

Operations Research

COURSE SYLLABUS

Code and name of specialty	122 Computer Sciences	Institute	Faculty of Computer Sciences and Software Engineering
Program name	"Computer Sciences and Intelligent Systems"	Department	Software Engineering and Management Information Technologies
Type of program	Educational and Professional	Language of teaching	Ukrainian

LECTURER

Lysytskyi Vasyl Lavrentiyovych

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Candidate of Technical Science, Associate Professor, Associate Professor of Software Engineering and Management Information Technology. Has prepared and published more than 223 publications Main lecturer of the courses: Operations Research (bachelors) (in Ukrainian); Discrete mathematics (bachelors) (in Ukrainian); System analysis (bachelors) (in Ukrainian); Modern management theory (bachelors) (in Ukrainian); Methods, models of modern business systems management (masters) (in Ukrainian); Strategic analysis (masters) (in Ukrainian).

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Doctor of Technical Sciences, Associate Professor, Professor of Software Engineering and Management Information Technologies Department. Number of scientific and educational publications – 90. (h-index = 5, i10-index = 1 in Google Scholar - https://scholar.google.com/citations?hl=en&user=ZEe2GlcAAAAJ&view_op=list_works&sortby=title; ORCID ID-<https://orcid.org/0000-0003-2938-4215>, Scopus ID-57203114988).

Leading lecturer of the courses: *Object-Oriented Programming (Bachelors) (Ukrainian), Numerical Methods (Bachelors) (Ukrainian), Operations Research (Bachelors) (Ukrainian), Intelligent Control Systems (Bachelors), Distributed Computing Models and Software (PhD) (Ukrainian)*

GENERAL DESCRIPTION OF THE COURSE

Summary

The course "OPERATION RESEARCH" (part 1)" is a discipline of the cycle of professional compulsory training in the specialty 122 -" Computer Science ". It is taught in the fifth semester in the amount of 180 hours (6 ECTS credits), including: lectures - 32 hours, laboratory classes - 32 hours, independent work - 116 hours The course provides two content modules: module1 "Theory and methods of operations research based on linear models", module 2 "Special tasks and methods of operations research".

The course involves the application of the methodology of systems analysis for the systematic study of deterministic models of operations, the acquisition of the ability to describe subject areas, apply the principles of a systematic approach to modeling and the study of operations of various natures.

The course teaches the concepts of operation, operation models, stages of its development, classification of economic and mathematical models and optimization methods.

In the process of studying the course students develop the ability to build a mathematical model of the problem of research operations, use modern analytical and computational apparatus of linear programming, find the optimal solution, adjust the model and solution based on new knowledge about the problem and operation, use modern software Operations Research.

The course "Operations Research (part 2)" is a course in the cycle of professional compulsory training of the specialty 122 "Computer Science". It is taught in the sixth semester in the amount of 150 hours (5 ECTS credits), in particular: lectures – 16 hours, laboratory classes – 32 hours, independent work – 102 hours. There are no individual tasks. The study of the discipline ends with the exam.

The subject of the discipline is the technology and implementation of typical and modern operations research for calculating technical, physical and economic problems.

The scientific basis for studying the discipline is the general mathematical training of students and the content of the disciplines "Higher Mathematics", "Discrete Mathematics", "Algorithmization and Programming", "Numerical Methods", as well as the use of modern mathematical packages.

Course objectives

The course "Operations Research (part 1)" aims to train professionals who are able to: systems thinking, application of systems analysis methodology for operations research; to the implementation of a formalized description of the study of operations in organizational, technical and socio-economic systems for various purposes, to determine their optimal solutions; to the use of modern methods of mathematical modeling of operations, development of models and algorithms for numerical solution of problems of operations research; to the study of mathematical models of operations, justification of the choice of methods for solving problems of research of operations in the field of computer science.

The course "Operations Research (part 2)" aims to form a set of knowledge, skills in the field of operations research, methods of their optimization, and the acquisition of skills in the practical use, formulation and solution of optimization problems. They are the study of numerical methods of one-dimensional and multidimensional unconditional optimization, as well as methods of global search and genetic algorithms.

Types of classes and control

Lectures, laboratory workshops, independent work, consultations. Final assessment - exam.

Term

5, 6

Student workload (credits)/Type of course (mandatory/selective)	11 / Mandatory	Lectures (hours)	48	Laboratory Workshops (hours)	64	Self-study (hours)	218
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Program competences

GC1. Ability to abstract thinking, analysis and synthesis.

GC 2. Ability to apply knowledge in practical situations.

GC 3. Knowledge and understanding of the subject area and understanding of professional activity.

GC 6. Ability to learn and master modern knowledge.

SC 1. Ability to mathematically formulate and study continuous and discrete mathematical models, justify the choice of methods and approaches for solving theoretical and applied problems in the field of computer science, analysis and interpretation.

