAT, notice what main parts it consists of;
close the tabs.

****

Task 3. *Overview critically appraised topics online libraries, make conclusions about CATs structure and purpose of their creation.*
Start **browser** (**Google Chrome**, **Mozilla Firefox**, **Opera**, **Microsoft Internet Explorer,** or other).
type *https://cats.uthscsa.edu/*;

in the menu on the left part of the page click **Search CATs Library**;
click **Public Health** in **Browse by Dental Specialty/Topic** region;
type *Allergy* in the **Search** field;
click the **CATs Search** button;
click any of the topics on the search results page;
overview the CAT, notice what main parts it consists of;
close the tabs.

****

Task 4. *A 58-year-old man with type 2 diabetes mellitus visits your primary care clinic. He states that he is concerned that his blood pressure may be elevated. During a routine physical examination, you confirm that he is hypertensive. Naturally, your first reaction is to help the patient relieve his hypertension, but you are unsure about the appropriate goal. You remember reading an article on research that demonstrated a marked reduction in major cardiovascular events when diastolic blood pressure was reduced. Determine whether the reduction in blood pressure reduces the risk of cardiovascular disease in a patient with type 2 diabetes mellitus and hypertension. Using CATmaker software create CAT summarising the best available research evidence on a topic.*

Search for the research on the topic of interest:
Start the **browser**;
type *www.cochranelibrary.com/*;
click the **Advanced Search** button;
in the **Search** field select *Search All Text*;
in the menu in the left part of the window click **Trials**;
in the **Search Term Box** type "*hypertension*" "*blood-pressure lowering*" "*diabetes mellitus*" *and* "*rate of cardiovascular events*" → click **Go** → search results will be displayed at the bottom of the screen;
in the list of search results click the title of the first article *Effects of intensive blood-pressure lowering and low-dose aspirin in patients with hypertension: principal results of the Hypertension Optimal Treatment (HOT) randomized trial. HOT Study Group* → short review of the article will appear;
read **Abstract**;
copy the title of the article → open a new tab in the **browser** → paste the title into the **Search** field → press **Enter** → search results will appear;
click second search result **[pdf]Effects of intensive blood-pressure lowering and low-dose…** →
save opened PDF file (right-click the article area → select **Save as…** → type **ABM_1** in the highlighted **File name** text box, click **Desktop** in the left part of the **Save** window, and click **Save** button);
open saved article;
review the article.
*Using **CATmaker** software create a **critically appraised topic**:*
https://www.cebm.ox.ac.uk/resources/ebm-tools/catmaker-and-ebm-calculators

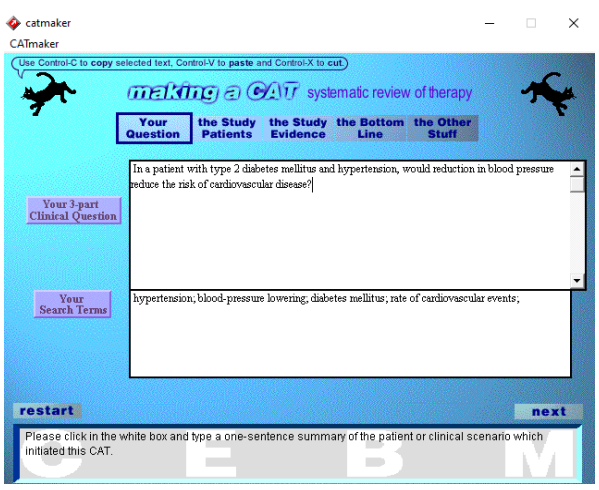


Fig. 1

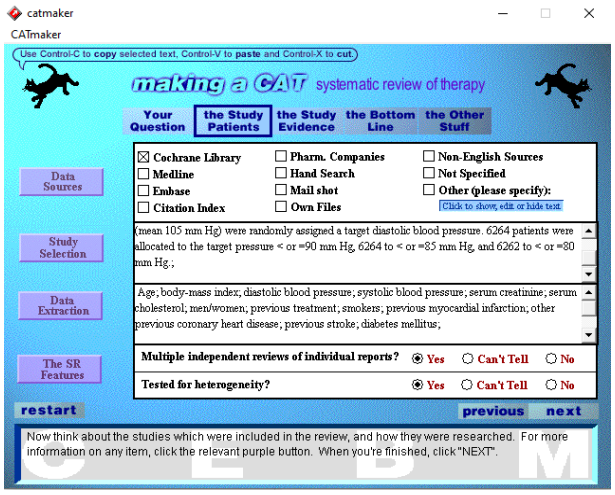


Fig. 2

start **CATmaker** program;
click **prognosis**;
on **Your Question** tab in **Your 3-part Clinical Question** box type *In a patient with type 2 diabetes mellitus and hypertension, would a reduction in blood pressure reduce the risk of cardiovascular disease?*;
in **Your Search Terms** box type *hypertension; blood-pressure lowering; diabetes mellitus; rate of cardiovascular events*;
click the **next** button;
in **Data Sources** select ☒ **Cochrane Library;**
in **Study Selection** type *18790 patients (1501 patients with diabetes mellitus), from 26 countries, aged 50-80 years (mean 61.5 years) with hypertension and diastolic blood pressure between 100 mm Hg and 115 mm Hg (mean 105 mm Hg) were randomly assigned a target diastolic blood pressure. 6264 patients were allocated to the target pressure < or =90 mm Hg, 6264 to < or =85 mm Hg, and 6262 to < or =80 mm Hg.*;
in **Data Extraction** type *Age; body-mass index; diastolic blood pressure; systolic blood pressure; serum creatinine; serum cholesterol; men/women; previous treatment; smokers; previous myocardial infarction; another previous coronary heart disease; previous stroke; diabetes mellitus*;
in **The SR Features** select: **Multiple independent reviews of individual reports..?** – *Yes*, **Tested for heterogeneity?** – *Yes*;
click the **next** button;
on **The Study Evidence** tab type data according to **Fig. 3**.
click the **next** button;
in **Clinical Bottom Line** type *Hypertensive patients with diabetes who maintained a target diastolic blood pressure of 80 mm Hg had a reduction in cardiovascular disease and all-cause mortality compared with those with a target of 90 mm Hg. There were no cardiovascular disease or mortality differences in patients without diabetes*;
in **CAT Title** type *Tight diastolic blood pressure control reduces the risk of cardiovascular disease in type 2 diabetes mellitus*;
in **Comments** type *Valid article to use in clinical practice*;
in **Kill or Update By** type the date in two years from the current date;
click the **next** button;
in **Citations** type *Hansson L, Zanchetti A, Carruthers SG, Dahlof B, Elmfeldt D, Julius S, et al, for the HOT Study Group. Effects of intensive blood-pressure lowering and with hypertension: principal results of the Hypertension Optimal Treatment (HOT) randomized trial. Lancet (London, England), 1998, 351(9118), 1755*;

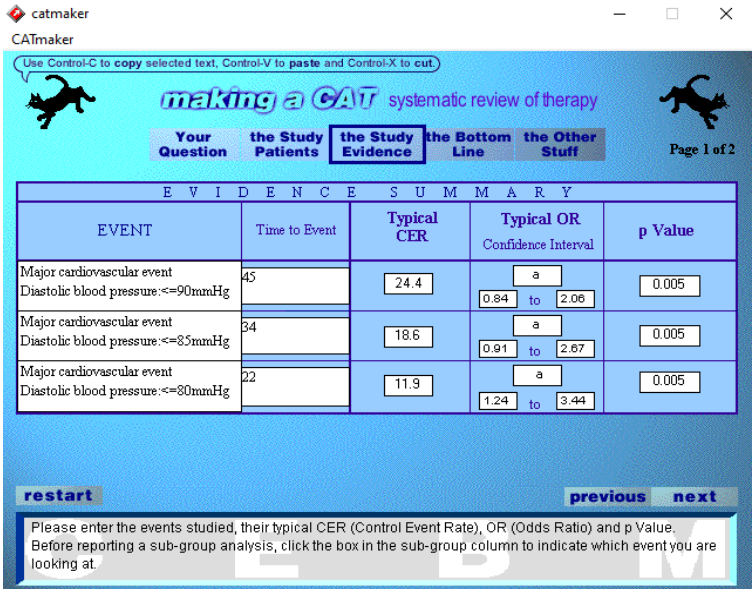


Fig. 3

in **Lead Author's Name & Fax** type *Hansson L.;*
in **Your Name/s Address & Fax** type your name, group;
in **Your Email** type your email;
in the **Date of Birth of this CAT** type the current date;

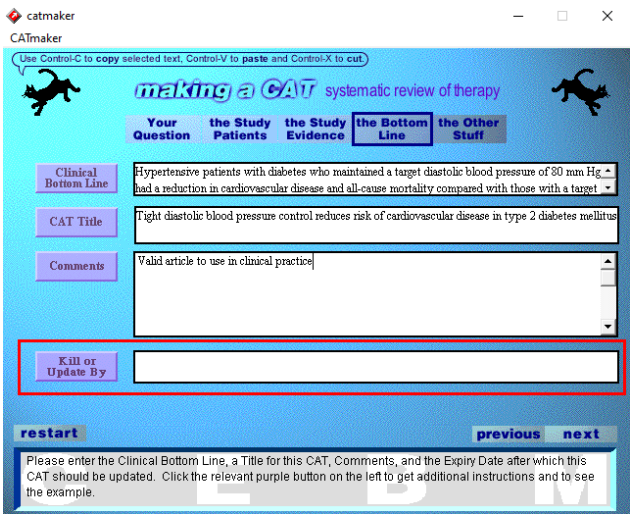


Fig. 4

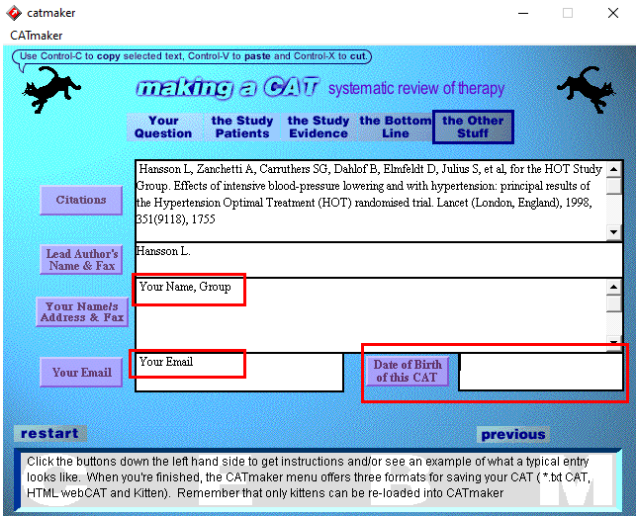
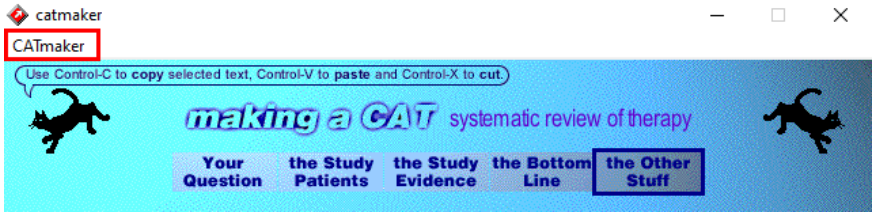


Fig. 5

click **CATmaker** button → **Output as WebCAT** → type **CAT_1.html** in the highlighted **File name** text box, click **Desktop** in the left part of the **Save** window, and click the **Save** button.



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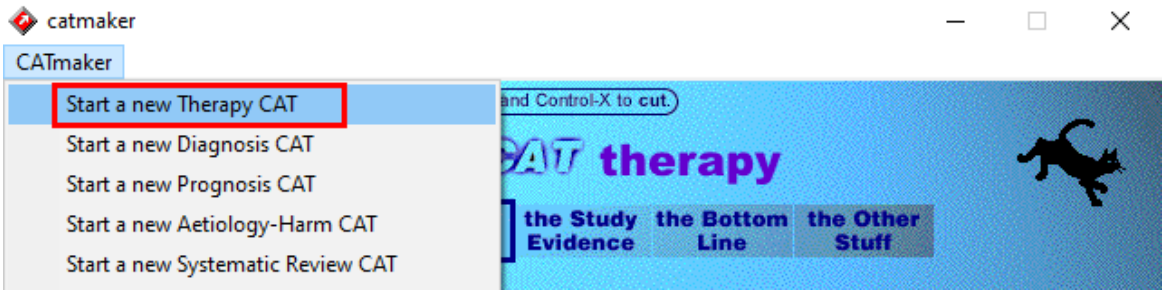
Task 5. *Pain at the burn site is a common side effect following serious burn injuries. Investigators propose that transcutaneous electrical nerve stimulation (TENS) is hypothesized to reduce pain secondary to burn injury. Determine whether there is evidence to support the use of TENS to reduce pain following a major burn injury. Using CATmaker software create CAT summarizing the best available research evidence on a topic.*

Search for the research on the topic of interest:
Start the **browser**;
type *www.cochranelibrary.com/*;
click the **Advanced Search** button;
in the **Search** field select *Search All Text*;
in the menu in the left part of the window click **Trials**;
in the **Search Term Box** type "*transcutaneous electric nerve stimulation*" "*pain*" "*burns*" → and click **Go** → search results will be displayed at the bottom of the screen;
in the list of search results click the title of the first article *Effects of auricular acupuncture-like transcutaneous electric nerve stimulation on pain levels following wound care in patients with burns: a pilot study* → short review of the article will appear;
read **Abstract**.

