МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
ХАРКІВСЬКИЙ НАЦІОНАЛЬНИЙ ЕКОНОМІЧНИЙ УНІВЕРСИТЕТ
ІМЕНІ СЕМЕНА КУЗНЕЦЯ

ЗАТВЕРДЖЕНО
на засіданні кафедри
економічної кібернетики і системного аналізу
Протокол № 1 від 2 вересня 2024 р.

ПОГОДЖЕНО
Проректор з навчально-методичної роботи

Каріна НЕМАШКАЛО

ДОСЛІДЖЕННЯ ОПЕРАЦІЙ І МЕТОДИ ОПТИМІЗАЦІЇ

робоча програма навчальної дисципліни (РПНД)

Галузь знань **07 «Управління та адміністрування»**
Спеціальність **075 «Маркетинг»**
Освітній рівень **перший (бакалаврський)**
Освітня програма **Маркетинг**

Статус дисципліни **обов'язкова**
Мова навчання, навчання та оцінювання **англійська**

Розробник(и):

к.е.н., доц _____ Світлана ПРОКОПОВИЧ

к.т.н., доц. _____ Ольга ТЮТЮНИК

Завідувач кафедри
економічної кібернетики
і системного аналізу _____ Тетяна ШАБЕЛЬНИК

Гарант програми _____ Олена НЕБИЛИЦЯ

Харків
2024

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
SIMON KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS

APPROVED
at the meeting of the Department
of Economic Cybernetics and
System Analysis
Protocol № 1 of 2 September 2024

ACCREED
Vice-rector for educational and methodical work

Karina NEMASHKALO

OPERATIONS RESEARCH AND OPTIMIZATION METHODS

Program of the course

Field of knowledge	**07 Management and Administration**
Specialty	**075 «Marketing»**
Study cycle	**first (bachelor)**
Study programme	**Marketing**

Course status	**mandatory**
Language	**English**

Developers:
PhD (Economics),
Associate Professor — Svitlana PROKOPOVYCH

PhD (Technical),
Associate Professor. — Olha TIUTIUNYK

Head of Department of Economic
Cybernetics
and System Analysis — Tetiana SHABELNYK

Head
of Study Programme — Olena NEBYLYTSIA

Kharkiv
2024

INTRODUCTION

The relevance of the course and its necessity and role in the training of specialists. Modern business and production processes are characterized by a large number of variables, complex relationships and significant limitations. Operations research allows you to find optimal solutions for complex tasks, such as resource allocation, logistics, project management and production processes. Optimization methods help companies reduce costs, increase productivity and use resources efficiently, which is critically important in conditions of competition and limited resources. Thus, the course “Operations Research and Optimization Methods” is an integral part of modern education and practice, contributing to solving current problems of business, economics, and technology.

The study program for the mandatory course “Operations Research and Optimization Methods” is compiled in accordance with the educational and professional program for bachelor's training in the specialty 075 “Marketing” of the study programme “Marketing”.

The object of the course is systems, processes, and phenomena related to decision-making in complex conditions, optimal use of resources, and achievement of set goals.

The subject of study of the course is a set of methods for developing and implementing optimal solutions in conditions of limited resources.

The purpose of teaching the course is to form a system of theoretical knowledge and master the skill of mathematically formulating an extreme problem and studying the conditions and possibilities of applying methods for solving such problems in real conditions.

The main objectives of studying the course are to master the basic concepts of optimization theory, master practical decision-making skills in the process of planning economic activity under conditions of limited resources through the use of optimization methods, algorithms, and software tools.

The learning outcomes and competencies formed by the course are defined in table 1.

Table 1

Learning outcomes and competencies formed by the course

Learning outcomes	Competencies
LO6	GC3
LO8, LO12	GC4
LO2, LO4	GC8
LO12	GC11

where LO2. Analyze and forecast market phenomena and processes based on the application of fundamental principles, theoretical knowledge and applied skills in implementing marketing activities;
LO4. Collect and analyze the necessary information, calculate economic and marketing indicators, justify management decisions based on the use of the necessary analytical and methodological tools.
LO6. Identify the functional areas of marketing activities of a market entity and their relationships in the management system, calculate the relevant indicators that characterize the effectiveness of such activities.
LO8. Apply innovative approaches to conducting marketing activities of a market entity, flexibly adapt to changes in the marketing environment.
LO12. Demonstrate skills in independent work, flexible thinking, openness to new knowledge, and be critical and self-critical.
GC3. Ability for abstract thinking, analysis and synthesis.
GC4. Ability to learn and master modern knowledge.
GC8. Ability to conduct research at an appropriate level.
GC11. Ability to work in a team.

