**THE MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE**
ODESSA STATE ENVIRONMENTAL UNIVERSITY

# Methodical instructions for laboratory work on discipline

# Mathematical Methods of Operations Research for the 3rd year students of the full-time education

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**Methodical instructions** in the discipline «Mathematical Methods of Operations Research» for the 3rd year students of the full-time education.

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# PREFACE

Operations research, or operational research, is a discipline that deals with the application of advanced analytical methods to help make better decisions. Further, the term 'operational analysis' is used military, as an intrinsic part of capability development, management and assurance. In particular, operational analysis forms part of the Combined Operational Effectiveness and Investment Appraisals (COEIA), which support defence capability acquisition decision-making.

It is often considered to be a sub-field of mathematics. The terms management science and decision science are sometimes used as synonyms.

Employing techniques from other mathematical sciences, such as mathematical modeling, statistical analysis, and mathematical optimization, operations research arrives at optimal or near-optimal solutions to complex decision-making problems. Because of its emphasis on human-technology interaction and because of its focus on practical applications, operations research has overlap with other disciplines, notably industrial engineering and operations management, and draws on psychology and organization science. Operations research is often concerned with determining the maximum or minimum of some real-world objective.

Tasks of the discipline «Mathematical Methods of Operations Research» is to teach students to correctly use learned techniques when solving problems and to correctly analyze the results of mathematical calculations. The study of discipline «Mathematical Methods of Operations Research» is based on the principles of integration of theoretical and practical knowledge acquired by students in General educational education institutions.

After studying the course the student should acquire basic knowledge and skills. He should know the basic definitions, terms and theorems of linear and non-linear programming, ability to use theoretical knowledge and skills in solving linear programming problems, problems of mathematical analysis and statistics, to apply a range of practical skills in the implementation of the methods of operations research to solve applied mathematical methods of operations research problems.

# Laboratory work №1
## *Introduction to GPSS World.*

The software package - GPSS World (GPSSW, General Purpose System Simulation World) company Minuteman Software is a versatile environment of modeling discrete and continuous processes for professional simulation modeling different types of objects. It includes a graphical shell for modeling and interpretation of results of modeling, multimedia and video, object-oriented programming, etc. The basis of the system laid simulation modeling language GPSS.

The system has a large set of commands to manage the modeling process, which can be used interactively or attach to the model.

Possible to conduct experiments generated by the system, user, and optimization experiments. In the System GPSSW realized visualization of the functioning model using methods of animation. It includes a new high speed translator, which is hundreds of times faster than its predecessors. For quick error correction, using full-screen text editor.

In this system there is no need numbered dates of the program. The system includes a large number of windows that simplify the review and analysis of model objects. It contains a library of probability distributions, library procedures, which provides term manipulation of data and allows you to perform calculations and extensive use of probability distributions.

During the installation of GPSS default directory is set to C: \ Program Files \ Minuteman Software \ GPSS World Student Version

After starting the main window opens in the title bar which indicates the name of the window - GPSS World, the second line - menu, in the third - the standard toolbar. The bottom line of the window - a line of system status, which is set a brief description of the selected command.

The main menu provides access to all the facilities of the system GPSS: *File, Edit, Search, View, Command, Window, Help.*

Item File of the main menu serves to work with files of documents, files of simulation models recorded in Model window and saved with the extension *.gps; text - in window Text File with the extension *.txt; simulation results - in report with the extension *.gpr; messages that appear in the modeling process - in window journal, with expansion *.sim.

Drop-down menu File includes a default set of points: *New, Open, Close, Save, Save As, Print, Recent File, Exit*.

Using New and click New Document in dialog box, you can create a file for simulation with the expansion *.gps or text file with the extension *.txt.

The system provides a standard report on the simulation results. For standard report in the presence of model control operator START, you must: select Command of the main menu and then click Create Simulation.

After the simulation will appear journal, and then report the results of simulations report.

In standard report includes the following main parameters:
– time of simulation system – end time;
– number of serviced channel requirements – entries;
– utilization of the channel – util;
– average service time requirements canal – ave time;
– maximum queue length – max;
– the average queue length – ave cont;
– average time requirement in line – ave time.

Edit Item of the main menu is the Edit drop-down menu that includes typical features: Undo; Cut; Soru; paste; Insert Line; *Delete Line*; *Font ...*, as well as specific functions: *Expression Window* – causes the dialog for editing; *Plot Window* – causes a dialog for editing graphics; *Insert GPSS Blocks* – causes a dialog box where you can select the text to insert the block of model *GPSS*; *Insert Experiment* – cause drop down menu to select the appropriate experiment; *Settings* – causes a dialog of *settings* to determine the system settings.

Settings dialog box includes five tabs to determine the settings: *Simulation; Reports; Random Numbers; Function Keys; Expressions.*

In the dialog box Insert GPSS Block into Model Object placed fifty-three block. Selecting block leads to appearance dialog box template Enter Block Information to input the necessary information

Selecting Search opens of the main menu drop-down menu, that includes items: Find/Replace; Go to Line; Next Bookmark; Mark; Unmark; Unmark All; Select to Bookmark; Next Error; Previous Error.

