MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE

SIMON KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS

Syllabus
of the academic discipline
"MATHEMATICAL MODELLING IN ECONOMICS AND MANAGEMENT: OPERATIONS RESEARCH"
for full-time students of training direction
6.030601 "Management"

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The content of the academic discipline according to its modules and themes, plans of lectures and laboratory studies, questions for self-study, test questions for self-assessment are presented. The list of recommended literature is provided.

For full-time students of training direction 6.030601 "Management".

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Introduction

Operations research (OR) is the application of scientific methods to the management and administration of organized governmental, commercial, and industrial processes. It uses mathematical techniques to solve management problems.

The British/Europeans refer to "operational research", the Americans to "operations research" – but both are often shortened to just "OR".

Operations research is a scientific approach to decision making that seeks to best design and operate a system, usually under conditions requiring the allocation of scarce resources. A system is an organization of interdependent components that work together to accomplish the goal of the system.

An OR study is rooted in teamwork, where the OR analysts and the client work side by side. The OR analysts' expertise in modelling must be complemented by the experience and cooperation of the client for whom the study is being carried out. As a decision-making tool, OR is both a science and an art. It is a science by virtue of the mathematical techniques it embodies, and it is an art because the success of the phases leading to the solution of the mathematical model depends largely on the creativity and experience of the operations research team.

The principal phases for implementing OR in practice include definition of the problem, construction of the model, solution to the model, validation of the model, implementation of the solution.

1. Description of the academic discipline

The structure of the academic discipline "Operations Research" is given in Table 1.

Table 1

The structure of the academic discipline "Operations Research"

Discipline characteristics: bachelor degree	The subject area, the direction of training, the educational level	Discipline characteristics
3 ECTS credits; 2 modules	The code and name of the subject area: 0306 "Management and Administration"	Educational qualification – Bachelor. The year of study – 2nd; the term – 4th
Total hours: 90; self-study work: 54 hours (60 %)	Training direction 6.030601 "Management"	Lectures – 18 hours. Workshops – 18 hours. Self-study – 54 hours
17 training weeks, 2 hours per week	Educational qualification – Bachelor	Form of control: passed

The ratio of class hours to self-study hours is 60 %.

2. The purpose and objectives of the academic discipline

The purpose of the academic discipline is to form theoretical knowledge and practical skills in formalizing management tasks with specialized methods.

The subject is economic and mathematical methods and models.

The main objective is to form quantitative rationale for decisions.

Additional tasks are:

comparative evaluation of different alternatives;

assessment of the impact parameters on the result of the operation.

To be successful in Operations Research students should know:

Maths – to understand OR theories and algorithms;

Statistics – to collect primary data correctly;

Economics – to make right assumptions about the variables relationships;

Informatics – to use special OR programs.

After studying the academic discipline students should know:

definitions of the following terms: operation, model, system, modelling, control, optimal solution, feasible solution;

core phases of the operations research study;

three basic properties of the linear programming model;

core steps of the linear model graphical solution;

definitions of direct and inverse operation research problems;

the way to define decision variables of the model;

the way to define objective variables of the model;

the product mix model structure;

the rules of constructing the dual model;

the way to define the optimal solution to a dual model;

the shadow price economic interpretation;

the definition of a Markov chain;

the classification of Markov processes;

the definitions of absolute and transition probabilities;

the elements of a queuing model;

the classification of queuing systems;

the exponential distribution features;

the Poisson distribution features;

the definition of a game model;

the game model structure;

the two-person zero-sum game features.

After studying the academic discipline students should have such skills and abilities as:

to correctly formulate primary operation goal and secondary goals;

to form a set of indexes which describe the problem;

to determine the control system structure;

to make a formalized definition of the problem in the form of a set of models;

to perform a formalized mathematical description of the product mix problem and find an optimal solution to it;

to perform a formalized mathematical description of the diet problem and find an optimal solution to it;

to perform post-optimal analysis of the results;

to perform a formalized mathematical description of the transportation problem and find an optimal solution to it;

to perform a formalized mathematical description of the assignment problem and find an optimal solution to it;

to perform a formalized mathematical description of the shortest pass problem and find an optimal solution to it;

to solve various tasks of complex socioeconomic systems control in terms of risks and uncertainties.