COURSE CONTENT

Content module 1
Methodological foundations of operations research

Topic 1. Operations research as a scientific approach to the analysis of economic objects and processes.

1.1. History of the formation of operations research (OR) as a science. Object, subject, goal and objectives of operations research. Sections of operations research.

Prominent scientists in the history of the formation of the science of operations research. Scientific societies, scientific publications on operations research. Purpose, object, subject, tasks of operations research. Sections of operations research.

1.2. Direct and inverse operations research problems.

Definition of direct and inverse problems. Formulation of questions answered by direct and inverse problems. General statement of the problem of operations research in deterministic and non-deterministic cases. Deterministic problem, problem under risk conditions, problem under uncertainty conditions.

1.3. Basic concepts of operations research.

The concept of an operation, an operating party, an external environment. The concept of an operation goal. The concept of an operation efficiency. An indicator of an operation efficiency. A structural diagram of an operation. Examples of economic operations.

1.4. Stages of operations research.

Defining goals. Forming a project development plan. Formulating the problem. Building a model. Choosing or developing a method. Verifying and adjusting the model. Implementing results.

1.5. Basic concepts and classification of optimization problems.

Basic concepts of optimization modeling. Classification of optimization problems. Separate classes of mathematical programming problems.

1.6. Basic types of optimization problems.

Main types of optimization problems. General formulation of the optimization problem. The problem of optimal use of raw materials. The problem of mixing (ration). The problem of optimal equipment loading. The problem of cutting.

Topic 2. General linear programming problem and some of the solution methods

2.1. Formulation of a linear programming problem. Basic concepts.

The concept of linear programming. General, standard and canonical linear programming (LP) problems. Equivalence of LPP forms. Reduction of linear programming problems to standard form. Additional variables.

2.2. Properties of the basic linear programming problem.

The concept of a support and optimal plan, basis, basic solution, degenerate and non-degenerate plan. Theorems on the set of plans of the basic LPP. The relationship of the properties of LPP with the properties of convex sets.

2.3. Graphical method for solving linear programming problems.

Graphical method of solving a linear problem. The concept of a polyhedron and a polygon of solutions, a gradient, a level line. Examples of regions of admissible solutions. Algorithm for finding the optimal plan of a linear problem based on its geometric interpretation.

2.4. Simplex method.

Theorems on the optimality of the reference plan. The general concept of the simplex method and its steps. The simplex algorithm and its stages. The simplex table.

2.5. Artificial basis method.

Extended problem. Artificial variables. Artificial plan. Theorem on the optimality of the plan of the extended problem. Algorithm of the artificial basis method.

Topic 3. Duality theory and analysis of linear models of optimization problems

3.1. Formulation of a dual problem.

Basic concepts: dual problem, dual pair. Rules for constructing a dual problem. Asymmetric and symmetric dual problems. Properties of a pair of dual problems. Duality theorems. Economic interpretation of dual problems. Example of finding the optimal plan of a dual problem based on the solution of a direct problem.

3.2. Stability analysis of dual estimates.

Stability analysis of dual estimates.

3.3. Dual simplex method.

The concept of a pseudoplane of a direct problem. Theorems (criteria for optimality of a pseudoplane). Algorithm of the dual simplex method.

Content module 2.
Separate linear and nonlinear optimization methods

Topic 4. Transport problem. Statement, methods of solution and analysis

4.1. Mathematical model of the transport problem.

Formulation of the transport problem (TP) and its mathematical model. Open and closed TP models. Conversion of an open model into a closed one. Reference plan of the transport problem.

4.2. Methods for constructing initial reference plans. The method of potentials.

Northwest corner method. Minimum cost method. Double advantage method. Degeneracy condition of the transport problem plan.