*Using **CATmaker** software create a **critically appraised topic**:*
start **CATmaker** program;
click **Start a new Therapy CAT**;



on **Your Question** tab in **Your 3-part Clinical Question** box type *Does Transcutaneous Electrical Nerve Stimulation (TENS) reduce pain in adults who have sustained severe burn injury?*;
in **Your Search Terms** box type *transcutaneous electric nerve stimulation; pain; burns*;

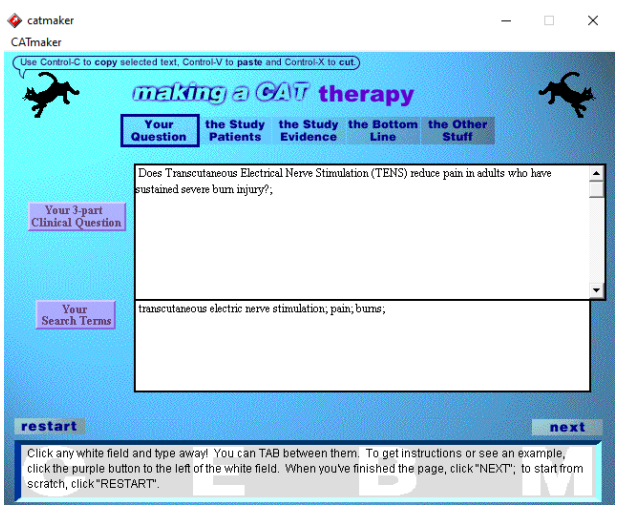


Fig. 6

Fig. 7

click the **next** button;

in **Patients' key Clinical Characteristics** type *Inclusion criteria included: 1. burns that involved less than 35% TBSA, 2. No burns on the face, neck, and ears, 3. extremity burns, including hip/buttocks and shoulder/scapula, 4. pain experienced in the burned area of the extremity just before treatment, 5. no opiate pain medications taken at least 24hrs before treatment, 6. eighteen years or older*;
in **Control Regimens and Durations** type *Placebo pill treatment with a minimum of 24 hours and a maximum of 5 days between each session. Treatment was administered in the subject's room within 15 to 75 minutes after wound debridement. Patients maintained a supine position for 30 minutes post-procedure*;
in **Experimental Regimens and Durations** type *Auricular acupuncture-like (high intensity, low frequency to six points on the ear) TENS treatment with a minimum of 24 hours and a maximum of 5 days between each session. Treatment was administered in the subject's room within 15 to 75 minutes after wound debridement. Patients maintained a supine position for 30 minutes post-procedure*;
in **The Study Features** select: **Randomised Controlled Trial?** – *Yes*, **Blinding?** – *Single*, **Intention-to-Treat?** – *Yes*;
click the **next** button;
on **The Study Evidence** tab type data according to the **Fig. 8**;
click the **calc** button;
click **Click here to Record Differences between Means** button and type data according to the **Fig. 9**;

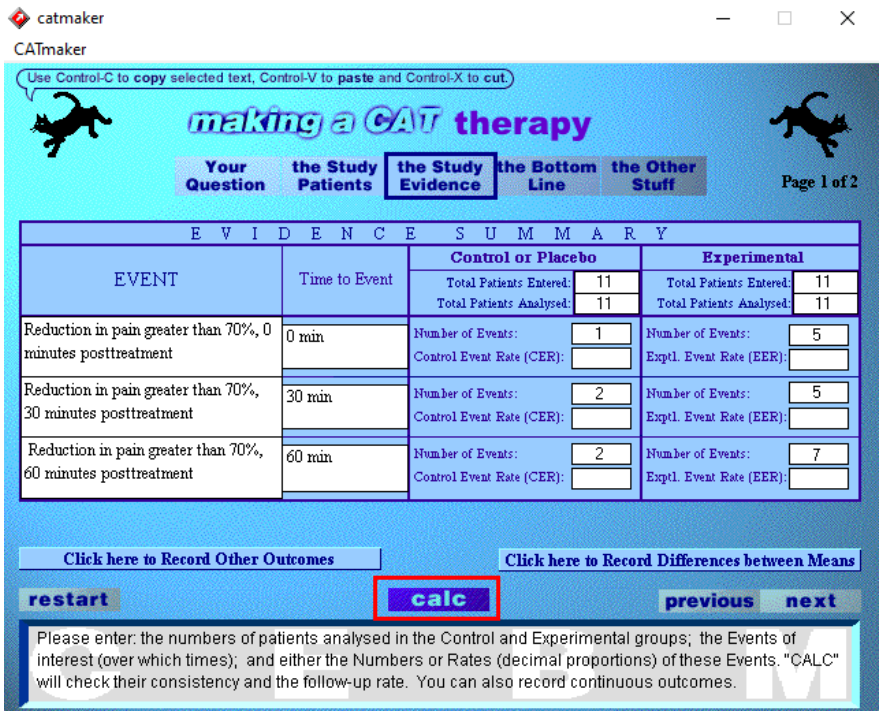

catmaker
CATmaker
Use Control-C to copy selected text, Control-V to paste and Control-X to cut.
making a CAT therapy
Your Question
the Study Patients
the Study Evidence
the Bottom Line
the Other Stuff
Page 1 of 2
E V I D E N C E S U M M A R Y
EVENT
Time to Event
Control or Placebo
Total Patients Entered: 11
Total Patients Analysed: 11
Experimental
Total Patients Entered: 11
Total Patients Analysed: 11
Reduction in pain greater than 70%, 0 minutes posttreatment
0 min
Number of Events: 1
Control Event Rate (CER):
Number of Events: 5
Exptl. Event Rate (EER):
Reduction in pain greater than 70%, 30 minutes posttreatment
30 min
Number of Events: 2
Control Event Rate (CER):
Number of Events: 5
Exptl. Event Rate (EER):
Reduction in pain greater than 70%, 60 minutes posttreatment
60 min
Number of Events: 2
Control Event Rate (CER):
Number of Events: 7
Exptl. Event Rate (EER):
Click here to Record Other Outcomes
Click here to Record Differences between Means
restart
calc
previous
next
Please enter: the numbers of patients analysed in the Control and Experimental groups; the Events of interest (over which times); and either the Numbers or Rates (decimal proportions) of these Events. "CALC" will check their consistency and the follow-up rate. You can also record continuous outcomes.

Fig. 8

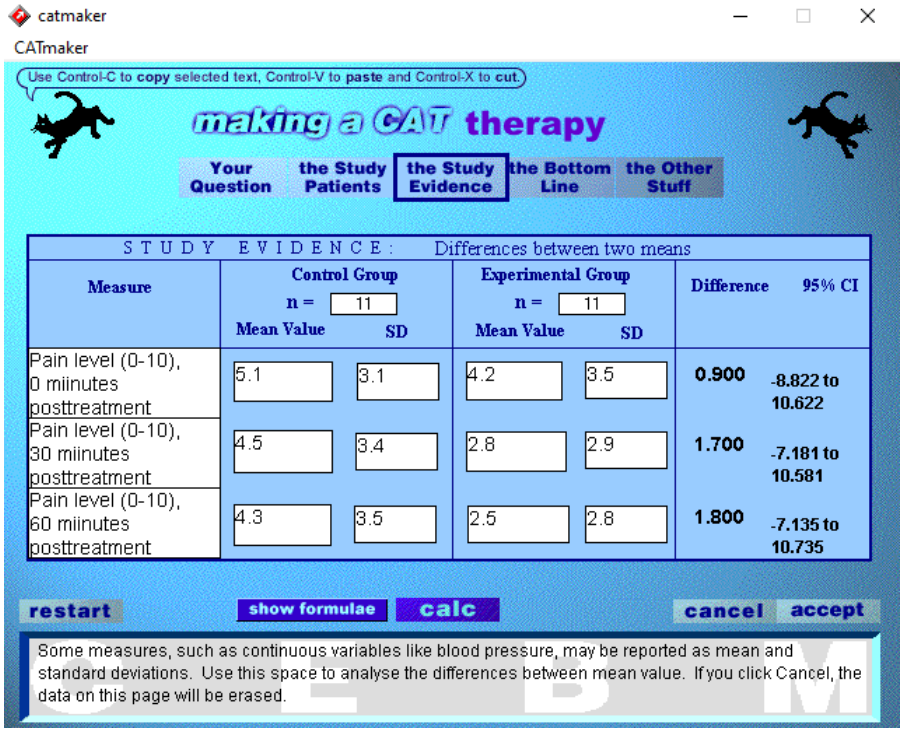

catmaker
CATmaker
Use Control-C to copy selected text, Control-V to paste and Control-X to cut.
making a CAT therapy
Your Question
the Study Patients
the Study Evidence
the Bottom Line
the Other Stuff
S T U D Y E V I D E N C E : Differences between two means
Measure
Control Group n = 11
Mean Value
SD
Experimental Group n = 11
Mean Value
SD
Difference
95% CI
Pain level (0-10), 0 miinutes posttreatment
5.1
3.1
4.2
3.5
0.900
-8.822 to 10.622
Pain level (0-10), 30 miinutes posttreatment
4.5
3.4
2.8
2.9
1.700
-7.181 to 10.581
Pain level (0-10), 60 miinutes posttreatment
4.3
3.5
2.5
2.8
1.800
-7.135 to 10.735
restart
show formulae
calc
cancel
accept
Some measures, such as continuous variables like blood pressure, may be reported as mean and standard deviations. Use this space to analyse the differences between mean value. If you click Cancel, the data on this page will be erased.

Fig. 9

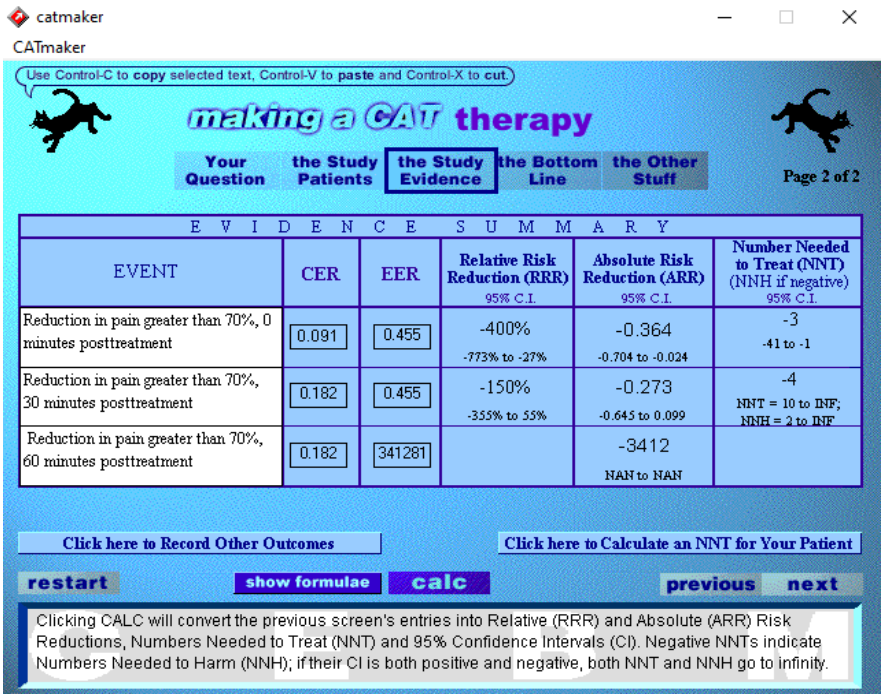


Fig. 10

click **calc** button → click **accept** button → click **next** button;
type data according to the **Fig. 10**;
click **calc** button → click **next** button;
in **Clinical Bottom Line** type *Acupuncture-like TENS may be more effective than a placebo pill at reducing pain levels in burn patients after a debridement procedure*;
in **CAT Title** type *Is Transcutaneous Electrical Nerve Stimulation (TENS) effective as a modality to reduce pain in patients with burn injuries*;
in **Comments** type *The investigators did not include information regarding burn depth, prior pain conditions, co-morbidities, or co-occurring injuries. Controlling for these variables may produce a different outcome. This was a pilot study; a larger sample population is necessary to determine a true effect. Further studies in this area are warranted to determine the effectiveness of acupuncture-like TENS at reducing pain levels within the burn population*;

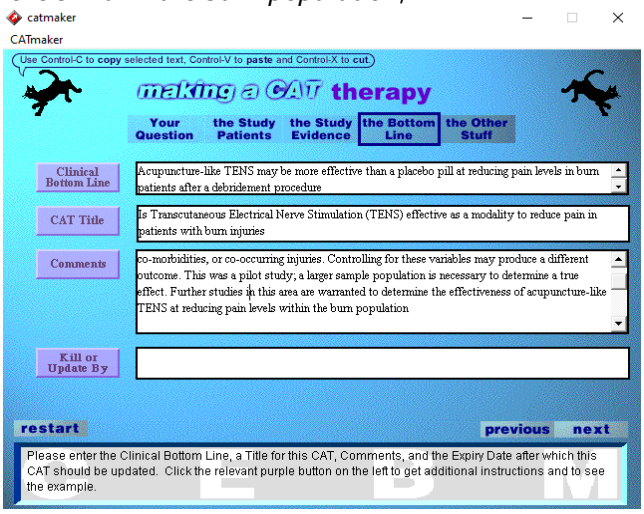


Fig. 11

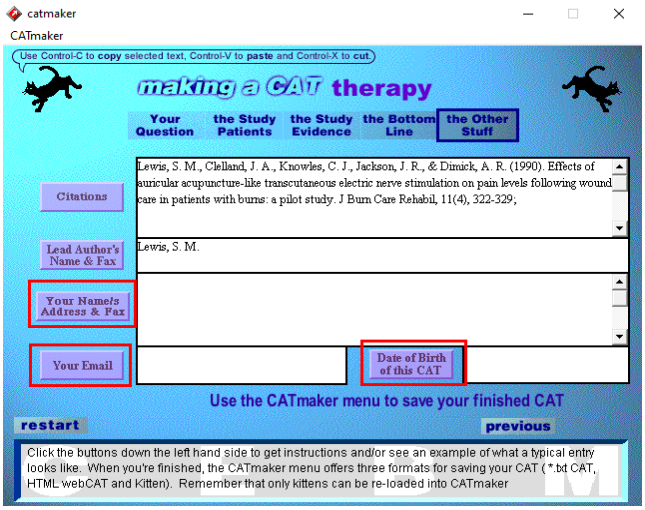


Fig. 12

in **Kill or Update By** type the date in two years from the current date;
click the **next** button;
in **Citations** type *Lewis, S. M., Clelland, J. A., Knowles, C. J., Jackson, J. R., & Dimick, A. R. (1990). Effects of auricular acupuncture-like transcutaneous electric nerve stimulation on pain levels following wound care in patients with burns: a pilot study. J Burn Care Rehabil, 11(4), 322-329*;
in **Lead Author's Name & Fax** type *Lewis, S. M.;*

in **Your Name/s Address & Fax** type your name and group;
in **Your Email** type your email;
in the **Date of Birth of this CAT** type the current date;
click **CATmaker** button → **Output as WebCAT** → type **CAT_2.html** in the highlighted **File name** text box, click **Desktop** in the left part of the **Save** window, and click the **Save** button.
3. Show the teacher the results of your work.