The core professional competences that should be formed during the study are shown in Table 2.

Table 2

The core professional competences

Competence code	Competence name	Competence components
OR* 1	To perform a formalized mathematical description of the deterministic problem and find an optimal solution to it	To determine the objective variable, decision variables and constraints of a socioeconomic problem
		To solve a product mix problem
		To perform post-optimal analysis results
		To solve a transportation problem
		To solve an assignment problem
OR 2	To perform a formalized mathematical description of the stochastic problem and find an optimal solution to it	To make optimal decisions about socio-economic processes that are defined as Markovian ones
		To make queuing systems optimization
		To solve various tasks of complex socio-economic systems control in terms of risks and uncertainties

* Operations research.

The structure of the competence components according to the National Qualifications Frame of Ukraine is presented in the Appendix A, Table A.1.

3. The contents of the academic discipline

Module 1. Deterministic models and methods

Theme 1. What is Operations Research

A historical review. The purpose, the object and the subject of the academic discipline. The syllabus. Operations research themes at a glance. Direct and inverse operations research problems. Deterministic and stochastic problems. An operations research model. Phases of an operations research study.

Theme 2. The product mix problem

Problem statement. Mathematical formulation of the product mix problem. Three basic properties of the linear programming model (proportionality, additivity, certainty). A graphical solution to the problem. Solution with the MS Office Solver.

Theme 3. Duality and post-optimal analysis

Definition of the dual problem. Primal-dual relationships. Economic Interpretation of duality. Post-optimal analysis.

Theme 4. Maths programming applications

The diet problem history. George Stigler's heuristic solution. Problem statement and its mathematical formulation. A graphical solution to the problem. A solution with the MS Office Solver. The urban planning problem. Investment production planning. The inventory control problem. The blending and refining problem. The transportation problem. The assignment problem. The shortest pass problem.

Module 2. Stochastic models and methods

Theme 5. Markov chains

Definition of a Markov chain. Absolute and n-step transition probabilities. Classification of the states in a Markov chain. Steady-state probabilities and mean return times of Ergodic chains. The first passage time. Analysis of absorbing states.

Theme 6. The queuing theory

Queuing systems. Elements of a queuing model. The role of exponential and Poisson distributions.

Theme 7. The game theory

The game theory basic concepts. The game model structure. Classification of games. Optimal solution to two-person zero-sum games. A solution to mixed strategy games.

4. The thematic structure of the academic discipline

The discipline is studied during lectures and workshops. The significant part of the total discipline time is devoted to self-study work (Table 3).

Table 3

The structure of the academic discipline

Theme	The number of hours		
	Lectures	Laboratory studies	Self-study work
Module 1. Deterministic models and methods			
1. What is Operations Research?	2	2	4
2. The product mix problem	2	2	9
3. Duality and post-optimal analysis	2	2	9
4. Maths programming applications	2	4	9
Total (module 1)	8	10	31
Module 2. Stochastic models and methods			
5. Markov chains	4	4	9
6. The queuing theory	2	2	9
7. The game theory	4	2	5
Total (module 2)	10	8	23
Total	18	18	54

5. Plans of lectures

Module 1. Deterministic models and methods

Theme 1. What is operations research (OR)?

1.1. A historical review.

1.2. The purpose, the object and the subject of the academic discipline. The syllabus. Operations research themes at a glance.