The essence of the potential method. Potentiality condition. Optimality criterion of the solution. Algorithm for solving the transport problem using the potential method.

4.3. Modifications of the transportation problem.

Finding the optimal plan for a transportation problem with complications in formulation. Finding a solution to some economic problems that are reduced to a transportation problem.

Topic 5. Integer programming

5.1. Formulation of an integer programming problem.

Formulation of an integer programming problem. Economic and geometric interpretation of an integer programming problem. Examples of economic integer programming problems.

5.2. Methods for solving integer programming problems.

Gomori method. Compilation of additional constraints and their geometric meaning. Disadvantages of the Gomori method.

Topic 6. Parametric programming problems

6.1. Parametric programming problem statement.

Mathematical formulation of the parametric programming problem. Economic and geometric interpretation of the parametric programming problem.

6.2. Methods for solving parametric programming problems.

Methods for solving parametric programming problems. Solving a problem whose objective function has a parameter. Solving a problem whose right-hand sides have a parameter.

Topic 7. Nonlinear optimization models of economic systems

7.1. Formulation of a nonlinear programming problem.

Formulation of a nonlinear programming problem. Economic and geometric interpretation of nonlinear programming problems.

7.2. Methods for solving nonlinear programming problems.

Unconditional optimization. Numerical optimization methods. Problems with constraints on variables. Lagrange multiplier method.

7.3. Convex programming problems.

Convex programming problem statement. Examples of convex programming problems. Quadratic programming. Kuhn-Tucker theorem. Quadratic form. Algorithm for finding a solution to a quadratic programming problem.

7.4. Gradient methods for finding solutions.

Gradient methods for finding solutions to nonlinear programming problems: Frank-Wolf, penalty functions, Arrow-Hurwitz.

7.5. Separable programming problems.

Statement of the separable programming problem. Piecewise linear approximation method.

Topic 8. Elements of game theory

8.1. The subject of game theory, basic concepts.

Conflict situations. The concept of a game. Player strategy. Pair game. Zero-sum game. Payoff matrix. Maximin and minimax strategies. Lower price of the game. Upper price of the game. Saddle point games. Mixed strategies.

8.2. Reducing a matrix game to a linear programming task.

Reduction of the matrix game to the task of linear programming.

8.3. Games with nature.

Games with nature. Decision-making problem under risk. Decision-making problem under uncertainty. Wald criterion. Hurwitz criterion. Savage criterion. Bayes criterion.

The list of practical studies in the course is given in table 2.

Table 2

The list of practical studies

Title of the topic and/or task	Content
Topic 1.	Solving practical tasks related to the mathematical formulation of optimization problems
Topic 2.	Solving practical tasks on finding the optimal plan of a linear system using the graphical method Solving practical tasks on finding the optimal plan of a linear system using the simplex method
Topic 3.	Solving practical tasks regarding the determination of dual estimates, solving linear programming problems by the dual simplex method
Topic 4.	Solving practical tasks related to finding the optimal transportation plan, solving a transportation tasks with a complicated formulation
Topic 5.	Solving practical tasks regarding the mathematical formulation and finding the optimal plan of integer programming problems
Topic 7.	Solving practical problems regarding the mathematical formulation and finding the optimal plan for individual nonlinear programming problems

The list of laboratory studies in the course is given in table 3.

Table 3

The list of laboratory studies

Title of the topic and/or task	Content
Topic 2.	Performing laboratory work on solving linear programming task graphically in the GLP application. Finding the optimal production plan
Topic 3.	Solving practical problems on finding the optimal plan for a direct and dual linear programming task. Finding the optimal solution to a dual problem, and investigating the stability of the resulting solution
Topic 4.	Finding the optimal transportation plan.
Topic 5.	Finding the optimal investment plan for the development of industry enterprises
Topic 7.	Finding the optimal plan and analyzing the stability of solutions to individual nonlinear programming problems

The list of self-studies in the course is given in table 4.