View Selecting of the main menu is a drop-down menu, that includes the following items: *Notices; Toolbar*; *Entity Details*; *Simulation Clock.*

Selecting Command of the main menu is the pull-down menu commands: *Create Simulation*; *Retranslate*; *Repeat Last Command*; *Conduct*; *Start; Start Command; Step 1*; *Halt*; *Continue*; *Clear*; *Reset*; *Show; Show Command*; *Custom* causing dialog *Simulation Command*.

GPSSW system can effectively handle multiple models. Under each model is given a separate window. Selecting Window of the main menu is the drop-down menu control work of multiple windows: Cascade; Tile; Simulation Window; Simulation Snapshot - is the pop-up menu with a list of windows of different images and modeling windows that are open at the moment.

Window Simulation Window is a popup menu that includes items: Blocks Window; Expressions Window; Facilities Window; Logic switches Window; Matrix Window; Plot Window; Queues Window; Save values Window; Storages Window; Table Window.

Selecting Help of the main menu opens a drop-down menu help system.

To work effectively with the environment GPSSW handy to have on-screen toolbar. Open or close the Standard toolbar can be activated via Toolbar dropdown menu View.

Window initial model designed to effectively develop, test and debug applications. This window is called automatically when you open a file from a program in GPSS.

The program, which is in the box model can transmit and receive the desired result. To do this, select the Create Simulation ... Command in point the main menu. If the program is error-free and it has a managing command Start, which is not accompanied by symbols NP (Not Print), then the simulation results appear in the window Report.

Diagnostic error messages are displayed in the program you will see in window Journal with the indication line number (Line) and position in the line (Col), where the error occurred. To quickly go to the line where an error occurred, you can use the menu item Search, Go to Line / Enter Line Number.

The system provides the ability to copy and transfer programs within the text window, between windows and between the windows and any application using the clipboard.

In operation, the system allows the use of multiple windows:

Model – full-screen text editor model;

Journal – journal to record messages;

Blocks Window – the dynamics of movement requirements for units;

Expressions Window – values of expressions;

Facilities Window – the dynamics of service channels;

Logic switches Window – speakers' logical switches;

Matrix Window – speakers values of matrix elements;

Plot Window – schedules;

Queues Window – speakers queues;

Save values Window – dynamics of the values stored values;

Storages Window – dynamics of change in the parameters of the drive;

Table – dynamics of the values of the table;

Transaction Snapshot – state requirements;

SES Snapshot – state chain of current events;

FEC Snapshot – state chain of future events.

For visualization of defined parameters in dynamic used window Expressions Window, which can be opened during the simulation (model to be broadcast). Activate the drop down menu items of the main menu Window: Simulation Window, Expressions Window. There will be two windows: Edit Expression Window and Expressions. Enter in the appropriate text boxes Edit Expression Window consistently expressions you want to view in dynamics, such as: utilization of channel FR$KAN; the maximum length of the queue QM$OCH; the average queue length Q$OCH.

For this field Label and Expression consistently introduce the necessary expression. After entering the title and button View activate expression and Memorize.

In Expressions box will display value of the selected parameters changed. At any time you can interrupt the simulation (button Halt) or continue the interrupted process (button Continue). For step simulation using the button Step. It should be borne in mind that the value of the coefficient of which appears in the Expressions box, presented to the scale of 1000.

To control the simulation customize the appearance of messages, content windows and the definition of the function keys using the appropriate settings. All of the objects inherit the settings to the current model. If you need a change of values for all models in your project, you should do it in the original object model. Text objects contain settings. Only these objects can be opened for editing in an external text editors.

For the determination report on the simulation should select the menu item Edit/Settings/Reports. Flag Create Standard Reports tab provides automatic creation of a set of standard messages after the modeling process. In Windows flag presentation provides results without saving them in a file.

Label elements flag Reports tab provides relevant results included in the report Blocks; Queues; Tables; Names; Facilities; Storages; SES (chain of current events); FEC (Chain future events); Save values; Logics witches; Matrices.

Function Keys tab is used to assign certain function keys teams manage the process modeling. Section Default Function Keys shows the default settings for function keys:

*F1 –HELP;*
*F2 – CONTINUE*;
*F3 – EXIT*;
*F4 – HALT*;
*F5 – STEP 1*;
*F6 – STOP*;
*F7 – STOP OFF*.

By default the system uses as a multiplication symbol #. You can use instead of the sign # traditional *. To do this, select the menu item: Edit/Settings Simulation, and include flag Switch * and #.

From the beginning you must choose from a folder examples Sample1.gps.

Then perform a broadcast model Command / Create Simulation. In the journal, which will appear after launch the model will display information about successful broadcast model.

Need to configure the graphics window. For the correct design of graphical information necessary to connect the value, which is dependent on what physical state we are interested in is your ID.

To prepare operational data modeling should call the configuration dialog schedule. You need to use the command Window/Plot Window. In the window that appears, type the current information for modeling.

*Plot (1)* – needed to build the current expression.