1.3. Direct and inverse operations research problems.

1.4. Deterministic and stochastic problems.

1.5. An operations research model.

1.6. The phases of an OR study.

Theme 2. The product mix problem

2.1. Problem statement.

2.2. Mathematical formulation of the problem.

2.3. Three basic properties of the linear programming model.

2.4. A graphical solution to the problem.

Theme 3. Duality and post-optimal analysis

3.1. Definition of the dual problem.

3.2. Primal-dual relationships.

3.3. Economic interpretation of duality.

3.4. Post-optimal analysis.

Theme 4. Maths programming applications

4.1. The diet problem mathematical formulation.

4.2. The diet problem graphical solution.

4.3. The transportation problem.

4.4. The assignment problem.

Module 2. Stochastic models and methods

Theme 5. Markov chains

5.1. Definition of a Markov chain.

5.2. Absolute and n-step transition probabilities.

5.3. Classification of the states in a Markov chain.

5.4. Analysis of absorbing states.

Theme 6. The queuing theory

6.1. Queuing systems.

6.2. The elements of a queuing model.

6.3. The role of exponential and Poisson distributions.

6.4. The queuing theory applications.

Theme 7. The game theory

7.1. The game theory basic concepts.

7.2. The game model structure.

7.3. Classification of games.

7.4. An optimal solution to two-person zero-sum games.

6. Plans of laboratory studies

Laboratory studies are one of the forms of the academic study within the discipline. It aims to form core practical abilities and skills in dealing with complex operations research problems.

The list of laboratory studies is presented in Table 4.

Table 4

The list of laboratory studies

Lecture theme	Laboratory studies	Hours
Module 1. Deterministic models and methods		
Theme 1. What is operations research?	Starting with Excel: pre-test of skills	2
Theme 2. The product mix problem	Introduction to the Microsoft Office Excel add-in programs: Solver	2
Theme 3. Duality and post-optimal analysis	Duality and sensitivity analysis	2
Theme 4. Maths programming applications	The diet problem: solution with MS Office Solver	2
	The balanced and unbalanced transportation problem	2
Module 2. Stochastic models and methods		
Theme 5. Markov chains	Markov chains applications	2
	Analysis of absorbing states	2
Theme 6. The queuing theory	Queuing theory applications	2
Theme 7. The game theory	Game theory applications	2

Here are examples of laboratory study tasks within Theme 4 – Maths programming applications.

Example. There are four factories that supply cars to four customers. The transportation costs per car on the different routes are given below.

	Customer 1	Customer 2	Customer 3	Customer 4
Factory 1	1	4	7	3
Factory 2	5	3	5	3
Factory 3	2	6	7	4
Factory 4	6	5	5	4

The capacities of the four factories are 120, 240, 350 and 150 cars. The demands of the four customers are 240, 180, 200, 160 cars.

1. Form a maths model and determine the shipping schedule that will minimize the total transportation cost while satisfying all the supply and demand restrictions.

2. Solve the first model with additional restrictions: Customer 2 must receive precisely 50 cars from Factory 2 and Factory 3 must ship at least 60 cars to Customer 4. Compare the results.

3. Change the unit cost of shipping from Factory 1 to Customer 1 to include this route into the optimal shipping schedule of the first model. Argue your choice.

Example. You are to assign 5 tasks to 5 persons. The cost of performing a task is a function of the skills of the persons. The table summarizes the cost of the assignments.

Cost	Task 1	Task 2	Task 3	Task 4	Task 5
Person 1	140	224	280	467	242
Person 2	119	123	276	435	532
Person 3	357	216	55	636	561
Person 4	324	555	271	540	255
Person 5	560	524	354	346	345

Determine the optimal assignment that minimizes the total costs.

7. Self-study work of students

To succeed in studying the discipline it is necessary to conduct self-study work of students.

7.1. The list of questions for self-study

Module 1. Deterministic models and methods

Theme 1. What is operations research?

Operations Research origins.

Theme 2. The product Mix Problem

The iterative nature of the simplex method.
Computational details of the simplex algorithm.
Integer programming.

Theme 3. Duality and post-optimal analysis

Post-optimal analysis for LP economics applications.

Theme 4. Maths programming applications

Non-linear Diet models.
Computation algorithm for the transportation problem.
The transhipment problem.

Module 2. Stochastic models and methods

Theme 5. Markov chains

The addition law of probability.
The conditional law of probability.
Random variables and probability distributions.
Finite-stage Markov dynamic programming model.
Infinite-stage Markov dynamic programming model.

Theme 6. The queuing theory

The pure birth model.
The pure death model.
The generalized Poisson queuing model.
Queuing decision models.