Table 4

List of self-studies

Title of the topic and/or task	Content
Topic 1.	Search, selection and review of literary sources on a given topic. Solving practical problems on the mathematical formulation of optimization tasks
Topic 2.	Search, selection and review of literary sources on a given topic. Solving practical problems on finding the optimal plan for a linear programming task using the graphical method. Solving practical problems on finding the optimal plan for a linear programming task using the simplex method
Topic 3.	Search, selection and review of literary sources on a given topic. Solving practical problems on finding the optimal plan for a direct and dual linear programming task. Finding the optimal solution to a dual problem, and studying the stability of the obtained solution
Topic 4.	Search, selection and review of literary sources on a given topic. Solving practical problems regarding the search for an optimal transportation plan, solving a transport problem with a complicated formulation
Topic 5.	Search, selection and review of literary sources on a given topic. Solving practical problems on mathematical formulation and finding the optimal plan of integer programming problems
Topic 6.	Search, selection and review of literary sources on a given topic
Topic 7.	Search, selection and review of literary sources on a given topic. Solving practical problems on finding the optimal plan of nonlinear optimization problems using various methods.
Topic 8.	Search, selection and review of literary sources on a given topic

The number of hours of lectures, practical, laboratory studies and hours of self-study is given in the technological card of the course.

TEACHING METHODS

In the process of teaching the course, in order to acquire certain learning outcomes, to activate the educational process, it is envisaged to use such teaching methods as::

Verbal (lecture (Topics 1-8), mini-lecture (Topic 3)).

Visual (presentations and cans of visual accompaniment (Topics 1-8)).

Practical (practical work (Topics 1-5, 7), laboratory work (Topics 2-5, 7), work in small groups (Topics 1, 2, 4, 7)).

FORMS AND METHODS OF ASSESSMENT

The University uses a 100-point cumulative system for assessing the learning outcomes of students.

Current control is carried out during lectures, practical, laboratory classes and is aimed at checking the level of preparedness of the student to perform specific work and is assessed by the sum of the points scored:

− for disciplines with a semester examination (exam): the maximum amount is 60 points; the minimum amount that allows a student to take the exam (exam) is 35 points.

Final control includes semester control and certification of the student.

Semester control is carried out in the form of a semester exam (exam). The semester exam (exam) is taken during the examination session**.**

The maximum score that a student can receive during an exam is 40 points. The minimum score at which an exam is considered passed is 25 points.

The final grade in the course is determined by summing the points for the current and final control.

The following control measures are used during the teaching of the course:

defense of individual calculation tasks (28 points);

conducting current testing (18 points);

colloquiums (14 points).

Semester control: Exam (40 points).

More detailed information on the assessment system is provided in technological card of the course.

Example of an examination card and assessment criteria for a course with a semester examination form (exam).

An example of an examination card

SIMON KUZNETS KHARKIV NATIONAL UNIVERSITY OF ECONOMICS
Study cycle Bachelor
Semester __
Specialty 075 «Marketing»
Course «Operations Research and Optimization Methods»
Examination card №1

Task 1

The goal is to assess the student's cognitive knowledge of the course, which allows determining the level of mastery of the educational material.

Single and multiple choice test questions "Exam tests" are located in the root directory of the course "Operations Research and Optimization Methods" on the website of the distance learning system https://pns.hneu.edu.ua/

Task 2

The goal is to assess the student's ability to apply the acquired knowledge in practice to solve a wide class of problems of managing various socio-economic objects (processes).

The meat processing plant has four plants, each of which can produce three types of sausage products. The capacities of each plant, the daily needs for sausage products, and the cost of 1 ton of each type of product are given below.

Input data

Plant	Types of sausage products			Capacity, t/day
	B_1	B_2	B_3	
A_1	1	3	4	40
A_2	2	1	8	25
A_3	8	3	6	30
A_4	4	2	1	25
Needs, tons	45	50	35	

Find such a distribution of sausage production between factories that minimizes the total cost (in US dollars). How will the optimal plan change if it becomes known that the demand for the second and third types of sausages must be satisfied in full?

Task 3

The goal is to assess the student's creative thinking, his ability to integrate the acquired knowledge to select and apply optimization methods and models for assessing, analyzing and planning socio-economic processes.

The company specializes in the production of furniture for residential premises. It can produce two types of furniture sets “Oksana” and “Stella”, which requires different labor costs at each stage of production. The initial data is given below.