*Memorize* – used to save the given expression for subsequent removal and restoration process modeling.

*Plot (2)* – needed to build the new saved expression.

*Field Expression* – syntax information processed.

When you click OK axis is the construction schedule:

Launch of graphic data. After the command Start, an interactive window will appear in which you must change the default number on your variant.

Open schedule. After starting the model in the graphics window displayed current relationship.

After the simulation of in the journal will appear – Simulation nod added. After this message appears on your report: Report is complete.

After the modeling process should examine the results. For this designed dialog Show.

In the interactive window, type a value C1.

This command displays a log window and status bar relative time range.

In the interactive window Show, write: SHOW Qm$BARBER

Command shows the maximum length of the queue for the device service Barber, which will also be entered into the log and status bar.

Variants values for the command Start:

| | | |
|---|---|---|
| 1. 50 | 5. 150 | 9. 250 |
| 2. 75 | 6. 175 | 10. 275 |
| 3. 100 | 7. 200 | 11. 300 |
| 4. 125 | 8. 225 | 12. 325 |

Report content

1. A simulation model of individual data.
2. Screenshots graphic settings window.
3. Graph.
4. Screenshot of the final state of the environment GPSSW.
5. Information from the log logging process modeling and time-stamped.
6. Report program (Report).

# Laboratory work №2

## *Research dynamic modeling windows*

The working model will be created in the previous laboratory work model – Sample1.gps. Need to open and broadcast model. Open the Expression Window (Window/Simulation Window/Expression Window). In the window that appears, in the box Label must add value Time and field Expression - AC1. Then you need to browse and memorizing the set values through View and Memorize (view the actual on the first run model). Then click OK.

In case of need, re-editing expressions made the active window Expression Window by menu item Edit. Need to edit an expression for the research of new active Transact. In Expression Window box must be written: Label - active Transact; Expression - XS1. Then click OK.

To the research instrument windows Facilities Window. Do restart process simulation with the task in the statement Start operand in the following format: START 10000, NP. You can watch the changes necessary statistics without stopping to report the withdrawal process modeling. Stop the process (using the command Halt), collapse the window Expression Window and Facilities Window. Open the Block Window (study of the conditions and delays stop). To continue the simulation using the command F2. Make sure a dynamic graphical simulation. Stop and mark the required operational unit. To select the backlight unit and it is necessary to press Place. After that, the simulation will stop every time when Transact any attempt to enter the selected block (everything necessary to track in the journal modeling).

Back to trace. Menu Command/Custom. In the dialog box that appears, enter the command TRACE. As a result, the active window will be displayed with information indexing trace. So, performed manual mode simulation (debugging), which is a mandatory part of complex models.

For further normal operation of the model to remove all stop following conditions: Window / Simulation Snapshot / User Stops / Remove All. Then perform a restart model (F2). Once the simulation is stopped or came to an end must withdraw a report using command Command/Custom/Report.

Variants values for the command Start:

| | | |
|---|---|---|
| 1 – 1000 | 5 – 5000 | 9 – 9000 |
| 2 – 2000 | 6 – 6000 | 10 – 10000 |
| 3 – 3000 | 7 – 7000 | 11 – 11000 |
| 4 – 4000 | 8 – 8000 | 12 – 12000 |

Report content

1. Window expressions during filling.
2. Window expressions.
3. Window devices.
4. Window blocks.
5. Log, including tracing messages.

### *Expression research*

An additional purpose SHOW command are using this dialog as a sophisticated calculator.

Show dialog box, you can compose complex expressions using specialized functions GPSS. The result of the calculated expression will be given in the Journal format double-precision (float).

The hierarchy of arithmetic and logical operations in GPSS:

1) ^ – raised to the degree
2) #, /, \ – multiplication, division, integer division;
3) @ – entire remainder;
4) –, + – subtraction, addition;
5) 'GE' * ≥, 'LE' * ≤, 'G' * >, 'L' * <, >=, <=, >, < – comparison operators;
6) 'E' * =, 'NE' * ≠ – equal, is not equal;
7) 'AND' – logical „and";
8) 'OR' – logical „or".

GPSS World Library has the following mathematical functions (procedures):

1) ABS(A) – Absolute value
2) ATN(A) – arctangent
3) COS(A) – Cosine
4) EXP(A) – exponent
5) INT(A) – Bold of an entire part
6) LOG(A) – Natural logarithm
7) SIN(A) – Sine
8) SQR(A) – Square root
9) TAN(A) – Tangent

Test calculation result of simple arithmetic. For this create model and open window Show, select Command/SHOW and enter value of your variant.

In the Journal window appeared answer format float. Simulation on Stop error. For this dialog Show deliberately enter an expression that expresses the result of errors: SHOW 3/0. After running this command in the log window will appear a statement of an error condition.

You must create a model that consists of only two lines and contains obvious errors. Manually enter in the code window of the program model two lines of error, such as:

HENERATE 10
TERMINATE 1

Then run the model created Command/Create Simulation. Perform editing error that was detected. For do this, click Search/Go To Line. Then you must change H to G and retransmit model Command/Retranslate, and check the log.