Theme 7. The game theory

The equivalence of matrix games and linear programming models.
A solution to mixed strategy games.

7.2. Test questions for self-study

Module 1. Deterministic models and methods

Theme 1. What is operation research?

1. Who are the famous OR scientists?
2. What is the OR purpose?
3. What does the term "OR" mean?
4. What does the term "operation" mean?
5. What does the term "model" mean?
6. Name the core OR steps.
7. Give definitions of direct and inverse operations research problems.

Theme 2. The product mix problem

1. What are the decision variables of the product mix problem?
2. What is the objective variable of the product mix problem?
3. What are the constraints of the product mix problem?
4. Describe the mathematical model of the product mix problem.
5. What is an optimal solution?
6. Name the linear programming model basic properties.
7. Name the graphical procedure steps.
8. What does the term "a feasible region of the problem" mean?
9. What does the feasible region represent?
10. How is the direction of increase in the object function defined?

Theme 3. Duality and post-optimal analysis

1. What is the meaning of shadow price?
2. Name the rules of constructing a dual model.
3. Construct the dual model of the product mix problem and the diet problem.
4. Explain the economic interpretation of duality.

Theme 4. Maths programming applications

1. What are the decision variables of the diet problem?
2. What is the objective variable of the diet problem?
3. What is the meaning of constraints in the diet problem?
4. Describe the mathematical model of the diet problem.

5. What are the decision variables of the urban planning problem, the investment production planning problem, the inventory control problem, the blending and refining problem, the transportation problem, the assignment problem, the shortest pass problem?

6. What is the objective variable of the urban planning problem, the investment production planning problem, the inventory control problem, the blending and refining problem, the transportation problem, the assignment problem, the shortest pass problem?

7. What are the constraints of the urban planning problem, the investment production planning problem, the inventory control problem, the blending and refining problem, the transportation problem, the assignment problem, the shortest pass problem?

8. Describe the mathematical model of the urban planning problem, the investment production planning problem, the inventory control problem, the blending and refining problem, the transportation problem, the assignment problem, the shortest pass problem.

Module 2. Stochastic models and methods

Theme 5. Markov chains

1. What does a Markov chain mean?
2. What do absolute transition probabilities mean?
3. What do n-step transition probabilities mean?
4. Describe the classification of the states in a Markov chain.
5. What does absorbing state mean?

Theme 6. The queuing theory

1. Give examples of queuing systems.
2. Name the elements of a queuing model.
3. Describe exponential and Poisson distributions.

Theme 7. The game theory

1. Name the game theory basic concepts.
2. Describe the game model structure.
3. Describe the classification of games.
4. How can an optimal solution to two-person zero-sum games be determined?
5. How can a solution to mixed strategy games be determined?

8. Individual consulting work

Individual consulting work is a special kind of the learning activity which means coworking of the lecturer and students. The aim of this activity is to help students cope with new material given during lectures and self-study.

Individual consulting work is conducted in the following forms:

consultations are provided for students, demonstrating difficulties in the understanding of theoretical and applied questions;

assessment of individual tasks;

current monitoring of the study progress.

9. Methods of improving the process of study

To improve the process of study the following educational techniques are provided: problem lectures, small-group work, special computer programs (Table 5).

Table 5

The use of learning technologies to enhance the learning process

Theme	Practical usage of educational techniques
Theme 1. What is operations research?	A problem lecture including pros and cons assessment of the modelling in the decision-making process
Theme 2. The product mix problem	Small-group work devoted to identifying decision variables and objective variables according to the primary operation goal
Theme 3. Duality and post-optimal analysis	Small-group work devoted to sensitivity analysis for different linear models
Theme 4. Maths programming applications	A problem lecture devoted to the discussion of pros and cons of the linear approach in modelling
Theme 5. Markov chains	Small-group work devoted to stochastic modelling particularities
Theme 6. The queuing theory	A problem lecture devoted to the queuing theory applications in modern economy

A problem lecture aims to develop logical thinking of students. Such lecture consists of one or two topics which are not widely presented in literature. Students are offered to find their own solutions to the discussed problem, to argue and defend their choice.