Input data

Production site	Work volume (person-hours) for 1 furniture set type:		Time reserve (person-hours)
	«Oksana»	«Stella»	
Sawmill	3	2	190
Assembly shop	2	3	160
Finishing shop	0,5	0,1	100

Revenue from the sale of 1 furniture set (UAH)	8000	9000	
Production cost of 1 furniture set (UAH)	7250	8120	

It is necessary to draw up a weekly plan for the production of furniture sets in order to maximize total profit, as well as to formulate a dual problem and determine its optimal plan. Draw economic conclusions.

Approved at the meeting of the department Economic Cybernetics and Systems Analysis.
Protocol №__ of _____ .

Head of the Department_____ / Tetiana SHABELNYK

Examiner _____/ Svitlana PROKOPOVYCH

Assessment criteria

The examination card includes one stereotyped, one diagnostic and one heuristic task, which are assessed in accordance with the Temporary Regulation "On the procedure for assessing students learning outcomes using the cumulative point-rating system" of the S. Kuznets KhNEU.

The first task is aimed at assessing the student's cognitive knowledge in the course, which allows determining the level of mastery of the educational material. The maximum number of points is 10. The following criterion is used for evaluation:

$$Number\ of\ points = \frac{percentage\ of\ correct\ answers \cdot 10}{100\%}.$$

The second task makes it possible to determine the student's ability to apply the acquired knowledge in practice to solve a wide class of problems of managing various socio-economic objects (processes). The following criteria are used when assessing this task:

15 points – for a completely correctly solved task, with full justification of the conclusions obtained and the student's explanations;

12 – 14 points – in the presence of a correctly solved task, with insufficiently complete justification of the conclusions obtained and the submission of explanations by the student;

9 – 11 points – if there is a correct solution, but in the absence of its justification and explanation;

5 – 8 points – if the task is partially solved, i.e. there are no final conclusions or a technical error was made during the solution;

1 – 4 points – in case the student has demonstrated only knowledge of the general course of the solution or the basic relationships of the proposed model;

0 points – if the task is not solved.

The third task is aimed at identifying the student's creativity of thinking, his ability to integrate the acquired knowledge to select and apply optimization methods

and models for the purpose of assessing, analyzing and planning socio-economic processes. The following criteria are used when assessing this task:

15 points the student receives for a completely clear and logically consistently solved task, with a full justification of the chosen course of solution and the conclusions obtained, a meaningful economic interpretation of the obtained results and the formed management decisions.

13 – 14 points – the student receives for a completely logically and consistently solved task, with insufficiently complete justification of the chosen solution and the conclusions obtained;

10 – 12 points – if the task is not fully solved, the economic justification is not complete, the conclusions are not complete;

7 – 9 points – if the research of the proposed model was not complete and there is no justification or clear logical conclusions are not drawn;

4 – 6 points – if a logical error was made during the research that affected the course of the solution and the final findings;

1 – 3 points – if the student was only able to suggest some solution, but was unable to conduct a model study or had only just begun such a study;

0 points – in case the task is not completely solved.

The points obtained are rounded according to general rounding rules.

RECOMMENDED LITERATURE

Main

1. Taha, H. A. (2016). Operations research: An introduction. Pearson Education. – [Electronic resource] – Access mode : https://zalamsyah.staff.unja.ac.id/wp-content/uploads/sites/286/2019/11/9-Operations-Research-An-Introduction-10th-Ed.-Hamdy-A-Taha.pdf
2. Kyprianou, A. E. (2013). Optimisation methods of operational research. – [Electronic resource] . – Access mode : https://people.bath.ac.uk/ak257/87/MA30087.pdf
3. Григорків В.С. Оптимізаційні методи та моделі : підручник / В.С. Григорків, М.В. Григорків, О.І. Ярошенко. – Чернівці : Чернівецький нац. ун-т, 2022. – 440 с.
4. Дослідження операцій в економіці : підручник / О. І. Черняк та ін. ; ред. О. І. Черняк. Миколаїв : МНАУ, 2020. 398 с.
5. Малкіна В. М. Дослідження операцій: навчальний посібник / В. М. Малкіна, О. Г. Зінов'єва, М.Ю. Мірошниченко. – Мелітополь: Люкс, 2020. – 201 с.
6. Методи оптимізації та дослідження операцій [Текст] : навчальний посібник / Укладачі: Я. Б. Сікора, А.Й. Щехорський, Б.Л. Якимчук. – Житомир: Вид-во ЖДУ ім. Івана Франка, 2019. – 148 с.
7. Методи оптимізації та дослідження операцій: навчальний посібник / О. О. Ємець. - Полтава : ПУЕТ, 2019. - Ч. 2. - 139 с. – [Електронний ресурс] . – Режим доступу : http://dspace.puet.edu.ua/handle/123456789/8599 .