***Attention**: After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:
1) Clinicaltrials.gov. Clinicaltrials.gov. [cited 2024 Nov 20]. Available from: https://clinicaltrials.gov/study-basics/learn-about-studies
2) Research guides: Introduction to evidence-based practice: Types of studies. 2017 [cited 2024 Nov 20]; Available from: https://guides.lndlibrary.org/c.php?g=705624&p=5011035
3) Greenhalgh, T. (2019). *How to read a paper: The basics of evidence-based medicine and healthcare (6th ed.)*. Wiley-Blackwell.
4) Straus, S. E., Glasziou, P., Richardson, W. S., & Haynes, R. B. (2018). *Evidence-based medicine: How to practice and teach EBM* (5th ed.). Elsevier.
5) Guyatt, G. (2014). *Users' guides to the medical literature: A manual for evidence-based clinical practice, 3e (3rd ed.)*. McGraw-Hill Education/Medical.
Additional
1) Forister, J. G., & Blessing, J. D. (2019). *Introduction to research and medical literature for health professionals (5th ed.)*. Jones & Bartlett.
2) Fletcher. (2019). *Clinical epidemiology: The essentials (6th ed.)*. Wolters Kluwer Health.
3) Heneghan, C. (2020, June 15). *Reflections on David Sackett's time at the Centre for Evidence-Based Medicine*. Ox.ac.uk. https://www.cebm.ox.ac.uk/news/views/reflections-on-david-sacketts-time-at-the-centre-for-evidence-based-medicine
4) *Critical appraisal tools*. (2020, June 2). Ox.ac.uk. https://www.cebm.ox.ac.uk/resources/ebm-tools/critical-appraisal-tools

Topic 17: TYPES OF INFORMATION SYSTEMS IN HEALTHCARE, HOSPITAL INFORMATION SYSTEMS, AND THEIR EVOLUTION.

Actuality: Modern healthcare facilities handle vast amounts of patient data, requiring efficient systems for clinical, financial, and operational management. Manual methods were time-consuming and inefficient, but hospital information systems (HIS) now streamline these tasks. At the heart of HIS are electronic medical records (EMRs), which improve care by tracking patient data, monitoring health metrics, and enhancing record-keeping accuracy. As healthcare becomes increasingly digital, understanding HIS and EMRs is essential for future medical professionals to deliver effective patient care.

Educational aims of the lesson:

To know:

1. what are hospital information systems (HIS);
2. types of hospital information systems;
3. types of digitized health records;
4. basics of work with digitized health records;

To be able to:

1. create digitized health records using electronic medical records (EMR) software;
2. edit digitized health records.

The list of questions for the survey:

1. Hospital information systems (HIS).
2. Types of hospital information systems.
3. Different types of digitized health records.
4. Electronic medical record (EMR), electronic patient record (EPR), electronic health record (EHR), and computer-based patient records (CPR).
5. Top Electronic Medical Records (EMR) Software Products.

The list of required practical skills:

1. Creating digitized health records using electronic medical records (EMR) software.
2. Editing digitized health records.

Brief theoretical information

A **Hospital Information System (HIS)** is a computer-based system that helps healthcare providers manage patient data and administrative tasks efficiently. Since their introduction in the **1960s,** HIS has evolved significantly alongside advancements in technology and the modernization of healthcare facilities [1].

Evolution of Hospital Information Systems

- 1960s: Early HIS was limited by the computing power of the time. They were primarily used for basic functions like billing and inventory management.

- Today: Modern HIS integrate clinical, financial, and administrative applications, allowing real-time data processing and comprehensive management of hospital operations.

Functions of Hospital Information Systems

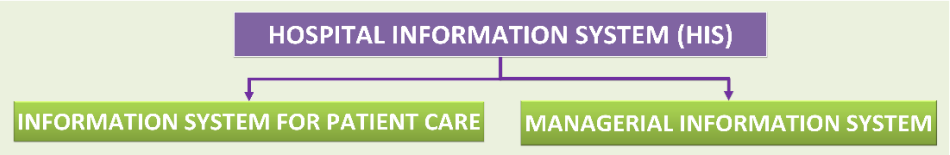
An effective HIS considers:

- **Healthcare Facility Functions:** Supporting all activities related to patient care and medical services.
- **Information Technology Capabilities:** Utilizing modern technology to collect, store, and share information seamlessly.

Components of Hospital Information Systems

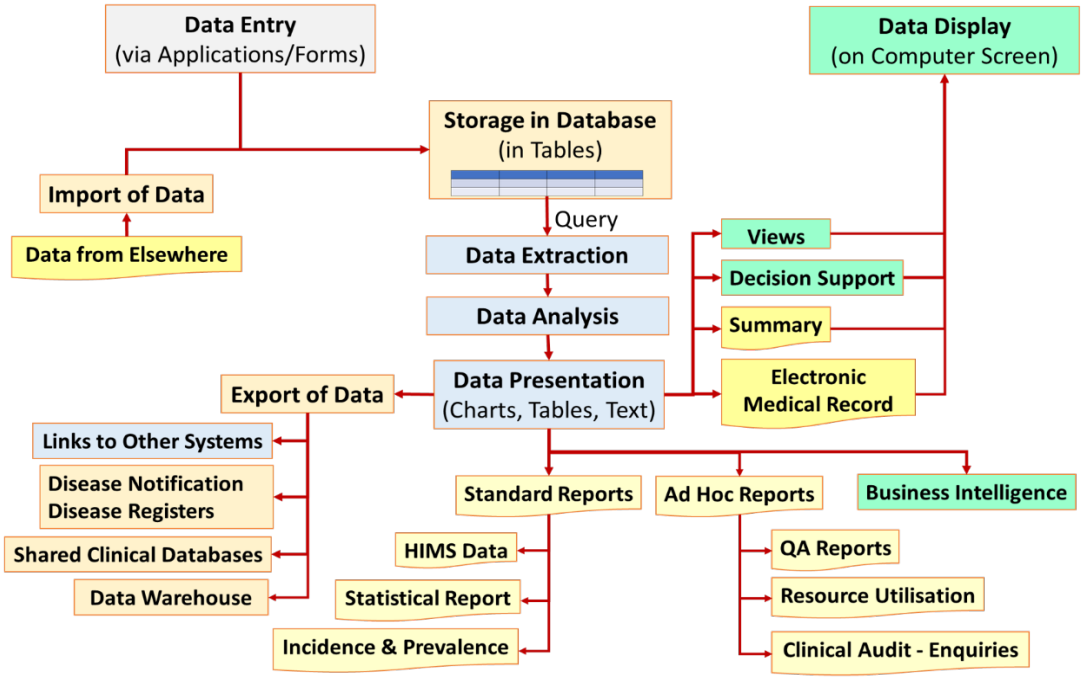
HIS typically consists of multiple subsystems or modules that work together to facilitate hospital services. These can be broadly categorized into **two main systems**:

1. **Patient Care Information System:** Focuses on managing patient-related information such as medical records, lab results, and treatment plans.
2. **Managerial Information System:** Handles administrative functions like scheduling, staffing, finance, and resource management.



A well-designed HIS can:

- **Share Data with Other Institutions:** Enable continuity of care by exchanging patient information with other healthcare providers through health information exchanges or data warehouses.
- **Support Public Health Efforts:** Contribute to national health databases, aiding disease prevention, health promotion, and early detection initiatives at local, regional, and national levels.
- **Provide Data to External Agencies:** Supply necessary information to organizations like insurance companies, regulatory bodies, and public safety departments.



[from: https://drdollah.com/hospital-information-system-his/]

Data Management Capabilities in a Computerized System

Advantages of Information Technology in HIS

- **Enhanced Data Management:** Centralized databases allow for efficient storage, retrieval, and analysis of data.
- **Improved Decision-Making:** Easy access to comprehensive information supports better clinical and administrative decisions.
- I**ncreased Efficiency:** Automation of routine tasks reduces manual workload and minimizes errors.
- **Better Patient Care:** Quick access to patient records and medical histories leads to more effective and timely treatments.

Hospital information system: characteristics

A Hospital Information System (HIS) can either be developed internally or purchased externally, but in both cases, the system must be thoroughly evaluated to ensure it meets the hospital's needs before implementation. Off-the-shelf systems often require customization to align with the hospital's specific services, policies, and equipment. Conversely, hospitals may need to adjust their existing processes to fit the capabilities of the new technology.

Data within an HIS must be stored in a **well-organized database**, structured by defining relationships, naming elements, and assigning appropriate values. This requires careful planning and involves reengineering business processes, customizing features, and designing a robust database. Standard

naming conventions tailored to the hospital, such as for services, locations, or care events, are crucial for clarity and consistency.

The **HIS** is typically divided into

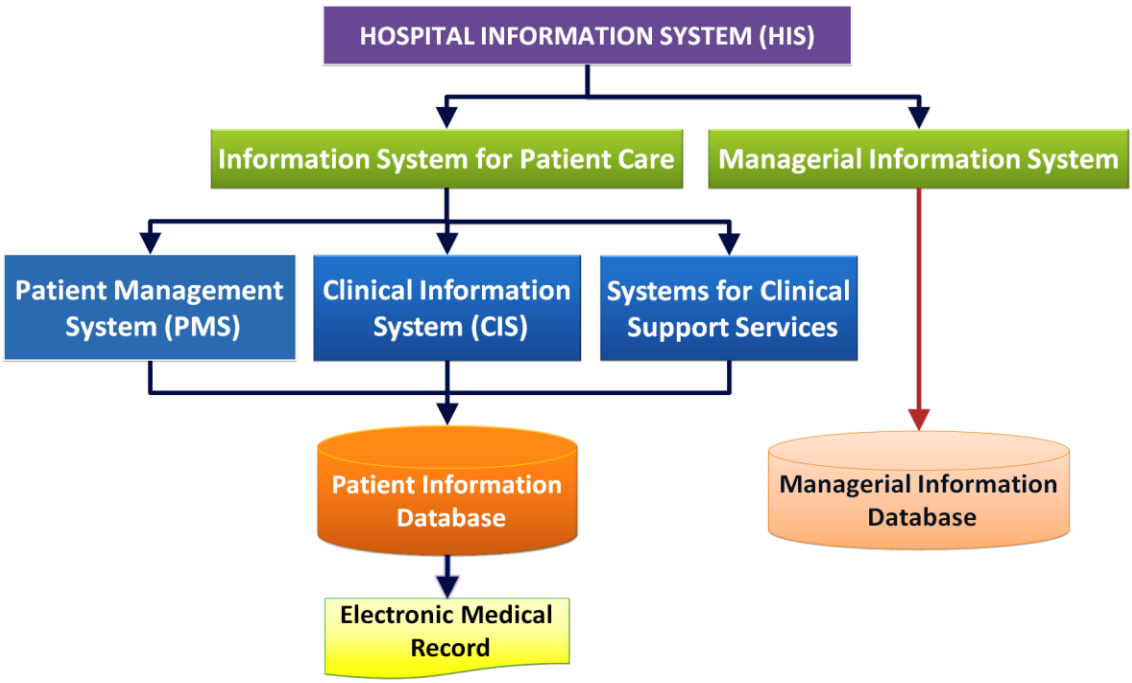
systems for patient care and **systems for administrative management**.

The patient care systems focus on clinical processes, aiming to improve productivity, effectiveness, efficiency, and quality of care while ensuring privacy and safety. These systems are designed to streamline patient care by guiding processes, facilitating communication among providers, automating workflows, and integrating with various hospital technologies like medical devices, printers, and scanners. They also support clinical decision-making, maintain detailed records such as electronic medical records (EMRs), and provide essential data for both individual and aggregated use.

The patient care system encompasses various components, including administrative tools for managing patient information, clinical documentation, and decision support. Specialized systems exist for tasks like laboratory management, blood banking, radiology, pharmacy services, and operating theater management. These systems also ensure data is centralized and accessible for monitoring and compliance with legal and clinical requirements.

Intermediary systems, such as computerized order entry and reporting tools, connect different parts of the HIS, facilitating seamless data flow. Applications supporting clinical governance and infection control, as well as those designed for quality management and data reporting, further enhance the system's functionality. HIS also enables data sharing with external healthcare organizations, contributing to broader health initiatives and improving patient care coordination across institutions.