Being a member of a small group gives an opportunity for each student to participate in solving the problem. Such activity helps to involve more students into the decision-making process.

10. Methods of control

The maximum number of points that may be achieved within the discipline equals 100.

Within the discipline the following activities have to be evaluated:

active work during lectures;

workshops activities;

individual home tasks;

modular tasks.

Every student may obtain 1 or 2 points during each lecture. The total value for all lectures equals 10 points. During workshop activities students are given some tasks according to the current theme.

A laboratory task example is represented below.

Example 1. We want to form a diet. The diet must contain four types of nutrients: A, B, C and D. These components can be found in two kinds of food: food 1 and food 2. The amount of every component in grams per kilogram of these foods is shown in Table 6.

Table 6

The initial data

Nutrients	The amount of every nutrient in grams per kilogram of food	
	food 1	food 2
A	5	2
B	4	9
C	2	8
D	10	3

Our diet must contain at least 86 grams of component A, 98 grams of component B, 110 grams of component C and 106 grams of component D.

Food 1 costs $33/kg and food 2 costs $42/kg. What quantities of foods must be purchased to minimize the total costs?

To cope with the task students should be able

to formulate a maths model of the problem;

to present the initial data on the Excel sheet;

to solve the model using Solver Add-in;

to interpret the results correctly.

The total number of workshops is seven. All workshops except the first one are evaluated at 6 points maximum. The first workshop is evaluated at 4 points maximum. The total value for all workshops equals 40 points.

Individual home tasks are given to stimulate self-study activity of students. Such tasks include several activities, which help students to develop the necessary abilities and skills according to the discipline competences. During the study period students are given two individual home tasks within each unit. Each individual home task is evaluated at maximum 10 points.

Two modular tasks are given to assess the level of knowledge, abilities and skills within each unit. They consist of several theoretical and practical tasks. Each modular task is evaluated at 10 points maximum.

A modular task example is given below.

Example 2. Preparing for the winter season, a clothing company is manufacturing parkas and goose down overcoats and gloves. All products are manufactured in four different departments: cutting, insulating, sewing, and packaging. The following table provides the initial for data to the situation.

Table 7

The initial data

Departments	Time requirements per unit of (hours)			Time available, hours
	Parka overcoat	Goose down overcoat	Pair of gloves	
cutting	5	3	8	480
insulating	2	6	3	398
sewing	5	8	4	439
packaging	5	7	7	187
profit per unit, UAN	608	1340	560	

1. Create an Excel file.

2. Suggest a primal model and a dual model (write down your answers on the paper sheet).

3. Solve the primal.

4. Form the answer report and the sensitivity report for the primal model.

5. Describe every figure in both reports.

6. Answer the following questions:

6.1. Do you recommend the available time of any of the four departments be increased or decreased?

6.2. Can the present unit contribution to the total profit as specified by the dual price be guaranteed if we increase the available time of each department by 10 %?

6.3. The present production schedule meets the needs of the company. However, because of the competition, the company may need to lower the profit of parka overcoats. What is the greatest reduction that can be effected without changing the present product mix?

6.4. Currently, goose down overcoats are not produced. By how much should the unit profit be increased to be included in the product mix?

The final mark is formed as a sum of all marks obtained during the study period. The discipline is passed if the final mark equals minimum 60 points.

11. Distribution of marks

The professional competences assessment system is presented in Table 8.

Table 8

The professional competences assessment system

Professional competences		Week	Hours		Forms of Study		Assessment of the competence level	
							Forms of assessment	Maximum mark
1		2	3		4		5	6
Module 1. Deterministic models and methods								
To perform a formalized maths description of the deterministic problem and find an optimal solution to it	The ability to determine the objective variable, decision variables and constraints of a socio-economic problem	1	lecture hall	2	**Lecture**	**Theme 1.** What is operations research?	Work during the lecture	1
				2	**Laboratory study**	Starting with Excel: pre-test of skills	Work during the workshop	4
			SSW	3	**Preparation for studies**	Literature survey according to the theme		

Table 8 (continuation)