8. Оптимізаційні методи та моделі : навчальний посібник /. Н. В. Бурєннікова, О. В. Зелінська, І. М. Ушкаленко, Ю. Ю. Бурєнніков. – Вінниця : ВНТУ, 2019. - 122 с.

Additional

9. Дослідження операцій та методи оптимізації. Методичні рекомендації до лабораторних робіт для студентів усіх спеціальностей першого (бакалаврського) рівня [Електронний ресурс] / укл. С. В. Прокопович, О. В. Панасенко, Л. О. Чаговець [та ін.]; Харківський національний економічний університет ім. С. Кузнеця. - Електрон. текстові дан. (10,2 МБ). – Харків : ХНЕУ ім. С. Кузнеця, 2019. - 61 с. - Загол. з титул. екрану. Режим доступу : http://repository.hneu.edu.ua/handle/123456789/21820

10. Дослідження операцій та методи оптимізації. Методичні рекомендації до практичних завдань для студентів усіх спеціальностей першого (бакалаврського) рівня [Електронний ресурс] / укл. С.В. Прокопович, О.В. Панасенко, Л.О. Чаговець; Харківський національний економічний університет ім. С. Кузнеця. - Електрон. текстові дан. (373 КБ). - Х. : ХНЕУ ім. С. Кузнеця, 2019. - 63 с. - Загол. з титул. екрану. Режим доступу : http://repository.hneu.edu.ua/handle/123456789/21045

11. Дослідження операцій: навчальний посібник для студентів напряму підготовки 6.030502 «Економічна кібернетика» всіх форм навчання / Т. С. Клебанова, О. Ю. Полякова, Н. Л. Чернова, Л. О. Чаговець, О. В. Панасенко. – Харків : Вид. ХНЕУ, 2013. – 192 с.

12. Кутова О. Загальна постановка завдань оптимізації технологічних параметрів у фармацевтичних дослідженнях / Кутова О., Сагайдак-Нікітюк Р., Кутовий Д. // Norwegian Journal of Development of the International Science. 2021. №62-1. – С. 37-40.

13. Математичне моделювання процесів і систем [Електронний ресурс] : Навч. посіб. / А. І. Жученко, Л. Р. Ладієва, М. С. Піргач, Я. Ю. Жураковський. – Київ : КПІ ім. Ігоря Сікорського, 2021. – 351 с.Математичне програмування : метод. реком. з вивч. дисципліни та виконання контрольних робіт здобувачами вищої освіти / О. В. Шебаніна та ін. Миколаїв : МНАУ, 2020. 132 с.

14. Оптимізаційні методи та моделі в підприємницькій діяльності: Навчальний посібник. / Л.О. Волонтир, Н.А. Потапова, І.М. Ушкаленко, І.А. Чіков., Вінницький національний аграрний університет. – Вінниця: ВНАУ, 2020 – 404 с.

15. Осипенко С.М. Обґрунтування цін на продукцію підприємства на основі оптимізаційних моделей / Осипенко С.М., Романчик Т. В., Писаревський С. В. // Бізнес Інформ. 2020. №6 (509). – С. 145-151.

16. Fomenko D., Kostenko V. Optimization increase of the rotors in gas pumping machines with the simplex method // The Scientific Heritage. 2019. №39-1 (39). – С. 58-62.

17. Modern Optimization Methods for Science, Engineering and Technology/ Edited by G R Sinha Myanmar Institute of Information Technology Mandalay, Myanmar/ IOP Publishing, Bristol, UK, 2020. – 433 p.

Information resources

18. ACML 2020 Tutorial: Optimization Methods for Machine Learning. - http://www.acsu.buffalo.edu/~haimonti/tutorial.html