Run the following operations:

1) Open the sample file Sample1.gps
2) Run the simulation.
3) Open the device.

In the box, there are no devices to appeal to him first using the command START, enter value of your variant. Click OK. Then in the devices appear certain blocks.

Calculate complex expression, such as: log (model time) + (maximum length of the queue). For this in window settings expression on field *Label* should write: complex expression, *Expression – LOG(C1)+(Q$BARBER)^2*

After filling the fields you must click View. Further, in view of devices will appear important. When using logical operators be sure to put quotes and avoid gaps between the operator and operands.

Run simulation logical expressions. To do this, Expression Window box in the Label field must be written: *Label* – less than 6 pending, *Expression* – 1+99#((Q$BARBER)‘GE’6)

This expression will give as a result one in case the queue is less than 6 customers, or in any other case 100. Run simulation stream of random numbers. To do this, choose Command/SHOW and Show dialog box make the following values: SHOW RN1000. RN is returns a random number between 0 and 999 in the status bar and log modeling.

Run the previous query again, and in the Journal with overwhelming probability will receive a different result.

Then perform a functional configuration of the random number. For do this, click Edit/Settings must go to the bookmark Function Keys and along with record label F9 set SHOW RN1000.

Go to Journal and about 5 times fulfill pressing F9. Thus, we can ensure that in several successive queries is issuing a stream of random numbers results.

On the Function Keys is the ability to consolidate any function key (except F1) separate command that will contain logical expression.

Variants values for the command Start:

| | | |
|---|---|---|
| 1. 87654 | 5. 48725 | 9. 39261 |
| 2. 34567 | 6. 52398 | 10. 92761 |
| 3. 92784 | 7. 27483 | 11. 18942 |
| 4. 29365 | 8. 92517 | 12. 39271 |

Variants values for the command Show:

| | |
|---|---|
| 1. 8762-2345/20#(120-112)^2 | 7. 1900@2#90/3+543 |
| 2. 275#32/20+(60#20)-125 | 8. 125+30^2/15#55+180 |
| 3. 1515+125-(60#20)-275#20/22 | 9. 8880@40/20#3+1200 |
| 4. 578+1678-320/20#85+1200 | 10. 9999\9/11#90+3578-125 |
| 5. (874-124)#120\5 | 11. 80#90/2+8520-1120 |
| 6. 1250\12#50+867/2 | 12. 100#40@20+980#2 |

Report content

The contents of the report should contain all the basic screenshots, and a full magazine modeling. Conclusions.

# Laboratory work №3
## *Queues and Q-table*

Blocks QUEVE and DEPART required for static data collection. Especially important static information about the structure of the queue. First, blocks QUEVE and DEPART not delay the promotion transact, but only designed for dynamic tagging of entry and exit transact. Turn the device creates a necessary service and needs no description explicitly. One of the important attributes of the queue parameter is called content queue. In addition, no less important parameter - the length of the queue.

When transact is a unit QUEVE content turn increases the magnitude transact when transact is a block DEPART - meaning reduced. The advantage of using queues is that GPSS generates statistics and numerical characteristics queue statistics published in this standard report

Graphically turn can be framed in a Q-table and in a chart. Also available QUEVES dialog to dynamically view the current state of the simulation.

Open File Sampque.gps. In this model blocks QUEVE and DEPART concludes between a block seize. For transact that can immediately take care unit waiting time will be registered, in addition, the average length and average time will be displayed in the standard report.

Statistics stage during simulation. Run creation process modeling.

Open the queue. For this Window/Simulation Window/Queues Window. In this state in the box to appoint a single stage, but in the case where the model will appear be one transact provides information about queues and their parameters. To do this, choose Command/START and enter the value (your variant). For example, value - 10000.

Stop the simulation by using the F4 and begin to create a histogram service. Histograms graphically display dynamic data that change. When you create histograms used to display the statistics based on the units QUEVE and DEPART. For a histogram must go model editor and add the last line in this format:

*Waittime QTABLE Barber,2,3,20;* Histogram.

where BARBER - a device based on statistics which are based histogram; 2 - initial value histogram; 3 - increment to operand B; 20 - number incremental to operand B.

Block QTABLE makes image formation Q-table, the construction of which may occur during the simulation. Run retransmission model Summand/Retranslate. Restart simulation and instead START 1 on the six-digit number (your variant), click OK, and immediately the same F4. Open the view diagrams. For use this command, select Simulation Window/Table Window in the box and select the desired mark WAIT TIME.

At the histogram represented on the vertical axis transact deposited on the horizontal column depicted in a number of them for each time interval mode.

To observe the dynamics of constructing histograms must press F2, then the column histogram come in a statistical movement. Open the window units Window / Simulation Window / Block Window. In this window will be vertical movement transact. Open the Device Facilities Window and to analyze the workload of both units of service.