The relationships of the systems are as shown in the chart below:



[from: https://drdollah.com/hospital-information-system-his/]

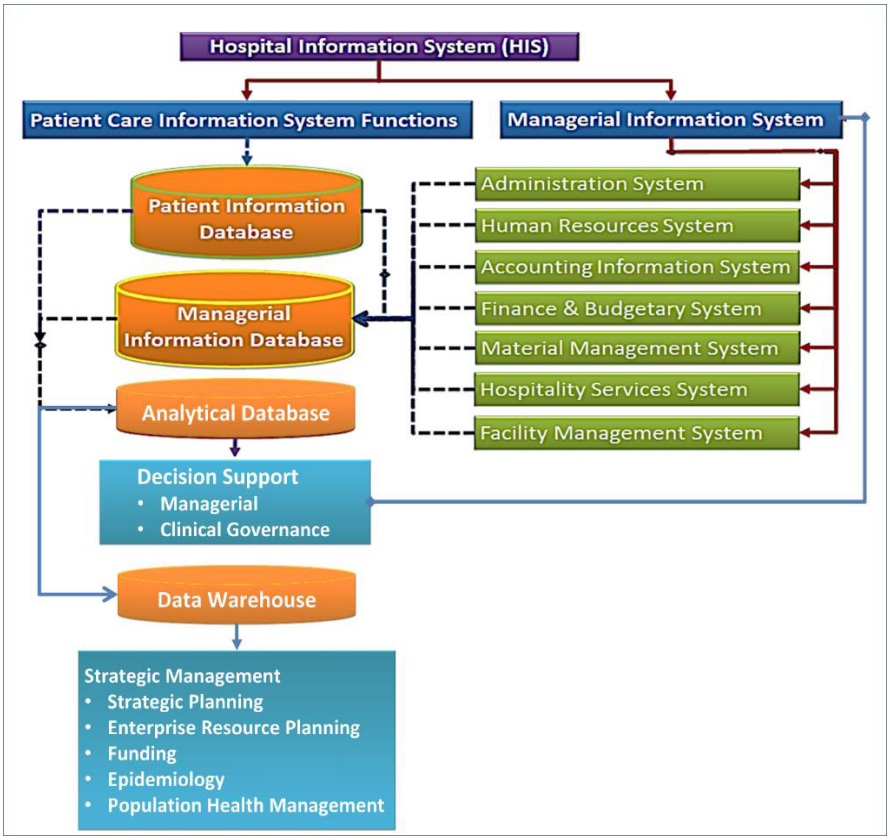
The Managerial Information System (MIS) is a group of tools and applications designed to help hospital managers effectively oversee operations. It supports the hospital as a business, a provider of hospitality services, and a physical facility. While the term "managerial" is used broadly here, it incorporates various systems essential for administration and operational management.

The **MIS** includes systems that handle core business operations like general administration, accounting for billing and payments, human resources, financial management, and inventory control for consumables. These systems ensure smooth administrative workflows and financial accountability.

Hospital hospitality services are also supported by the MIS, with tools for managing bed allocation and food and beverage supplies to meet patient needs efficiently. Additionally, it helps manage the hospital as a physical facility, covering areas like equipment maintenance, environmental safety, housekeeping, and waste management.

Decision Support Systems (DSS) are an integral part of MIS, offering managers insights to make informed decisions. These can range from basic statistical tools to advanced business intelligence software. DSS applications may support both business management and clinical governance. Larger healthcare organizations might also use systems like data warehouses or enterprise resource planning (ERP) software to further enhance their operational capabilities.

While the scope of MIS is extensive and involves many components, its integration with the patient care systems ensures streamlined workflows and better coordination between clinical and managerial functions. This integration is essential for maintaining operational efficiency and improving overall hospital performance.



[from: https://drdollah.com/hospital-information-system-his/]

Choosing a Hospital Information System (HIS)

When selecting a hospital information system, several factors need to be considered to ensure it meets the hospital's needs effectively.

The total cost of the system is a crucial factor. Many HIS providers are willing to discuss your hospital's specific requirements and can offer solutions that fit different budgets. It is essential to choose a system with low overall ownership costs. Some systems are designed to require minimal hardware and fewer servers, which reduces upfront expenses and keeps maintenance costs lower over time.

A good HIS should also be web-based, allowing authorized personnel to access information from anywhere at any time. This flexibility frees healthcare providers from being tied to their desks and ensures they have access to critical data when it's most needed. A web-based system is especially valuable for sharing information between hospitals in different locations. For example, if a patient is transferred to another facility for specialized care, their medical history and records can be instantly accessed, even if the patient cannot provide the details themselves.

Implementing or upgrading HIS can face resistance from staff, as change is often met with hesitation. It is helpful to involve the system vendor during the implementation process to provide training and support for employees. Selecting a vendor that offers 24/7 support, either online or via telephone, ensures your staff can get immediate assistance when needed. Consulting hospital staff before making a purchasing decision can also provide valuable insights, helping to identify specific needs or considerations that might otherwise be overlooked.

Electronic Medical Record Systems

For centuries, healthcare relied on paper-based records, but over the last 20 years, many countries have begun replacing them with digital systems. Unlike industries such as finance or retail, healthcare has been slower to adopt computerized information systems. Implementation also varies widely across countries and medical specialties, often using local systems designed for specific needs.

At the heart of any modern health information system is the **electronic medical record** (**EMR**). Without EMRs, advanced tools like decision support systems cannot fully integrate into clinical workflows. The vision of a paperless, interoperable digital medical record system that serves multiple providers and specialties is now becoming a reality in many developed nations. This shift has been driven by increasing political and professional recognition that current paper-based or fragmented systems do not provide the level of safety, quality, or efficiency required in modern healthcare. EMRs are now seen as a crucial step toward delivering better and more cost-effective care.

Key Terms and Differences

Terms like **electronic medical record (EMR), electronic health record (EHR),** and **computer-based patient record (CPR)** are often used interchangeably, but they have specific distinctions.

An **EMR** is essentially a digital version of the patient's chart within a single clinic or hospital. It primarily focuses on medical diagnoses and treatments and usually cannot transfer data outside its system.

In contrast, an **EHR** is more comprehensive, tracking a patient's care across different providers and institutions. It emphasizes overall health and wellness, facilitating care coordination and patient engagement. EHRs can share information seamlessly, for instance, between a doctor's office and an external hospital, ensuring continuity of care.

A **CPR** goes even further, aiming to provide a lifetime record of a person's health, storing each piece of data in a unique and searchable format. However, the technical challenges of achieving this have slowed CPR adoption.

Defining Features of EMRs

The Institute of Medicine (IOM) describes an EMR as a system that:

- Collects and stores electronic health information over time.
- Provides authorized users with instant access to both individual and population-level data.
- Offers decision-support tools to improve the quality, safety, and efficiency of care.
- Improve the efficiency of delivery processes.

While EMRs and EHRs focus on displaying health information electronically, CPRs emphasize precise data organization, making each piece of information uniquely identifiable and easy to search. However, the technical complexities of coding every data element remain a significant barrier to CPR adoption.

Impact on Healthcare

Electronic medical record systems are essential for improving healthcare delivery. By replacing paper records, they enable better access to patient information, enhance decision-making, and allow integration with advanced technologies. As healthcare systems worldwide continue to modernize, EMRs and their advanced counterparts like EHRs and CPRs play a key role in ensuring efficient, safe, and high-quality care.

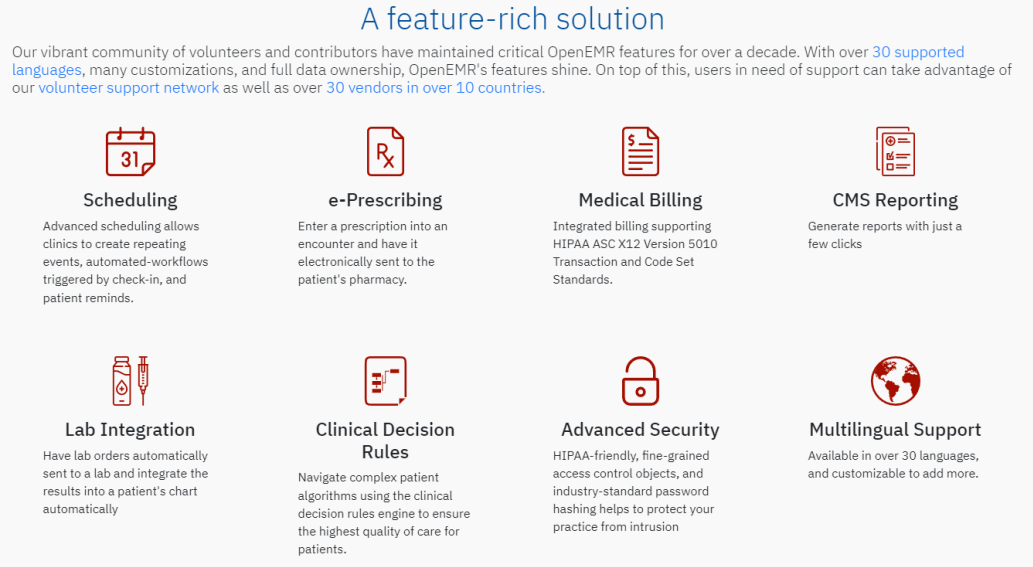
Top Electronic Medical Records (EMR) Software Products

SOAPware;	Insta HMS;	AllegianceMD;
iPatientCare HER;	WRS Health;	EMR Software.
Praxis EMR;	A.I.med;	

OpenEMR

https://www.open-emr.org/

OpenEMR is free and open-source software designed to manage electronic health records and improve the efficiency of medical practice operations. It provides a fully integrated system that combines health record management, practice administration, scheduling, electronic billing, and more. **OpenEMR** also supports international use and offers free assistance to its users, making it a comprehensive solution for healthcare providers.



Practical tasks for students. Instructions for execution of practical work

1. Start PC and load **Windows OS**.
2. Start **OpenEMR** application.

http://93.175.192.116/ or https://demo.openemr.io/openemr

Credentials at https://www.open-emr.org/demo/

Username	Password	Description
admin	pass	Administrator
physician	physician	Physician (more access than clinician)
clinician	clinician	Clinician (less access than physician)
accountant	accountant	Accountant
receptionist	receptionist	Front desk receptionist

Press **Login** button

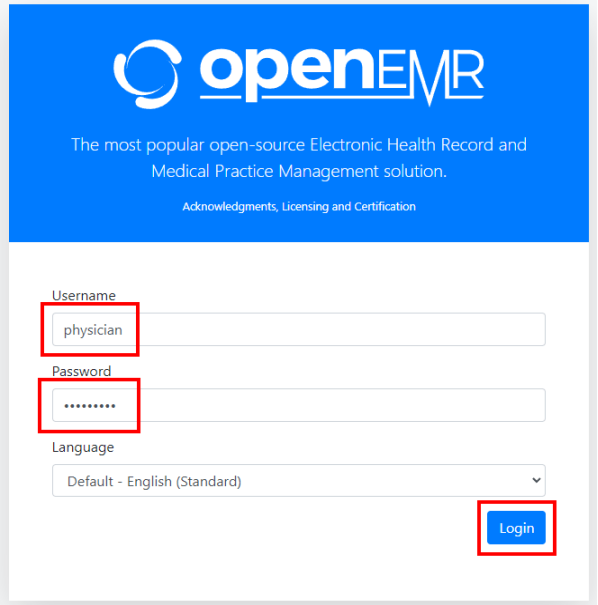
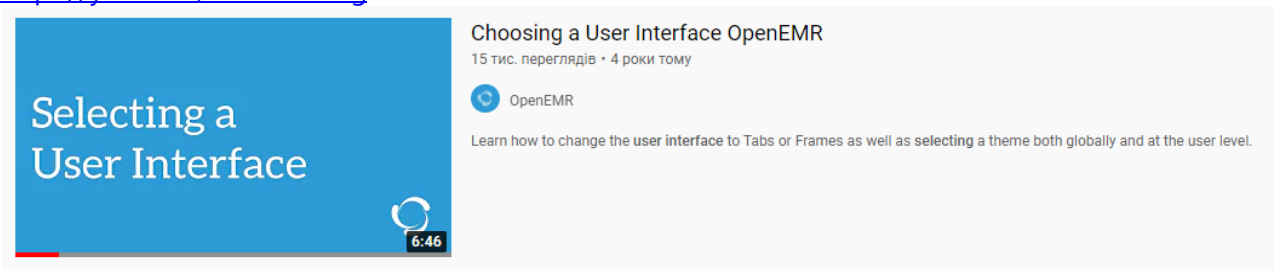


Fig. 1

3. For more information you can watch the video overview of the application.
https://youtu.be/-XtYLXFPo8g



Task №1. Overview **OpenEMR** management application window.