1		2	3		4		5	6
						Fulfilment of theoretical and practical tasks		
	The ability to determine the objective variable, decision variables and constraints of a socio-economic problem	2	SSW	3	**Preparation for studies**	Literature survey according to the theme		
						Fulfilment of theoretical and practical tasks		
	The ability to solve a product mix problem	3	lecture hall	2	**Lecture**	**Theme 2.** The product mix problem	Work during the lecture	1
				2	**Laboratory study**	Introduction to the Microsoft Office Excel add-in programs: Solver	Work during the workshop	6
			SSW	3	**Preparation for studies**	Literature survey according to the theme		
						Fulfilment of theoretical and practical tasks		
	The ability to solve a product mix problem	4	SSW	3	**Preparation for studies**	Literature survey according to the theme		
						Fulfilment of theoretical and practical tasks		
	The ability to perform post-optimal analysis of results	5	lecture hall	2	**Lecture**	**Theme 3.** Duality and post-optimal analysis	Work during the lecture	1
				2	**Laboratory study**	Duality and sensitivity analysis	Work during the workshop	6

Table 8 (continuation)

1		2	3		4		5	6
			SSW	3	**Preparation for studies**	Literature survey according to the theme Fulfilment of theoretical and practical tasks		
	The ability to perform post-optimal analysis of results	6	SSW	3	**Preparation for studies**	Literature survey according to the theme Fulfilment of theoretical and practical tasks		
	The ability to perform post-optimal analysis of results	7	lecture hall	2	**Lecture**	**Theme 4.** Maths programming applications	Work during the lecture	1
				2	**Laboratory study**	A modular task	Assessment of the task	15
			SSW	3	**Preparation for studies**	Literature survey according to the theme Fulfilment of theoretical and practical tasks		
	The ability to solve a transportation problem	8	SSW	3	**Preparation for studies**	Literature survey according to the theme		
Unit 2. Stochastic models and methods								
To perform a formalized math description of the stochastic problem and find an optimal solution to it	The ability to solve a transportation problem	9	lecture hall	2	**Lecture**	**Theme 5.** Markov chains	Work during the lecture	1
				2	**Laboratory study**	The balanced and unbalanced transportation problem	Work during the workshop	6
						An individual home task	Assessment of the task	10
			SSW	3	**Preparation for studies**	Literature survey according to the theme		

Table 8 (continuation)

1		2	3		4		5	6
						Fulfilment of theoretical and practical tasks		
	The ability to make optimal decisions about socioeconomic processes that are defined as Markovian ones	10	SSW	3	**Preparation for studies**	Literature survey according to the theme		
						Fulfilment of theoretical and practical tasks		
	The ability to make optimal decisions about socioeconomic processes that are defined as Markovian ones	11	lecture hall	2	**Lecture**	**Theme 5.** Markov chains	Work during the lecture	1
				2	**Laboratory study**	Markov chain applications	Work during the workshop	6
			SSW	3	**Preparation for studies**	Literature survey according to the theme		
						Fulfilment of theoretical and practical tasks		
	The ability to make optimal decisions about socioeconomic processes that are defined as Markovian ones	12	SSW	3	**Preparation for studies**	Literature survey according to the theme		
						Fulfilment of theoretical and practical tasks		
	The ability to solve various tasks of complex socioeconomic system control in terms of risks and uncertainties	13	lecture hall	2	**Lecture**	**Theme 6.** The queuing theory	Work during the lecture	1
				2	**Laboratory study**	Analysis of absorbing states	Work during the workshop	6
			SSW	3	**Preparation for studies**	Literature survey according to the theme		
						Fulfilment of theoretical and practical tasks		
	The ability to make optimal decisions about socioeconomic processes that are defined as Markovian ones	14	SSW	3	**Preparation for studies**	Literature survey according to the theme		
						Fulfilment of theoretical and practical tasks		

Table 8 (the end)