Variants values for the command Start:

| | | |
|---|---|---|
| 1. 35000 | 5. 55000 | 9. 75000 |
| 2. 40000 | 6. 60000 | 10. 80000 |
| 3. 45000 | 7. 65000 | 11. 85000 |
| 4. 50000 | 8. 70000 | 12. 90000 |

Variants values for the command Start:

| | |
|---|---|
| 1. 111111 | 7. 650000 |
| 2. 222222 | 8. 700000 |
| 3. 333333 | 9. 750000 |
| 4. 444444 | 10. 800000 |
| 5. 550000 | 11. 900000 |
| 6. 600000 | 12. 950000 |

Report content

1. Model code added team building histogram.
2. Queues window QUEVE.
3. Histogram.
4. Window blocks.
5. Window devices.
6. Report (Report).
7. Conclusion.

### *Formation process of redefining the matrix means GPSS.*

In GPSS matrix supported formation dimension to 6.

Open File Sample9.gps. To set the matrix in GPSS use the following command format:

<name> MATRIX ,B,C,D,E,F,G

After block MATRIX operand A is skipped. The operands from B to G determine the dimension of the matrix. In GPSS there is no concept of row or column. For each dimension matrices is used index dimension, which is set in the appropriate window configuration. For example, to specify the matrix dimension of 5*10 should be written:

<name> MATRIX ,5,10

To access the dimension of the matrix, use the command MSAVEVALUE. However, this treatment only applies to the first two dimensions. The rest of the dimensions should seek the help of a specially formed PLUS - procedures. Matrix is never removed from the scope of GPSS, but you can override the block re-using MATRIX. At the time of its creation all the matrix elements assigned zero values. However, in case you need to change the type of data element must use the command INITIAL, after which all elements assigned unspecified type USP. After changing the type of element can form a matrix that interests us. To access the elements of the matrix using standard numerical attribute MX:

MX MATRIX (1,2) then the name of the matrix code dimension.
SHOW MX$MATR1 (1,2)

Run the model creation process.

To view the matrix there is some dialog that displays any two selected dimension matrix. Open the matrix Window/Simulation Window/Matrix Window.

As the first file Sample9 given only one matrix, its name will be immediately entered into the field. After the setting will be marking matrix
To change the display planes should be in the configuration matrix binding to reorient dimension. Run the simulation by using the START value of 100. Go to the window display matrix Matrix Window, which appear calculated value.

MATRIX1 MATRIX
MSAVEVALUE MATRIX1,2,2,QA$PROCESS
A B C D

Command MSAVEVALUE recorded in the following format:
A operand – the name of the matrix;
B operand – conventional line;
C operand – conditional column;
D operand – value for the newly formed cell.
You must select the optimal placement of elements in the matrix using INDEX field in the settings window.
Apply to manual modeling followed by overrides 25 matrix elements (your variant). To do this, click Command/Custom and all subsequent tasks perform the following:

MSAVEVALUE MATRIX1,1,1,1000

After the command Custom is necessary in the journal modeling sure to assign values, and then open the matrix and check the corresponding item. Thus, the form and fill in the data set, which consists of 25 elements. Define a matrix of higher dimension (for options). To do this in the Custom command must be set in the following format:

MATRIX2 MATRIX 2,3,4,2,5,7

Be sure to create an array, and then must go to the configuration dialog matrix, in which the upper field need to choose a new name matrix. Since six bit matrix, active all fields in window Cross Section. To change the visible section of the matrix, you must decide which of the dimensions will act as a line, and that as columns. For other measurements must select index for optimal task corresponding measurement.

Variants values for the matrix:**

1)

| | | | | |
|---|---|---|---|---|
| 800 | 100 | 555 | 800 | 5000 |
| 350 | A | 600 | 333 | 215 |
| 200 | 2000 | 700 | 0 | 750 |
| 500 | 450 | 0,5 | 3050 | 600 |
| -200 | 300 | 900 | D | 950 |

2)

| | | | | |
|---|---|---|---|---|
| 333 | 121 | 676 | 932 | 100 |
| F | 0 | 586 | 821 | 756 |
| 222 | 343 | One | 654 | 565 |
| 444 | 454 | 346 | 545 | 465 |
| Lab | 565 | 768 | 0 | 354 |

3)

| | | | | |
|---|---|---|---|---|
| For | 700 | 1500 | 7000 | M |
| 500 | 300 | 1,9 | 320 | 9000 |
| 900 | 180 | 300 | 0 | 1005 |
| 200 | 4000 | R | 4009 | 2000 |
| 150 | 400 | 750 | 800 | 500 |

4)

| | | | | |
|---|---|---|---|---|
| 100 | 710 | 680 | 840 | 900 |
| 500 | 320 | -99 | 400 | 250 |
| 0,85 | 150 | 550 | 9050 | 300 |
| 800 | 640 | 770 | 810 | 555 |
| 200 | 600 | 0 | 340 | 880 |

5)

| | | | | |
|---|---|---|---|---|
| 800 | 100 | 555 | 800 | 5000 |
| 350 | A | 600 | 333 | 215 |
| 200 | 2000 | 700 | 0 | 750 |
| 500 | 450 | 0,5 | 3050 | 600 |
| -200 | 300 | 900 | D | 950 |