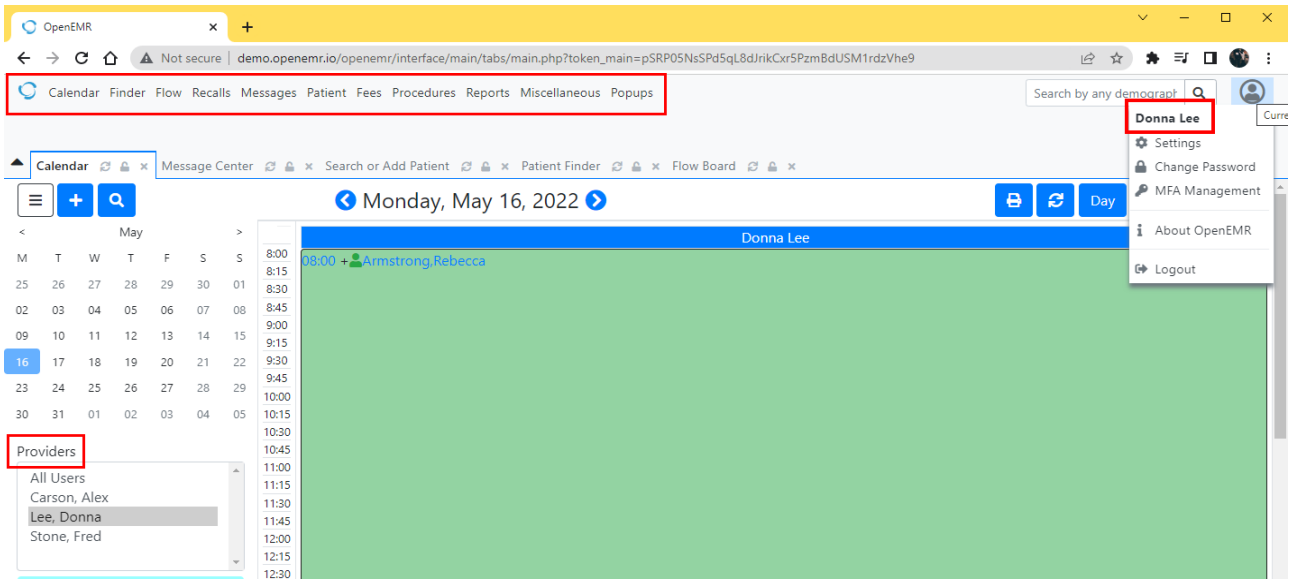


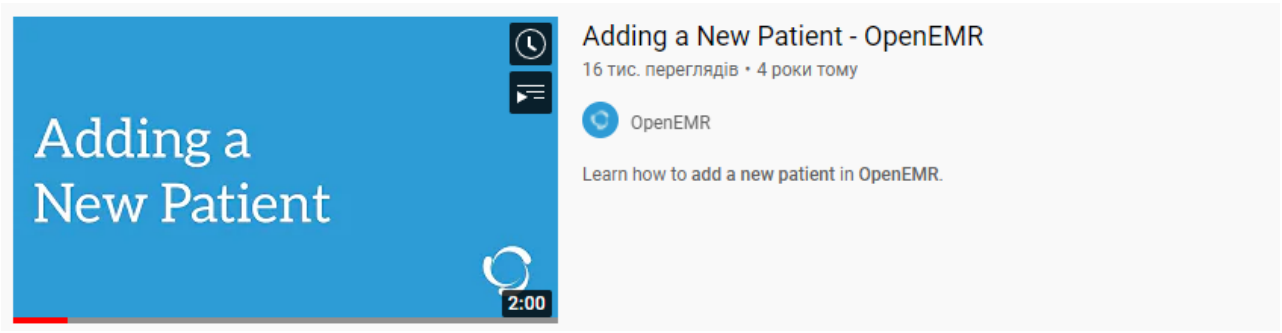
Fig. 2

Task №2. *Create a new record for **Monica Gellar**.*

(*) In case the system alerts about a duplicate patient, choose any other name.

For more information, you can watch the video instruction for the patient's adding.

https://www.youtube.com/watch?v=q_yXYgg7EdE



click **Patient** → **New/Search**;

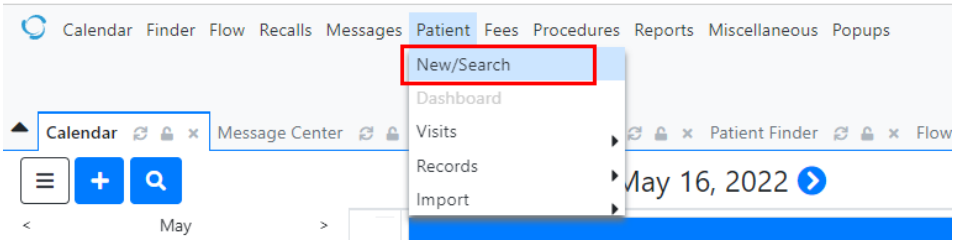


Fig. 3

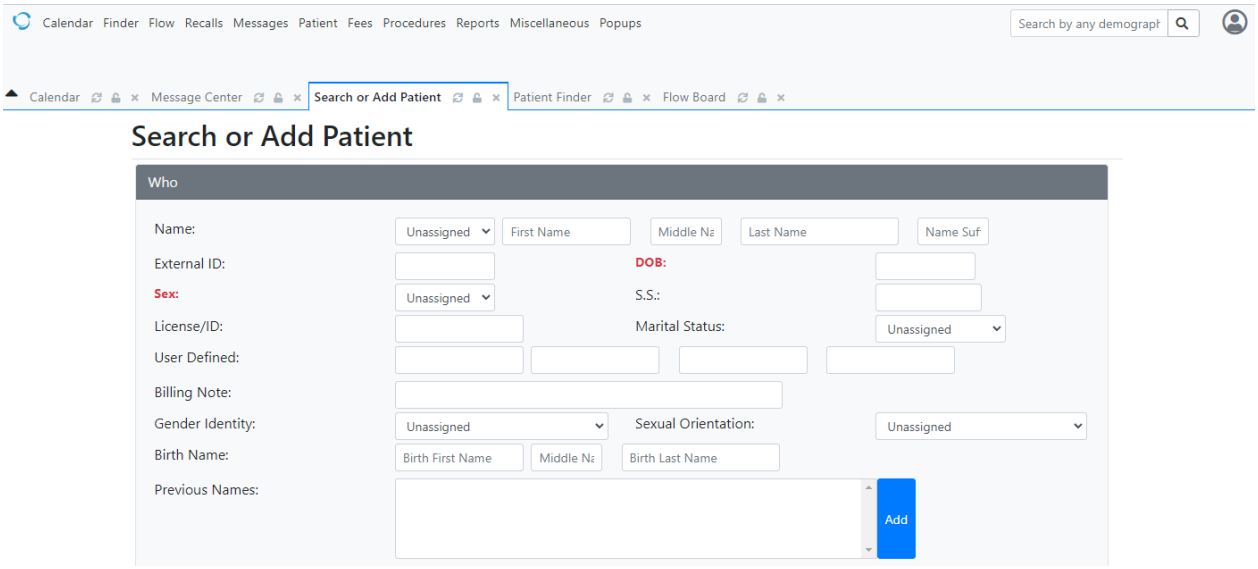


Fig. 4

in **Name** line**:**
Unassigned choose **Mrs.;**
First Name box type **Monica**;
Last Name box type **Geller**;
in **External ID** line**:** A-99-898-96
DOB: April 22 1969
in **Sex** line**:**
Female
in **License/ID** line**:** 9279080-71
Marital Status: Married
Click **Create New Patient:**

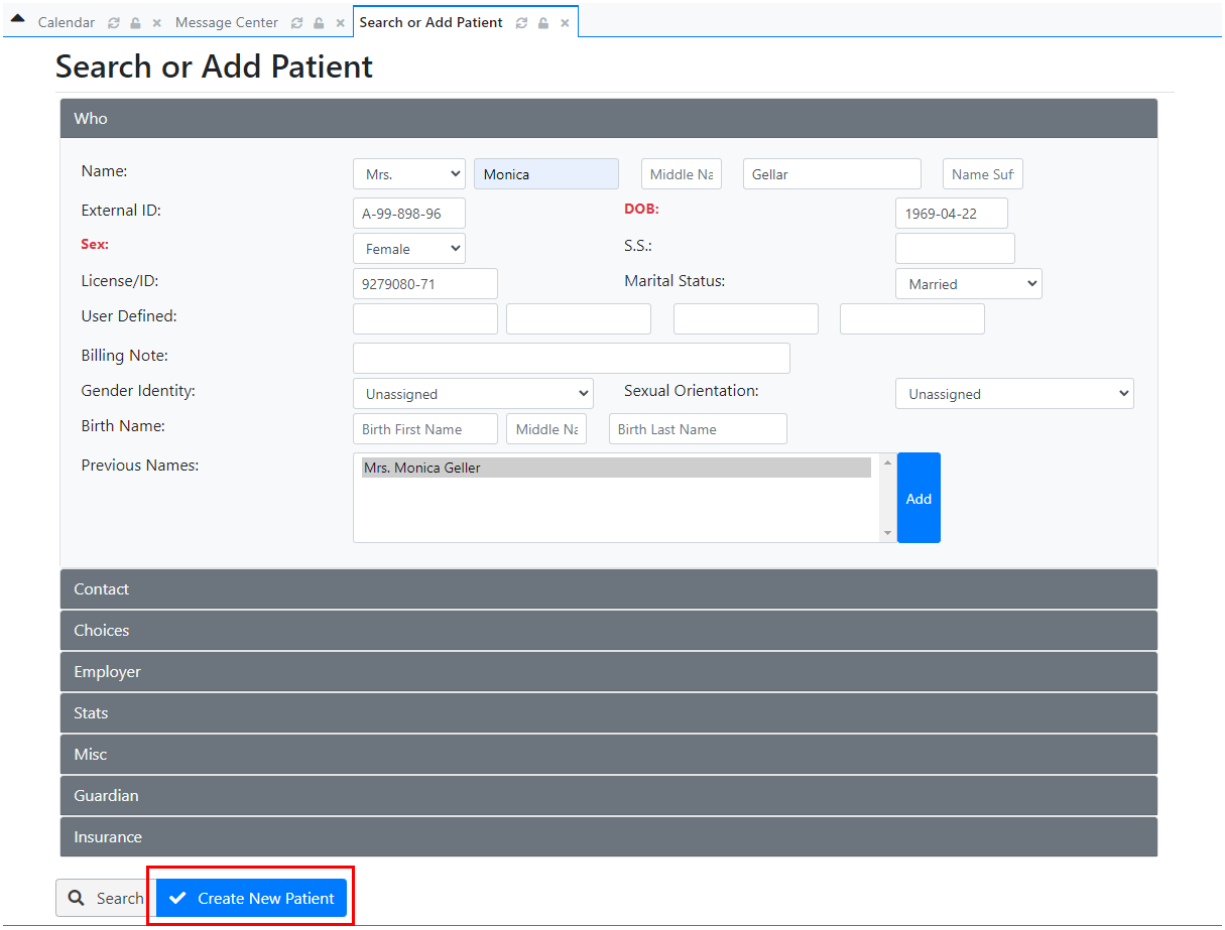


Fig. 5

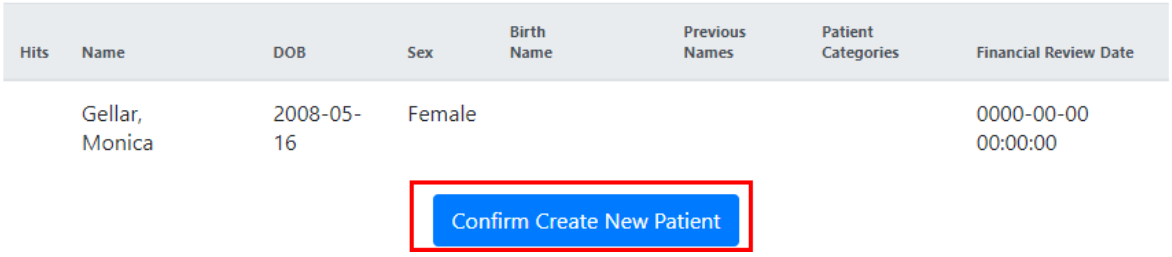


Fig. 6

<u>Task №3.</u> *Edit personal record of the patient.*

Click **Pen** tool in the **Demographics** section;