1		2	3		4		5	6
	The ability to make queuing systems optimization	15	lecture hall	2	**Lecture**	**Theme 7.** The game theory	Work during the lecture	1
				2	**Laboratory study**	Queuing theory applications, Games theory applications	Work during the workshop	6
						An individual home task	Assessment of the task	10
			SSW	4	**Preparation for studies**	Literature survey according to the theme		
						Fulfilment of theoretical and practical tasks		
	The ability to solve various tasks of complex socio-economic system control in terms of risks and uncertainties	16	SSW	4	**Preparation for studies**	Fulfilment of theoretical and practical tasks		
	The ability to solve various tasks of complex socio-economic system control in terms of risks and uncertainties	17	lecture hall	2	**Lecture**	**Theme 7.** The game theory	Work during the lecture	2
				2	**Laboratory study**	A modular task	Assessment of the task	15
			SSW	4	**Preparation for studies**	Fulfilment of theoretical and practical tasks		
Total hours				**90**	**Final maximum mark**			**100**

The distribution of marks within separate weeks is presented in Table 9.

The distribution of marks within separate themes and modules is presented in Table 10.

Table 9

Distribution of marks within separate weeks

Type of Study Activity		Week																	Examination period	S
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18 – 20	
Total study time of students, hours per week																				
Lecture hall hours	Lectures	2		2		2		2		2		2		2		2		2		18
	Laboratory studies	2		2		2		2		2		2		2		2		2		18
	Consultations		c		c		c		c		c		c		c		c			
Lecture hall hours		4		4		4		4		4		4		4		4		4		36
SSW	Study of theoretical material	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		17
	Practical tasks	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3		37
Self-study work		3	3	3	3	3	3	3	3	3	3	3	3	3	3	4	4	4		54
Total hours		7	3	7	3	7	3	7	3	7	3	7	3	7	3	8	4	8		90
Accumulation of points within the discipline																				
Type of study activity		Week																	Examination period	S
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18 – 20	
Assessment timetable, points per week																				
Methods of assessment	Lectures	1		1		1		1		1		1		1		1		2		10
	Laboratory studies	4		6		6				6		6		6		6				40
	Tasks within themes									10						10				20
	Modular tasks							15										15		30
Total mark per week		5		7		7		16		17		7		7		17		17		100
Mark accumulation		5	5	12	12	19	19	35	35	52	52	59	59	66	66	83	83	100	100	

Table 10

Distribution of marks within separate themes

Theme	Lectures	Workshops	Individual home tasks	Modular control	Total
What is Operations Research?	1	4			5
The product mix problem	1	6			7
Duality and post-optimal analysis	1	6	10	15	32
Maths programming applications	1	6			7
Markov chains	2	12	10	15	39
The queuing theory	1	3			4
The game theory	3	3			6
	10	40	20	30	100

The final mark is converted into the grade on the ECTS scale (Table 11).

Table 11

The assessment scale

The score point scale used in KhNUE	The ECTS assessment scale	The national scale of assessment
90 – 100	A	excellent
82 – 89	B	good
74 – 81	C	
64 – 73	D	satisfactory
60 – 63	E	
35 – 59	FX	unsatisfactory
1 – 34	F	

12. Recommended literature

12.1. Main

1. Клебанова Т. С. Дослідження операцій : навчальний посібник / Т. С. Клебанова. – Харків : Вид. ХНЕУ, 2013. – 160 с.

2. Dantzig G. Linear Programming and Extensions / G. Dantzig. – Princeton : Princeton University Press, 1963. – 634 p.

3. Dantzig G. Linear programming. Vol. 1. Introduction / G. Dantzig, M. Thapa. – New-York : Springer, 1997. – 474 p.

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5. Miller H. R. Optimization: Foundations and Applications / H. R. Miller. – New-York : Wiley-Interscience, 1999. – 676 p.

6. Taha H. A. Operations Research: An Introduction / H. A. Taha. – Chicago : Prentice Hall, 2006. – 838 p.

7. Williams H. P. Model Building in Mathematical Programming / H. P. Williams. – Wiley, 2013. – 432 p.

12.2. Additional

8. Исследование операций. В 2-х томах. Т. 1 / под ред. Дж. Моудера, С. Элмаграби. – Москва : Мир, 1981. – 712 с.