6)

| | | | | |
|---|---|---|---|---|
| Hi | 510 | 700 | 100 | -20 |
| 600 | 290 | 200 | 660 | 955 |
| 0,01 | 300 | 0 | 490 | 380 |
| 800 | 750 | 810 | 260 | 765 |
| 430 | 900 | 500 | 170 | U |

7)

| | | | | |
|---|---|---|---|---|
| 500 | 200 | 1000 | 430 | Are |
| 770 | 630 | 380 | 400 | 690 |
| 0 | 470 | -999 | 850 | 910 |
| 999 | 407 | 305 | 405 | 300 |
| 555 | 800 | And | 400 | 700 |

8)

| | | | | |
|---|---|---|---|---|
| 910 | 390 | 420 | 500 | 0 |
| 740 | 930 | 840 | 330 | 440 |
| Five | 370 | 730 | 955 | 700 |
| 500 | 800 | 6,06 | 900 | 310 |
| 1000 | 200 | 745 | 890 | -11 |

9)

| | | | | |
|---|---|---|---|---|
| D | 320 | 126 | 439 | 790 |
| 3000 | 500 | 810 | 950 | 260 |
| 250 | -33 | 710 | L | 800 |
| 499 | 555 | 300 | 888 | 200 |
| Zero | 800 | 420 | 950 | 500 |

10)

| | | | | |
|---|---|---|---|---|
| One | 710 | 680 | 750 | 810 |
| 900 | 840 | 330 | 900 | 500 |
| 6000 | 730 | 40,5 | 232 | 300 |
| 800 | 640 | 222 | 343 | 0 |
| Null | 444 | 750 | 340 | -9 |

11)

| | | | | |
|---|---|---|---|---|
| 0 | 165 | 3400 | 1000 | Boom |
| 900 | SM | 250 | 888 | 215 |
| 999 | 2,05 | 700 | 650 | 810 |
| 4000 | 450 | 100 | 500 | 111 |
| 0 | 300 | 77,7 | 555 | -666 |

12)

| | | | | |
|---|---|---|---|---|
| A | 650 | 300 | 0 | 1000 |
| 350 | 400 | 777 | 560 | 610 |
| 700 | -1,5 | 7500 | 410 | 333 |
| 111 | 450 | 900 | Null | 850 |
| 5555 | 280 | 490 | 790 | Z |

Overriding matrix:

1) 1,2,4,5,6,3
2) 3,5,7,2,1,4
3) 2,6,1,2,7,3
4) 4,3,1,7,5,2
5) 1,5,4,3,2,6
6) 3,5,4,2,7,1
7) 1,2,4,3,6,7
8) 3,7,2,4,1,6
9) 4,6,5,7,1,3
10) 7,1,3,4,5,2
11) 3,5,6,1,2,4
12) 2,4,7,1,5,6

Report content

1) File model;
2) Preferences window Cross Section;
3) The initial layout matrix;
4) Completed array;
5) Custom window with a completed command of 2 matrix;
6) Preferences window 6-dimensional matrix;
7) Template markup made in terms of non-standard;
8) The protocol (log).
9) Conclusion.

# Laboratory work №4

## *Logic cell frames modeling process.*

Open File Sample9.gps. Run the simulation, setting this value to the command START: 1000NP. Stop the simulation by pressing F4. Open the Window/Simulation Window/Logic switches Window. Open the cell Window/Simulation Window/Save values Window. Choose how to display that does not overlap windows (mosaic). Run the simulation step by step (F5) and to observe the behavior of logical keys. Next, press F2, and then stop the simulation. Disconnect detailed review View/Entity Detail for each window. Continue the simulation and make the current screenshot.

Images modeling process reflect a static picture of the model. Images of the modeling process are not updated during the simulation, however, may be called as many times as defined by the user.

It should be relayed model, after closing the windows key and cells. Set parameter START 1000NP and stop after running the simulation. Select the window frame list of current events. To do this, select the command Window/Simulation Snapshot/CEC Snapshot and a window. This window displays transact grouped by priority. Detail gives priorities transact options that are presented in the form of appropriate notes. After further detail a list of parameters, which consists of flags transact. Choose got transact and enter it in the appropriate frame transact Window/Simulation Snapshot/Transaction Snapshot. In the dialog box, enter the number transact. Window appears transact. In this frame contains information about transact including the current value of time priority, block number, the next block number, line number, family number transact. In the drop-down list displays the parameters transact. Run start and stop the process of modeling at least 3 times and after each stop to watch the content windows. Run simulations list of upcoming events. To do this, use the command Window/Simulation Snapshot/FEC Snapshot and perform a similar action, but with one transact. Run framing of transact Window/Simulation Snapshot/XN Groups Snapshot. Then a window frame headers Transaction Group Snapshot. Run framing numerical groups Window/Simulation Snapshot/User chains Snapshot. Run framing numerical groups Window/Simulation Snapshot/Numeric Groups Snapshot. In the current window will appear modeled on Inland numerical hierarchy. In the latter group there are two numerical values added to the simulation. By numerical values attached groups transact, and when you start modeling process attached output values, which are then used in the interim control checking system. Thus, this model, each transact adds value to the group.