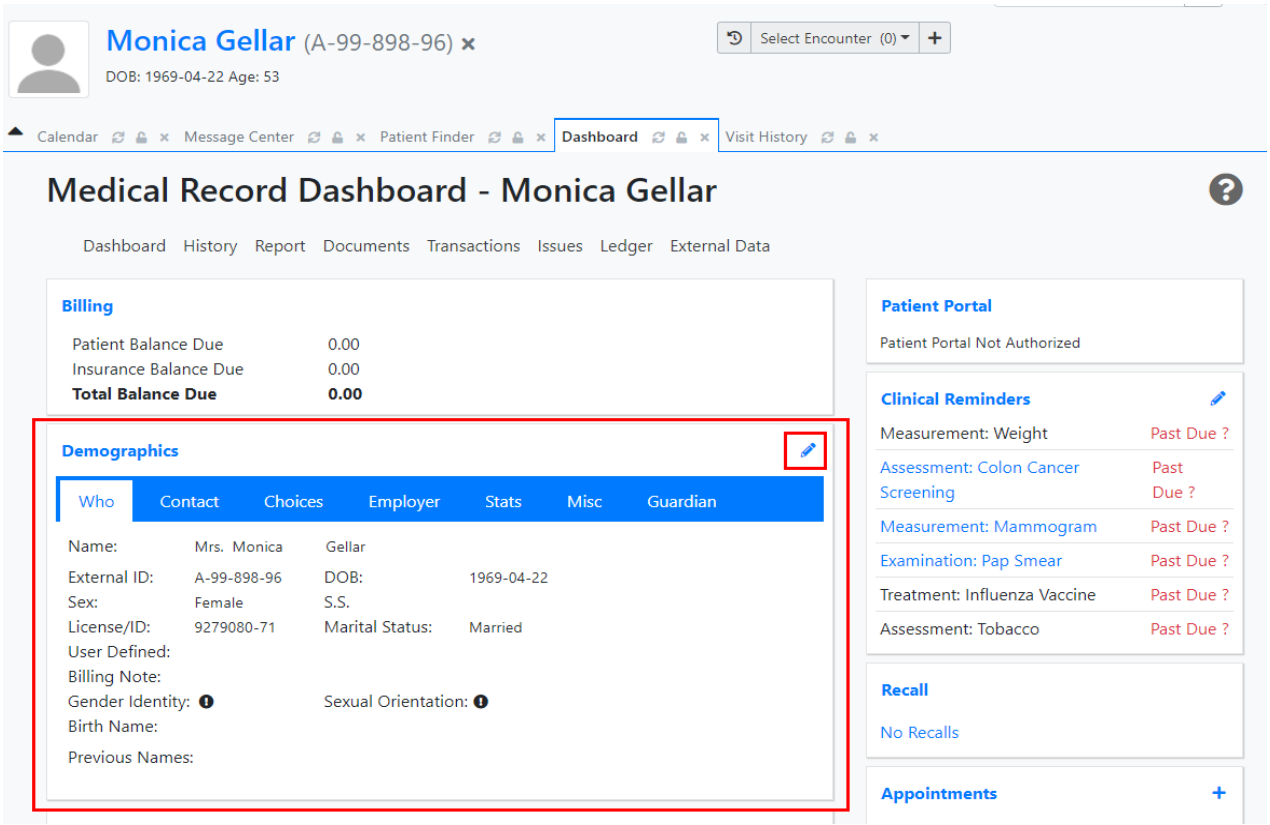


Fig. 7

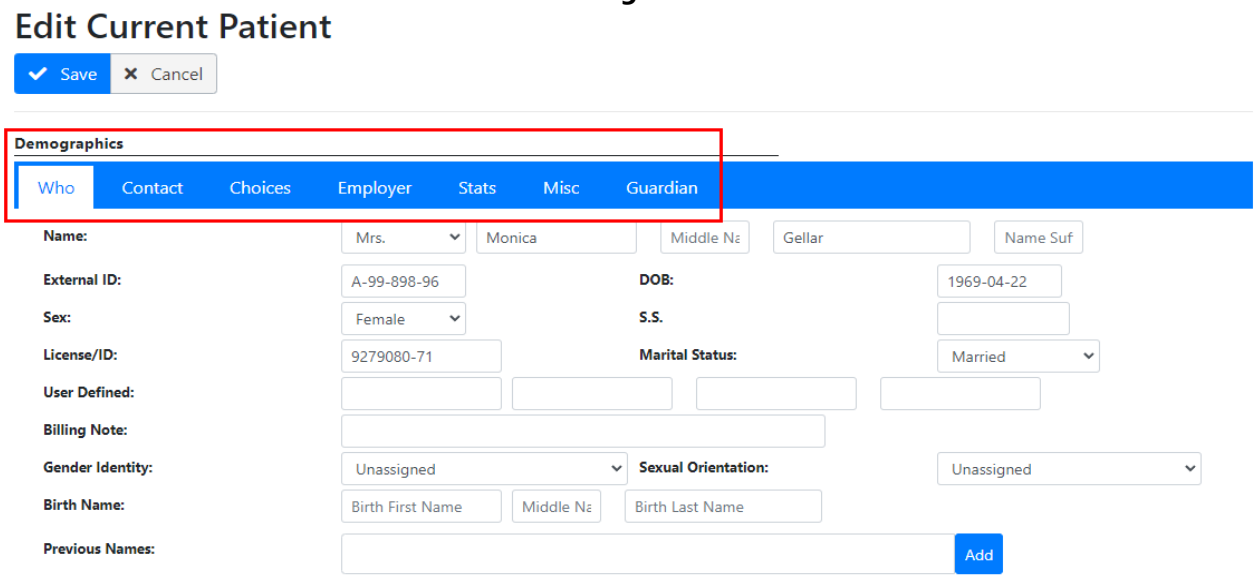


Fig. 8

Patient Identification Data Table 1

Who			
Name:	Monica Gellar		
External ID:	A-99-898-96	**DOB:**	1969-04-22
Sex:	Female		
License/ID:	9279080-71	**Marital Status:**	Married
Contact			
Address:	495 Grove Street		
City	New York	**State:**	New York

Postal Code:	10014	**Country**	USA
Mother`s Name:	Judy Geller	**Emergency Contact:**	1-212-123-5543
Emergency Phone:	1-212-635-4570	**Home Phone:**	1-212-620-5120
Work Phone:	1-212-563-4157	**Mobile Phone:**	
Contact Email:	contact@email.email.com	**Trusted Email:**	trusted@email.email.com

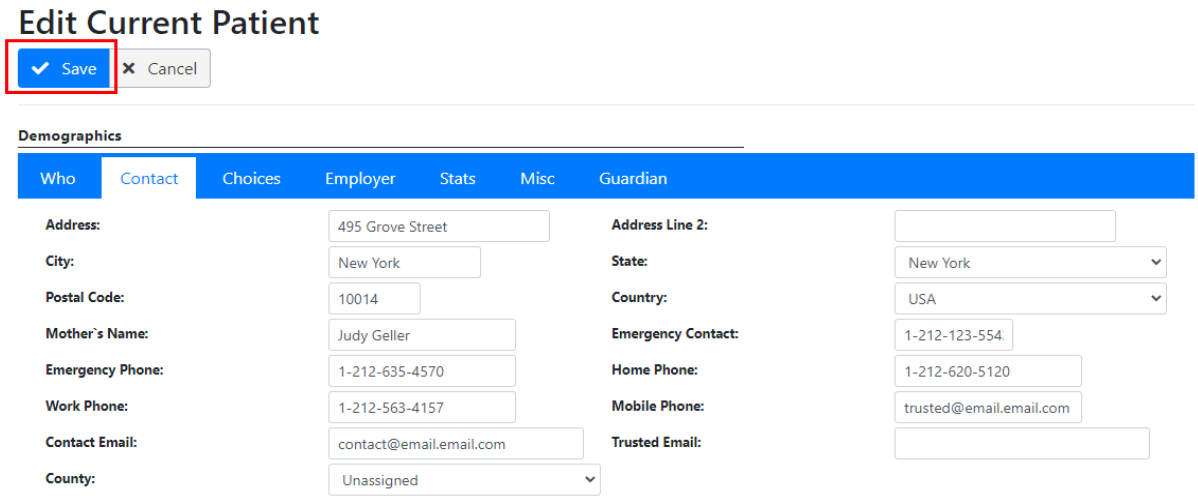
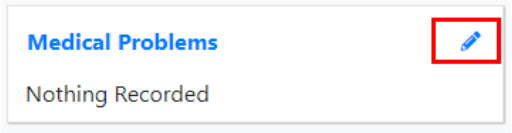


Fig. 9

Click **Save**;

<u>Task №4.</u> *Add current **Medical Problems** of the patient.*



Click **Pen** tool;
Click **Add** button;

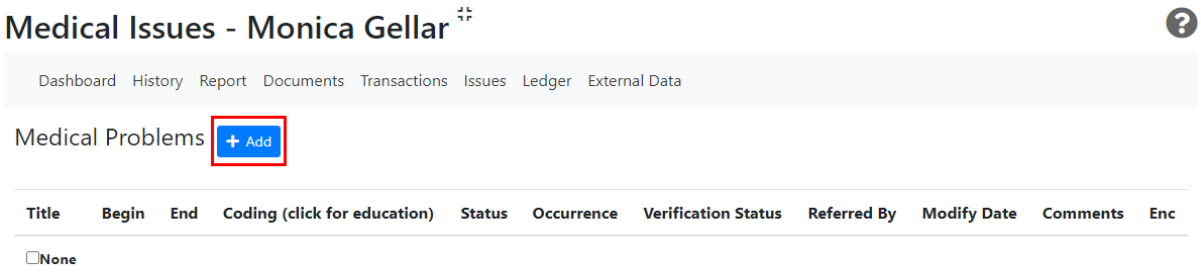


Fig. 10

Medical Problems. Type:
Table 2

Problem:	diabetes
Coding:	ICD10:E08.22 (Diabetes mellitus due to underlying condition with diabetic chronic kidney disease)
Begin Date:	2016-05-16
Occurrence:	Chronic/Recurrent
Verification Status:	Confirmed

Click **Save** button;

<u>Task №5.</u> *Edit patient's **History and Lifestyle**.*

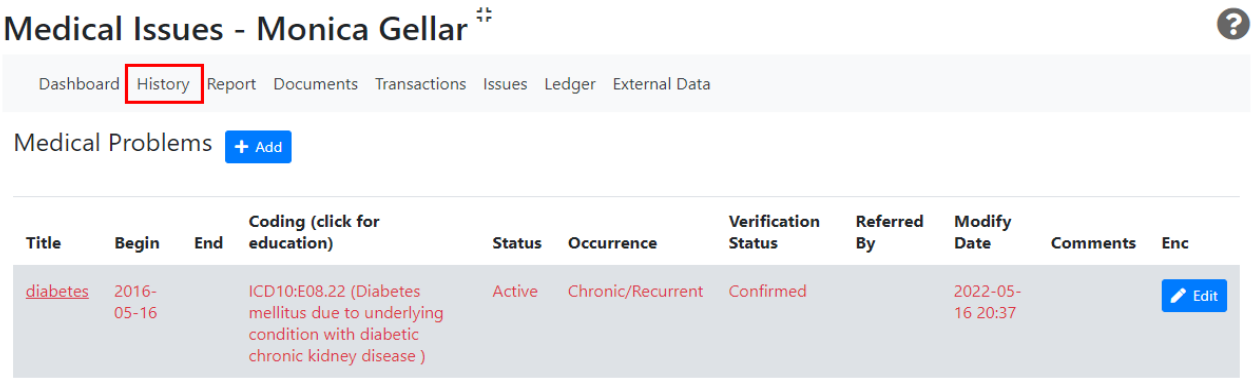


Fig. 11
Click **the History** button;
Click **Edit** button;

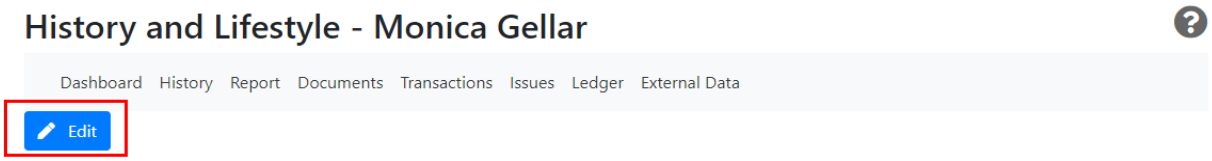


Fig. 12

Fill Risk Factors:

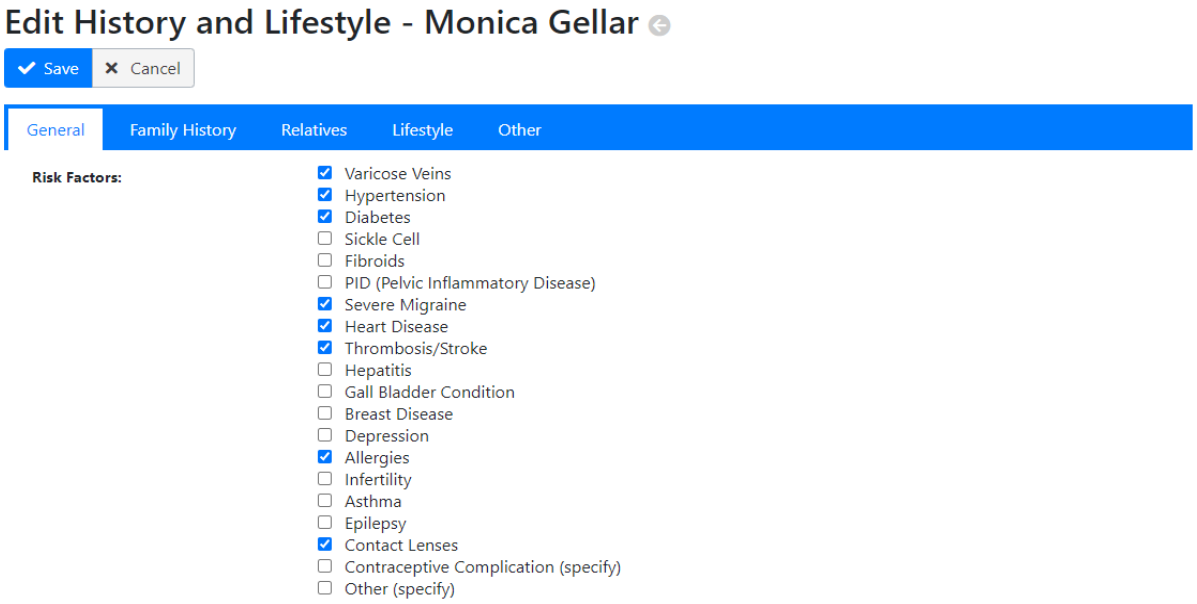
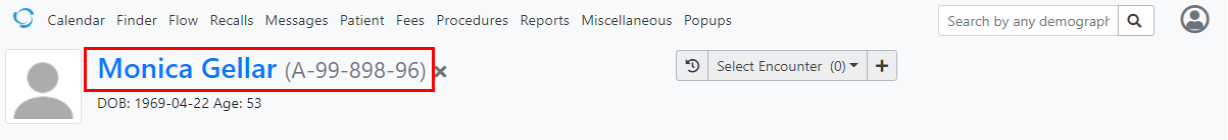
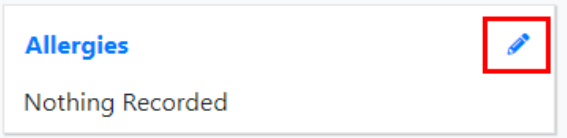


Fig. 13
Click **the Save** button;

<u>Task №6.</u> *Add patient's* ***Allergies***.
Return to the main page of the patient's record. Click on the patient's name.

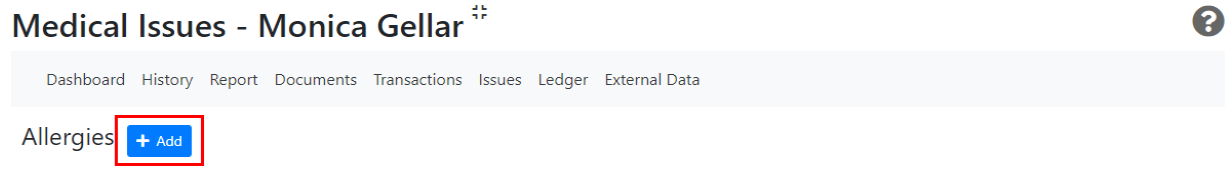


Scroll down to the **Allergies** section.