9. Моделирование экономики : учебное пособие / Т. С. Клебанова, В. А. Забродский, О. Ю. Полякова. – Харьков : ХГЭУ, 2001. – 140 с.

10. Рамазанов С. К. Математичні моделі в менеджменті та маркетингу : навчальний посібник / С. К. Рамазанов. – Луганськ : СПД Резніков В. С., 2010. – 311 с.

11. Рогоза М. Є. Нелінійні моделі та аналіз складних систем : навчальний посібник. В 2 ч. Ч. 1 / М. Є. Рогоза, С. К. Рамазанов, Е. К. Мусаєва. – Полтава : РВВ ПУЕТ, 2011. – 300 с.

12. Шикин Е. В. Исследование операций : учебник / Е. В. Шикин, Г. Е. Шикина. – Москва : ТК Велби, Изд-во Проспект, 2006. – 280 с.

12.3. Information resources

13. Institute for Operations Research and the Management Sciences [Electronic resource]. – Access mode : https://www.informs.org.

Appendices

Appendix A
Table A.1

The structure of the academic discipline competence components

Competence elements formed within the theme	Minimum experience	Knowledge	Abilities	Communication	Autonomy and responsibility
1	2	3	4	5	6
Theme 1. What is Operations Research?					
The ability to determine the objective variable, decision variables and constraints of a socioeconomic problem	Definition of the following terms: operation, system, objective variable, decision variables, constraints, model	Core operations research steps, rules for determining objective variable and decision variables	Qualitative description and analysis of different complex socioeconomic operations, transition to the formalized maths description in the form of a model	The ability to present quantitative analysis results, to effectively form a communication strategy	Responsibility for validity of the results
Theme 2. The product mix problem					
The ability to solve a product mix problem	The product mix problem structure	Core steps of a linear product mix model solution	The ability to correctly define decision variables and the objective variable of the model, to solve the model, to interpret the results	The ability to present analysis results, to effectively form a communication strategy	The ability to make decisions about the product mix problem, to be in charge of the decision-making process

Appendix A (the end)
Table A.1 (the end)

1	2	3	4	5	6
Theme 3. Duality and post-optimal analysis					
The ability to perform post-optimal analysis of results	Rules of transition from primal to dual	The dual modal structure	Economic interpretation of duality	The ability to present post-optimal analysis results	Validity of economic decisions made on the post-optimal analysis basis
Theme 4. Maths programming applications					
The ability to solve a transportation problem	The transportation problem structure	Rules of transition from an unbalanced to balanced model	Economic interpretation of a dummy source and dummy destination	The ability to present an optimal transportation strategy	Validity of economic decisions made on the transportation model basis
Theme 5. Markov chains					
The ability to make optimal decisions about socio-economic processes that are defined as Markovian ones	The state of a system, absolute probability, transition probability	Classification of Markov processes, core Markov models	The ability to describe complex socio-economic processes in terms of the Markov theory	The ability to present results of analysis	Responsibility for implementation of the modelling results
Theme 6. The queuing theory					
The ability to optimize queuing systems	Basic queuing theory terms and concepts	Ways of estimation of core objective variables	The ability to optimize core objective variables of queuing systems	The ability to present results of analysis	The ability to be responsible for implementation of modelling results
Theme 7. The game theory					
The ability to solve various tasks of complex socio-economic system control in terms of risks and uncertainties	Basic game theory terms and concepts	The game model structure. Classification of games	The ability to find optimal solution to two-person zero-sum games, to find a solution to mixed strategy games	The ability to present results of analysis	The ability to be in charge of the decision-making process

Contents

НАВЧАЛЬНЕ ВИДАННЯ

Робоча програма
навчальної дисципліни
"МАТЕМАТИЧНЕ МОДЕЛЮВАННЯ В ЕКОНОМІЦІ ТА МЕНЕДЖМЕНТІ: ДОСЛІДЖЕННЯ ОПЕРАЦІЙ"
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Подано зміст навчальної дисципліни за модулями та темами, плани лекційних та лабораторних занять, питання для самостійного опрацювання, контрольні запитання для самодіагностики. Наведено список рекомендованої літератури.

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