Report content

1. File a model.
2. Screenshot box Logic switch Entities.
3. Dialog Save value Entities.
4. Window Current events chain snapshot.
5. Transaction Snapshot.
6. Transaction Group Snapshot.
7. User chain Snapshot.
8. Numeric Group Snapshot.
9. Protocol simulation.
10. Conclusions.

## *Reading and writing data to external files.*

In GPSS blocks are designed to read and write data to external text files. These blocks may be required when reading data file from an external source, format your report or the collection of one or two blocks of data in an external file at regular intervals. For input/output data used commands open, read, seek, write, close. When using these blocks or procedures compatible with the library-term procedures in GPSS World user can perform efficient data processing and formatting. For each model there is a text file, which is work. The files – plain text files with the extension *.txt. For files in which the account exists tsttempl.txt file, which is used to bring each of these files to the original state. After the assignment file tsttempl.txt copy the following files: tstskinw.txt, tstappw.txt, tstskrw.txt, tstsqrw.txt, tsrsqr2w.txt, and then delete the following two files: tstcatw.txt, tststw.txt. Files tstrd.txt and tststrd.txt used to read data. The names of the text files created by code.

*Letters and operation of input/output that represent them:*

CAT = Catenate (a string procedure)
IN = insert
R = Replacement
RD = Reading
SK = search
SQ = consistent
ST = string
W = entry

Open the model Tstrd.gps. Create the simulation Command/Create Simulation. Open the dialog Matrix Window. In the drop-down list displays the label TOTAL, as the only matrix in this model. Set parameter START 1NP. During the simulation matrix filled with values from 1 to 7, found in the file Tstrd.txt. Block OPEN placed in a separate segment model, as the file is opened

once. transact with the highest priority above all when starting the modeling process opens the file for reading. Each of the read parameter value is placed in transact Numero. The next three blocks renews counter (cell), which is then recorded in the parameter and is used as a line number in the matrix. Then the value of the block MSAVEVALUE, read off in P$Numero, placed in the appropriate row matrix TOTAL. When the end of file, TRANSACT sent to the block CLOSE labeled Finis, closing the data file. Close the window of model and the window Matrix Window. Open model file Tstskrd.gps. Create the simulation. Open the matrices Window/Simulation Window/Matrix Window. Set the setting for START 1NP then a dialog box appears matrices. After the modeling process in the cell array (lines 4 and 6) were made to value 4 and 6 (your variants), which were set in the code model. OPEN Block is located in a separate segment model, as the file is opened once. Then transact, which will make reading part of the SEEK unit, moving the current line position in line 4. The value is read with a block READ, then entered into a matrix and then be scanned to determine the need to perform the next reading. Such actions are carried out and the second value. If an error occurs in a block OPEN or CLOSE transact enters into blocks labeled Flag and Flag1.

In the examples folder models to create a new text file that will contain 10 rows with the following values: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10. After creating the file must register its opening in the file of the model.

```
; GPSS World Sample File - TSTSKRD.GPS
************************************************
; Read a file in two specific locations
; using SEEK and puts the stores the values
; in a matrix. Closes file after second value
; is read and stored.
************************************************
Total   MATRIX      ,10,1
        GENERATE    ,,,1
        OPEN        ("TSTRD_NEW.TXT"),,Flag
        SEEK        4
        TRANSFER    ,Dord
Again   SEEK        6
Dord    READ        Numero,,Finis
        MSAVEVALUE  Total,P$numero,1,P$numero
        TEST E      P$Numero,4,Finis
        TRANSFER    ,Again
Finis   CLOSE       Prob,,Flag1
        TERMINATE   1
Flag    TERMINATE   1
Flag1   TERMINATE   1
```

To work with the model TSTSKRD.gps. Change the values for blocks SEEK.

```
; GPSS World Sample File - TSTSKRD.GPS
************************************************
; Read a file in two specific locations
; using SEEK and puts the stores the values
; in a matrix. Closes file after second value
; is read and stored.
************************************************
Total   MATRIX      ,10,1
        GENERATE    ,,,1
        OPEN        ("TSTRD_NEW.TXT"),,Flag
        SEEK        4
        TRANSFER    ,Dord
Again   SEEK        6
Dord    READ        Numero,,Finis
        MSAVEVALUE  Total,P$numero,1,P$numero
        TEST E      P$Numero,4,Finis
        TRANSFER    ,Again
Finis   CLOSE       Prob,,Flag1
        TERMINATE   1
Flag    TERMINATE   1
Flag1   TERMINATE   1
```

Variants values:

1) 1; 3.
2) 2; 5.
3) 1; 4.
4) 2; 4.
5) 3; 5.
6) 5; 8.
7) 3; 6.
8) 6; 8.
9) 5; 7.
10) 4; 7.
11) 6; 9.
12) 7; 9.