Click **Pen** tool;

Click **Add** button;

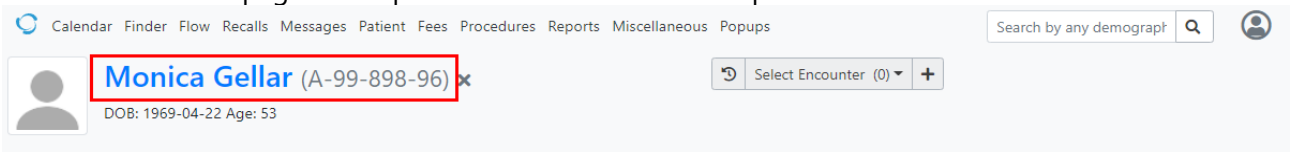


Medical Problems. Type: Allergy
Table 3

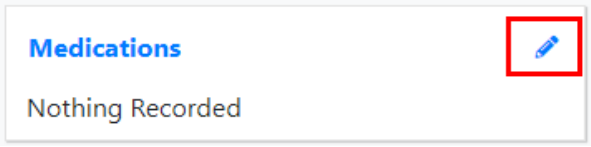
Title:	Penicillin; Antibiotics containing sulfonamides (sulfa drugs); Codeine; Iodine; Ibuprofen

Click **Save** button;

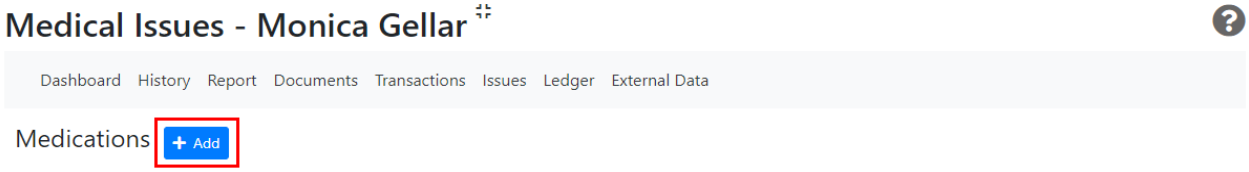
Task №7. *Add patient's* ***Medications***.
Return to the main page of the patient's record. Click on the patient's name.



Scroll down to the **Medications** section.



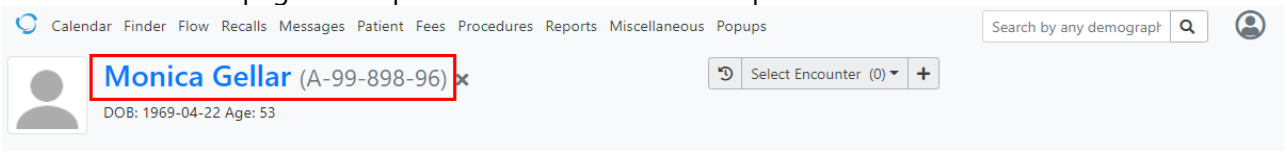
Click **Pen** tool;
Click **Add** button;



Medical Problems. Type: Medication
Table 4

Title:	Prinivil tabs 20 mg (lisinopril)
Medication Dosage Instructions:	1 po qd
Title:	Humulin inj 70/30 (Insulin Reg & Isophane (Human))
Medication Dosage Instructions:	20 units ac breakfast

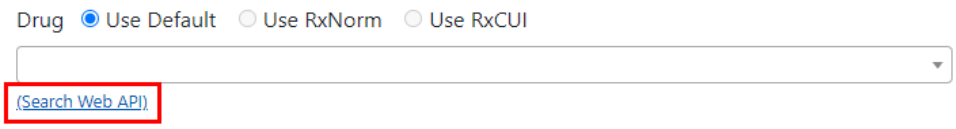
Click **Save** button;
Task №8. *Add patient's* ***Prescription***.
Return to the main page of the patient's record. Click on the patient's name.



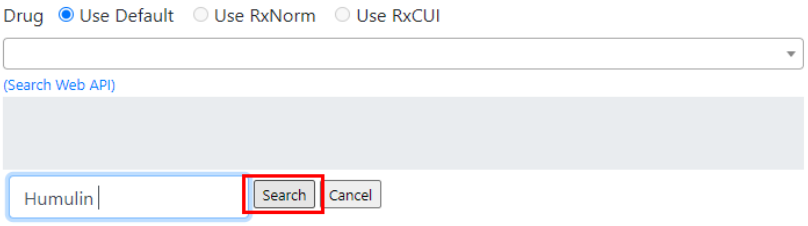
Scroll down to the **Prescription** section.

Click **Pen** tool;
Click **Add** button;

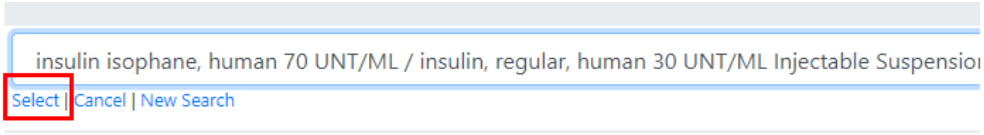
Click **Search Web API;**



Type **Humulin**;
Click **Search;**



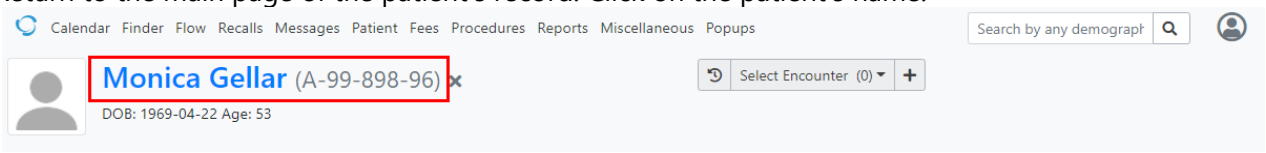
Find the right medication. Click **Select**;



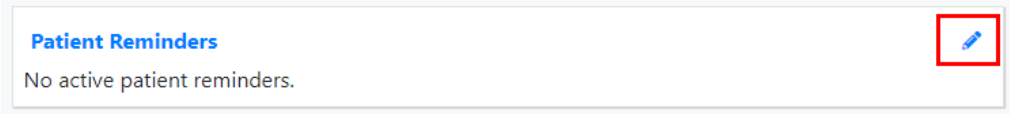
Fill other fields according to the recipe;
Humulin Inj 70/30 20 u ac breakfast
Click **Save**;

In the same way, add another medication.
Prinivil tabs 20 MG 1 qd

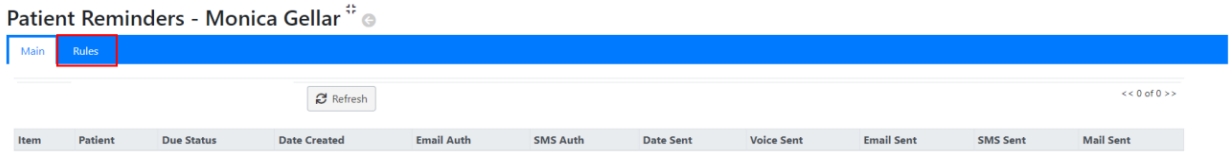
Task №9. *Add **Patient Reminders***.
Return to the main page of the patient's record. Click on the patient's name.



Scroll down to the **Patient Reminders** section.



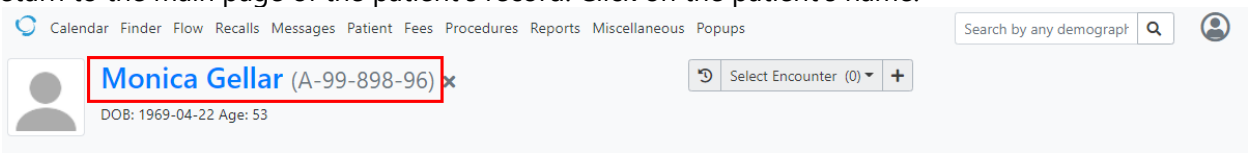
Click **Pen** tool;
Click **Add** button;
Click **Rules;**



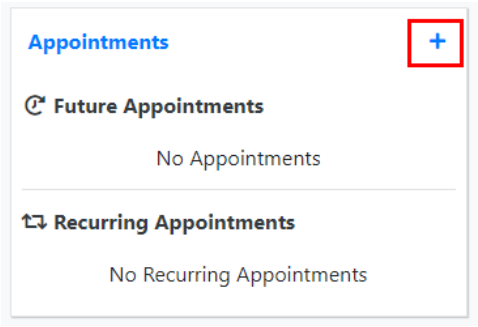
Add reminder for
Measure Blood Pressure
Diabetes: Eye Exam
Diabetes: Foot Exam
Diabetes: Hemoglobin A1C

Diabetes: Urine Microalbumin

Task №10. *Plan an **Appointment**.*
Return to the main page of the patient's record. Click on the patient's name.

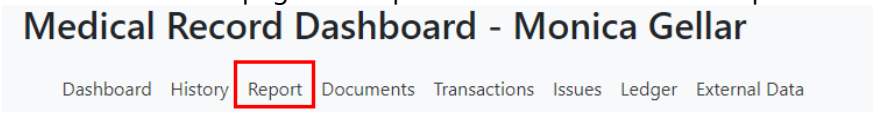


Scroll down to the **Appointments** section.

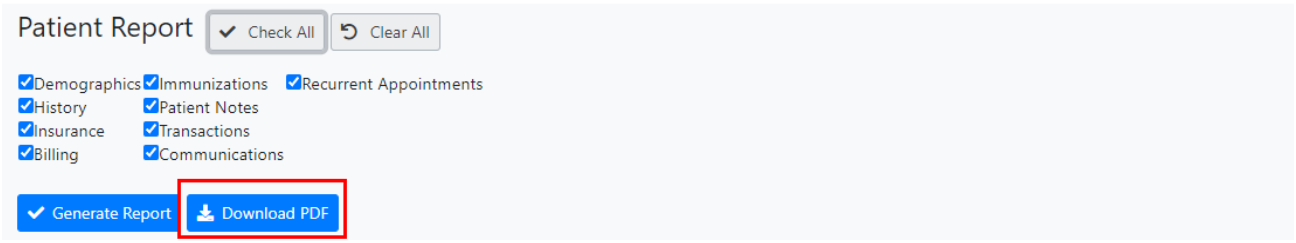


Click on the **Blue Plus** sign;
Choose category **Health and Behavioral Assessment**;
Plan the appointment for the next month, 10 am, duration 15 minutes;
Click **Save;**

Task №11. Generate Patient's report and download PDF file.
Return to the main page of the patient's record. Click on the patient's name.

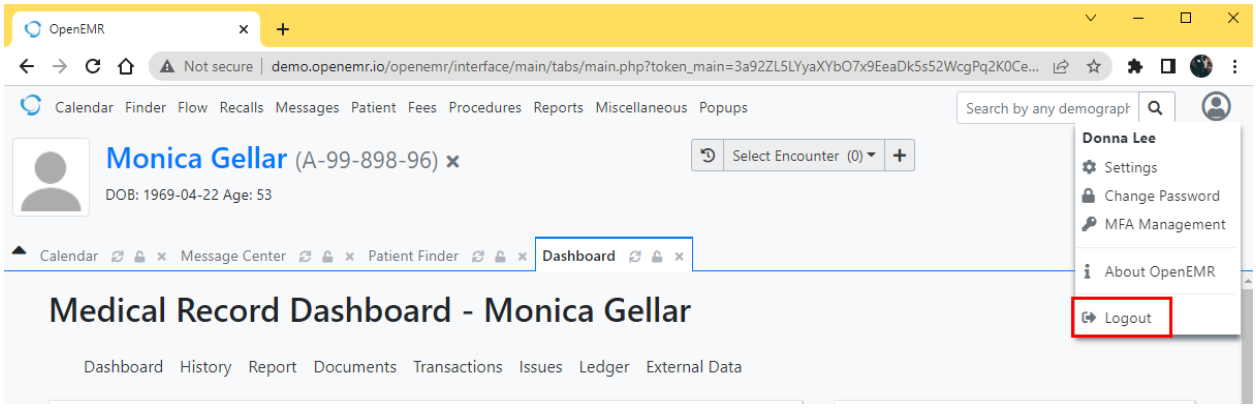


Under the line "Medical Record Dashboard - Monica Gellar" **find and click the** Report **button**;
Scroll down to Patient Report;
Check All **and** Download PDF**;**



****

4. Show the teacher the results of your work.
5. Logout from the **OpenEMR** application.



Attention: *After completing all tasks, close all open windows, shut down the Windows operating system, and turn off the computer.*

Literature:

Main:

1) Information systems in healthcare. Healthcare service delivery. 2014 [cited 2024 Nov 20]. Available from: https://drdollah.com/hospital-information-system-his/

2) Hersh, W. R., & Hoyt, R. E. (2018). *Health informatics: Practical guide seventh edition*. Lulu.com.

3) Sittig, D. F. (Ed.). (2021). *Electronic health records: Challenges in design and implementation*. Apple Academic Press.

4) Mastrian, K., & McGonigle, D. (2020). *Informatics for health professionals* (2nd ed.). Jones and Bartlett.

Additional

1) Payne, T. (Ed.). (2014). Practical guide to clinical computing systems: Design, operations, and infrastructure (2nd ed.). Academic Press.

2) Wager, K. A., Lee, F. W., & Glaser, J. P. (2022). Health care information systems: A practical approach for health care management (5th ed.). Jossey-Bass.

The policy of academic discipline

The course "**Medical Informatics**" is taught in accordance with the regulatory documents of IFNMU, which govern the organization of the educational process (https://ifnmu.edu.ua/uk/normatyvni-dokumenty). These documents include:
- IFNMU Statute
- Internal Labor Regulations
- Regulations on the Organization of the Educational Process at IFNMU
- IFNMU Code of Academic Integrity
- Regulations on Academic Integrity at IFNMU
- Regulations for Handling Appeals (Applications, Complaints, Proposals) from IFNMU Students, among others.

The course includes both practical classes and independent study for future specialists. For practical classes, the department staff has developed instructional materials for teachers and guidelines for students, which contain task accomplishment algorithms. These can be accessed at https://ifnmu.sharepoint.com/KMIMtBF/.

Independent study allows future doctors to grasp the educational material outside of mandatory sessions. To facilitate this process, the department staff has created guidelines for students' independent work, including task completion algorithms (see https://ifnmu.sharepoint.com/KMIMtBF/).