Report content

1. Screenshot created text file
2. File a model.
3. Configuration Window Cross Section.
4. Dialog Matrix Window with values.
5. Dialog Matrix Window with values placed in cells.
6. Protocol simulation.
7. Report.
8. Conclusions.

# Laboratory work №5

## *The entry in the selected line of the file by using random access.*

Open model file Tstskinw.gps. Create the simulation. Set your command START 1NP. Open the modified file data. To do this, choose File/Open. In the dialog box, you must select the type of file with the extension * .txt, then choose from a list of file Tstskinw.txt (variants on tasks), and click Open.

Before the third line of the file were inserted values that were specified in the code of the model (in this case - 123456). In case if the unit is not used SEEK data would be inserted before the first line of the file. SEEK unit is used to move the fluid line to position the text string three, where the block WRITE to record information. In blocks of OPEN, WRITE and CLOSE in case of input/output error are alternative outlets. On error CLOSE block produces the error code and output code mistakes and puts it in the parameter transact. Close all windows that belong to the task.

### *Addition of data to the end of the file.*

Open model file Tstappw.gps. Run the simulation. Choose Command/START 1NP. Open the modified file data Tstappw.txt (your variants). In this case, the use of block WRITE possible to add value 123456 at the end of the file. WRITE block operates in insert mode (indicated value of one of the operands «ON»). Close all windows that belong to the task.

### *Daily replacement block write.*

Open model file Tstskrw.gps. Create the simulation. Set your command START 1NP. Open the modified file data Tstskrw.txt (your variants). In line 2 was recorded new value 123456. In this case, the unit worked WRITE mode replacement. For this latter operand must specify the parameter label «OFF». Close all windows that belong to the task.

### *Daily replacement without specifying the position of line.*

Open model file Tstsqrw.gps. Create the simulation. Set your command START 1NP. Open the modified file data Tstsqrw.txt (your variants). In this case, since the line item does not indicate the first row is replaced by another. Close all windows that belong to the task.

### *Daily replacement with multiple consecutive records.*

Open model file Tstsqr2w.gps. Create the simulation. Set parameter value for the command START 1NP. Open the modified file data Tstsqr2w.txt (for variants). In this case, after each entrance transact a block WRITE current line item increases by 1 line thus replaced lines 1 and 2. Close all windows that belong to the task.

### *Working with strings.*

Open model file hairdresser Tstcatw.gps. Create the simulation. Set options for the command START 1NP. Open the modified file data Tstcatw.txt. In block WRITE for combining text data with real data was used procedure Catenate, which need when formatting the report or output the selected information in the simulation performed at predetermined intervals. Close all windows that belong to the model.

### *Processing of the data that are read from the file.*

Open model file Tststrdw.gps. Run the simulation. Select Team Command/START and enter the value: 1NP. Open the modified file data Tststrdw.txt (variants on tasks). In this case, the data from the file Tststw.txt were scanned and processed, thanks to their section into smaller parts and then was chosen piece of information that was read off from a given place in the file.

Variants tasks:

To perform the first five tasks (topics) in the folder examples of models, create text files with changed names models (example first model – Tstskinw_NEW.txt). As the information contained in a text file to write, for example:

Name on line 1
Surname on line 2
Date of birth on line 3
Number of group on line 4

After that, you must register the opening created text file in the code model (block OPEN). Change the setting that is registered in the block WRITE, on the date of the laboratory work, without separators, for example: 01092016.

When performing tasks 6 and 7, use described in the example files intact.

Report content for each model used:

1. Model file;
2. Text file;
3. Modified text file;
4. Protocol design;
5. Report;
6. Conclusions.

## Basic literature


1. Konyukhovskii P.V., "Mathematical methods of operations research in the economy." -St. Petersburg, Peter. 2000. - 208C.
2. Glushkov O.V., Khetselius O.Yu., Ambrosov S.V., Swinarenko A.A., Ignatenko G.V., “Probability theory and mathematical statistics.” -Odessa: Ecology. 2011.
3. Glushkov O.V., Serbov M.G., Khetselius O.Yu., Dubrovska Yu.V., Florko T.O., “Applied mathematics.” -Odessa: Ecology. 2007.
4. Glushkov O.V., Kruglyak Yu.O., Chernyakova Yu. G., “Lecture notes linear algebra.” -Odessa, TES, 2004.- 117C
5. Glushkov O.V., Ambrosov S.V, Vitavetska L.A., Loboda A.V., “Lecture notes mathematical programming.” -Odessa, TES. 2003- 95C.
6. Velikodniy S.S., “Mathematical Methods of Operations Research.” - Odessa: E-print. 2015.


## Additional literature


1. GPSS World reference manual. Fourth Edition 2001. Copyright Minuteman Software. Holly Springs, NC, U.S.A. 2001.
2. Lapin L. Quantitative methods for business decisions with cases. Fourth edition. HBJ, 1988.
3. Liitle I.D.C., Murty K.G,, Sweeney D.W., Karel C. An algorithm for traveling for the traveling salesman problem. — Operation Research, 1963, vol.11, No. 6, p. 972-989
4. Taha H. Introduction to Operations Research / Ed. from English. Moscow, 1985.

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