Attendance at practical classes is mandatory, and missed sessions should be made up with proper authorization (e.g., medical certificate, permit issued by the dean's office, application with a resolution granting permission for rework, or dean's or university orders). Make-up sessions must be completed within the timeframe set by the dean or rector's office. Students should arrange these sessions in advance. Rework classes are held at the department **every Monday from 4:00 p.m. to 5:30 p.m.**, with the teacher on duty. Students will complete practical tasks and pass the theoretical test on a computer.

Students can retake assignments that received unsatisfactory grades within two weeks of receiving them, but no later than the day of the final module control (FMC).

A student who hasn't earned the **minimum score** (**Module 1** – **64 points**, **Module 2** – **64 points**) or has uncompleted practical classes isn't allowed to take FMK at the first attempt. However, they can re-take FMK according to schedule if they gain admission by completing all missed classes and achieving a satisfactory final score.

Students who have not passed the final module control are **allowed to retake** it no more than twice:
- **First attempt:** Within 10 days after completing the module, with a teacher appointed by the head of the department.
- **Second attempt:** With a commission appointed by the department head and approved by the rector, within 10 days after the first retake.

The points scored in the discipline are converted to a 4-point scale as follows:

ECTS Score	4-point scale score
A	5
B, C	4
D, E	3
FX, F	2

In the discipline, the FX or F ("2") grade is given to students who have not passed at least one module by the end of the course.
- Grade **FX** is assigned to those who have earned the minimum number of points in their coursework but have not passed the final module control (FMK).
- Grade **F** is given to students who did not achieve the minimum points required in their coursework and are not eligible for the FMK.

Students who receive an **F** ("2") on the **ECTS** scale must repeat their studies according to an individual plan. Re-enrollment for "Medical Informatics" is done only upon approval by the rectorate, based on relevant documentation submitted by the dean's office.

One of the assessment methods for students specializing in **222 "Medicine,"** within the field of

22 "Healthcare," is the Unified State Qualification Examination (UEQI). However, the course "Medical Informatics" is not included in the integrated test exam "KROK."
While studying "Medical Informatics," students must strictly adhere to academic integrity principles. The following behaviors are not permitted:
- Being late for or missing classes without a valid reason.
- Using smartphones, tablets, or other devices for communication during discussions or assignments (unless explicitly allowed).
- Plagiarism.
Remember, cheating during coursework tests and the FMK is strictly prohibited. Smartphones and tablets can only be used for online testing or as educational tools for learning purposes.
In this course, students who demonstrate active participation, initiative, and creativity will be encouraged.

Questions for Student Preparation for the Final Exam

Module 1. Fundamentals of Information Technologies in Healthcare and Analysis of Medical-Biological Data.

Content module 1: Fundamental Concepts of Medical Informatics and the Role of Computers in Medical Practice.

1. Information and its properties. Units of information measurement.
2. Subject and tasks of medical informatics. Information processes and flows in medicine.
3. Basic theories for evaluating information: structural, statistical, semantic.
4. Configuration of a personal computer (PC). PC hardware. PC software.
5. Operating systems (OS) of personal computers. Structure and main functions of the OS.
6. File systems. Means of organization and work with files and directories. Physical media of files.
7. Archivers. General functions of modern archivers. Criteria for choosing a specific type of archiver.
8. Computer viruses. Antivirus programs.
9. The concept of new information technologies and their general characteristics.
10. Text preparation systems, their general functions, main features and characteristics.
11. Electronic tables, their general functions and main characteristics.
12. Purpose of charts. The most common types of standard charts and their varieties.
13. Logical expressions and their purpose. The structure of a logical expression. Comparison operators used in logical expressions.
14. Logical functions: assignment; syntax; arguments Use of logical functions to solve medical and biological problems.
15. Databases. Data bank. Types of database organization.
16. Basic concepts of the theory of relational databases. Database management systems (DBMS). Basic functions of DBMS.

Content module 2: Medical Data and Methodologies for Processing and Analysis.

17. Basic principles for applying statistical analysis methods in clinical practice and biomedical research.
18. Characteristics of medical data analysis.
19. Principles of data processing and analysis using a personal computer.
20. MS Excel software package and its application for statistical data analysis.
21. Basic concepts of mathematical statistics used in computer-based data analysis.
22. Algorithms for statistical data processing methods.
23. Fundamental concepts of statistical hypothesis testing.
24. General framework for hypothesis testing.
25. Testing sample homogeneity.
26. Verifying the analysis method for systematic errors.

27. Analysis of correlated populations: testing the hypothesis of equality of distribution centers for two correlated populations.
28. Analysis of correlated populations: sign test.
29. Analysis of correlated populations: comparison of the effects of two drugs.
30. Laws of random variable distributions and their characteristics.
31. Empirical distribution laws.
32. Fundamental concepts of variance analysis.
33. One-way variance analysis and its procedure.
34. Significance of differences in group mean values of outcome variables.
35. Fundamental concepts of correlation analysis.
36. Scope and challenges of regression analysis. Univariate regression analysis.
37. Mathematical regression model, correlation field, and regression line. Least squares method.
38. Linear regression function. Estimation of linear regression parameters using the least squares method.
39. Nonlinear regression: least squares method.
40. Polynomial regression function and exponential regression function.
41. Methods for processing biosignals.
42. Types of signals.
43. Quantitative, qualitative, and ordered data.
44. Medical images and their processing.
45. Two-dimensional and three-dimensional images.
46. Types of images and their transformations.

Module 2. Medical Knowledge and Decision-Making in Medicine.

Content module 3: Medical Knowledge and Decision-Making.

47. Modern systems for mathematical information processing.
48. The components of the MathCad system and its main functions.
49. Features of a MathCad document.
50. Characteristics of the MathCad user interface.
51. Logical expressions and their purposes: the structure of a logical expression and comparison operators used in logical expressions.
52. Logical functions: definition, syntax, and arguments. Application of logical functions to solve medical and biological problems.
53. Modeling in medicine: models, types of models, and modeling as a method for studying objects in biology and medicine.
54. Forecasting in medicine: types of forecasts.
55. Marketing research in medicine.
56. Classification of diagnostic technologies and their main characteristics.
57. Issues in the informatization of medicine and healthcare: levels of informatization in medical activities and key aspects of the problem.
58. Problems addressed using computer technologies in medicine and healthcare: general technological framework of the medical and diagnostic process.
59. Medical cybernetics and its tasks in healthcare.
60. Computer-based disease diagnosis and decision support systems in medicine.
61. Expert systems: basic concepts.
62. General structure of expert systems.
63. Classification of expert systems based on methods of knowledge representation. Models of knowledge representation in expert systems.
64. Classification of expert systems into categories.
65. Modes of the main menu of an expert system and their functionalities.
66. Methods for processing biosignals.

67. Types of signals.
68. Quantitative, qualitative, and ordered data.
69. Medical images and their processing.
70. Two-dimensional and three-dimensional images.
71. Types of images and their transformations.

Content module 4: Medical Knowledge and Decision-Making.

72. General concepts of networks and their purposes.
73. Computer information networks and their types.
74. Communication protocols.
75. The global computer network (Internet): the physical structure of the Internet, servers, and Internet providers. Internet addresses.
76. Tools for using the Internet: software.
77. Internet services: email, teleconferences, and the World Wide Web (WWW).
78. Email: basics of email functionality, key operations, and addressing email messages.
79. Basic methods of accessing Internet information resources.
80. Tools for searching for information on the Internet: general-purpose search engines and specialized medical search systems.
81. Internet medical resources: general characteristics, bibliographical systems, and thematic searches for medical information.
82. Distance medical education.
83. Fundamental principles of telemedicine.
84. Medical information systems (MIS) and their classifications.
85. Stages of development and key characteristics of MIS and their environments.
86. Medical information systems at basic, institutional, territorial, and state levels.
87. Medical device-computer systems and their characteristics.
88. Classification and brief description of information technologies for managing documentation in medical and preventive institutions.
89. Automated workplaces (AWP) and their purposes. Classification of AWPs by purpose in medical and preventive institutions. Problems addressed by hospital specialists using AWPs. Structure of information support in AWPs.
90. Structure and purpose of integrated software systems for automating healthcare institution operations.
91. Purpose and functionalities of specific types of AWPs: polyclinic registration, nursing staff, chief physician, doctor, family doctor, and information diagnostic systems.
92. Automated control systems (ACS): prospects for the development of ACS in medicine and healthcare.
93. Information medical environments and their general purposes. Capabilities of information medical environments.
94. Ethical and legal principles of information management in the healthcare system.

List of Practical Skills for Preparing Students for the Final Assessment of the Discipline

Module 1. Fundamentals of Information Technologies in Healthcare and Analysis of Medical-Biological Data.

Content module 1: Fundamental Concepts of Medical Informatics and the Role of Computers in Medical Practice.

1. Start the Windows operating system.
2. Desktop: main objects and control elements of Windows and how to work with them; shortcuts and object icons.
3. Main menu: commands, their purposes, and usage.
4. Access and use of Windows OS reference information.
5. Search for and launch necessary programs in the Windows environment.
6. Folder window in Windows OS and its structure.
7. Managing windows (minimizing, maximizing, closing, switching between windows, and arranging windows using the Taskbar).
8. Working with folders and files (searching, copying, renaming, deleting, creating folders and shortcuts, and obtaining object information).
9. Updating and deleting objects using the Recycle Bin.
10. Creating and extracting archive files.
11. Performing virus checks.
12. Overview of the Microsoft Word word processor: launching MS Word; MS Word program window and the purpose of its elements.
13. MS Word: document display modes; using menu bar commands; MS Word toolbars and their functions.
14. Creating a text file in MS Word.
15. Managing processor windows: previewing and printing documents.
16. Using text editing commands in MS Word.
17. Using text formatting commands in MS Word.
18. Using list formatting commands in MS Word.
19. Using paragraph formatting commands in MS Word.
20. Using page formatting commands in MS Word documents.
21. Document printing: previewing and printing.
22. Creating tables in MS Word.
23. Editing and formatting tables in MS Word.
24. Creating graphic objects in MS Word.
25. Working with images in MS Word.
26. Managing pictures in MS Word.
27. Using the formula editor in MS Word.
28. Overview of the Microsoft Excel spreadsheet processor: launching MS Excel; MS Excel program window and the functions of its elements.
29. Document display modes; using bar commands; MS Excel toolbars and their functions.
30. Creating an MS Excel worksheet: selecting MS Excel objects; adjusting column and row sizes; text input and formatting; entering and formatting numbers; inputting interval-type data; autofilling cells; cell operations.
31. Performing calculations in MS Excel: entering and calculating formulas; absolute and relative cell referencing; copying formulas using autofill; using the Function Wizard.
32. Editing operations: modifying cell data; undoing and redoing actions; moving and copying worksheet objects; inserting and deleting columns, rows, and cells; searching and replacing worksheet content.
33. Formatting table frames: auto-formatting and building table frames.
34. Managing workbooks: creating, saving, opening, and closing workbooks.
35. Creating charts using the Chart Wizard: data input; selecting chart types; selecting data for charts; setting chart parameters; choosing chart locations; completing chart creation.

36. Editing charts: moving and resizing charts; formatting chart elements; modifying chart components; changing chart types; adding additional data; deleting charts.
37. Using logical functions in Excel spreadsheets.
38. Managing databases in MS Excel: creating a database; sorting database data; searching database records; using the auto filter and advanced filter; creating forms.
39. Starting DBMS Access and loading a database. Sorting database data.
40. Searching data using Access database filters and queries.
41. Creating databases in DBMS Access.
42. Creating forms and reports in DBMS Access.

Content module 2: Medical Data and Methodologies for Processing and Analysis.

43. Statistical data analysis using the MS Excel Spreadsheet Functions Wizard.
44. Creation of a spreadsheet to determine the main statistical characteristics of a random variable.
45. Creation of a spreadsheet to determine the limits of a confidence interval for estimating the mathematical expectation of a random variable.
46. Creation of a spreadsheet to estimate the probability of the difference in means between two homogeneous indicators.
47. Creation of a spreadsheet to determine the coefficient of pair correlation.
48. Creation of a spreadsheet to test a sample for homogeneity.
49. Creation of a spreadsheet to verify the analysis method for the presence of systematic errors.
50. Creation of a spreadsheet to test the hypothesis of the equality of distribution centers for two correlated populations.
51. Creation of a spreadsheet to compare the effects of two drugs.
52. Creation of a spreadsheet to perform analysis of variance (ANOVA) to verify the influence of a factor on a resulting characteristic.
53. Creation of a spreadsheet to determine the coefficient of pair correlation and assess its reliability.
54. Creation of a spreadsheet to determine the parameters of a linear regression equation.
55. Creation of a spreadsheet to construct linear, exponential, and polynomial regression lines and compare their quality.
56. Processing of biosignals using MS Excel.
57. Processing of two-dimensional images.

Module 2. Medical Knowledge and Decision-Making in Medicine.

Content module 3: Medical Knowledge and Decision-Making.

58. Skills for working with the MathCad system interface.
59. Working with the toolbar in the MathCad system.
60. Application of the MathCad system for solving practical problems.
61. Computer modeling and solving physical and chemical problems using the MathCad system.
62. Creation of a spreadsheet to build mathematical models based on the results of medical and biological research.
63. Modeling and solving marketing problems in medicine using MS Excel.
64. Launching and working with diagnostic expert systems.
65. The main stages of creating expert systems.
66. Creation, editing, and recording of diagnostic expert systems.

Content module 4: Medical Knowledge and Decision-Making.

67. Connecting a computer to the Internet: methods of connection; network access via modem; connection configuration.
68. Network navigation: hyperlinks and toolbar icons.
69. Searching for information on the Internet: image searches, refining search queries, shareware and

freeware libraries, links, and bookmarked pages.
70. Searching for information on specific topics using browsers.
71. Sending and receiving messages via email.
72. Utilizing Internet medical resources.
73. Working in chats and social networks.
74. Launching and working with medical information systems.
75. Launching and working with automated workplaces (ARM).

List of educational and methodical literature

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