SC 3. Ability to think logically, build logical conclusions, use formal languages and models of algorithmic calculations, design, development and analysis of algorithms, evaluate their efficiency and complexity, solvability and insolvability of algorithmic problems for adequate modeling of subject areas and creation of software and information systems.

SC 4. Ability to use modern methods of mathematical modeling of objects, processes and phenomena, to develop models and algorithms for numerical solution of mathematical modeling problems, to take into account the errors of approximate numerical solution of professional problems.

SC 5. Ability to provide a formalized description of operations research tasks in organizational, technical and socio-economic systems for different purposes, determine their optimal solutions, build models of optimal management taking into account changes in the economic situation, optimize management processes in different systems and hierarchies.

SC 6. Ability to systems thinking, application of systems analysis methodology to study complex problems of different nature, methods of formalization and solution of system problems that have conflicting goals, uncertainties and risks.

Learning outcomes**Teaching and learning methods****Forms of assessment
(continuous assessment CAS, final assessment FAS)**

PLO2. Use a modern mathematical apparatus of continuous and discrete analysis, linear algebra, analytical geometry, in professional activities to solve problems of theoretical and applied nature in the design and implementation of informatization objects.

Interactive lectures with presentations, discussions, practical classes, teamwork, case method, method of feedback from students, problem-based learning

Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), express survey (CAS), final / semester control in the form of a semester exam, according to the schedule of the educational process (FAS)

PLO5. Design, develop and analyze algorithms for solving computational and logical problems, evaluate the efficiency and complexity of algorithms based on the use of formal models of algorithms and computational functions

Interactive lectures with presentations, discussions, practical classes, teamwork, case method, method of feedback from students, problem-based learning

Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), collection of data on individual assignments and reporting on research results (CAS), final / semester control in the form of a semester exam, according to the learning process schedule (FAS)

PLO6. Use methods of numerical differentiation and integration of functions, solution of ordinary differential and integral equations, features of numerical methods and possibilities of their adaptation to engineering problems, have skills of software implementation of numerical methods

Interactive lectures with presentations, discussions, practical classes, teamwork, case method, research, project training

Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), collection of data on individual assignments and reporting on research results (CAS), final / semester control in the form of a semester exam, according to the learning process schedule (FAS)

PLO7. Understand the principles of modelling organizational and technical systems and operations; use methods of operations research,

Interactive lectures with presentations, discussions, practical classes, teamwork, case method, research, project training

Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), collection of data on individual assignments and reporting on research results (CAS), final / semester control in the form of a

solve single- and multicriteria optimization problems of linear, integer, nonlinear, stochastic programming.		semester exam, according to the learning process schedule (FAS)
PLO8. Use the methodology of system analysis of objects, processes, and systems for the tasks of analysis, prediction, management, and design of dynamic processes in macroeconomic, technical, technological, and financial objects.	Interactive lectures with presentations, discussions, practical classes, teamwork, case method, research, project training	Written individual assignments for laboratory work (CAS), assessment of knowledge in laboratory classes (CAS), collection of data on individual assignments and reporting on research results (CAS), final / semester control in the form of a semester exam, according to the learning process schedule (FAS)

ASSESSMENT AND GRADING

Ranges of points corresponding to grades	core (points) for all types of learning activities	ECTS grading scale	The national grading scale	Allocation of grade points
	90-100	A	excellent	
	82-89	B	good	
	74-81	C		
	64-73	D	satisfactory	
	60-63	E		
	35-59	FX	Unsatisfactory (with the exam retake option)	
	0-34	F	Unsatisfactory (with mandatory repetition of the course)	

100% final assessment in the form of exam (30%) and intermediary assessment (70%).
30% exam: semester exam, according to the schedule of the educational process
70% intermediary assessment:

- 30% assessment of tasks in laboratory workshop;
- 30% intermediary assessment (2 test works)
- 10% calculation task

Course policy	Follow the rules of the internal regulations of the university. Take an active part in the learning process. Students are required to attend classes according to schedule and adhere to ethics of conduct. In the absence of students will need to complete all tasks to compensate for missed classes. Performing laboratory work requires prior preparation and advance processing of all necessary materials. Written assignments must be submitted by the deadline.
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COURSE STRUCTURE AND CONTENT

Part 1

Topic	Lectures	Laboratory Workshop	Self-study
Topic 1	Features of the implementation of the principles of system control in the process of tracking the operation.	Laboratory Workshop 1	Study of the principles of the system approach.
Topic 2	Examples of meaningful problems of operations research.	Laboratory Workshop 2-3	Study of meaningful tasks of operations research.
Topic 3	General properties of linear programming	Laboratory Workshop 4	Geometric interpretation of

Study of the principle of systematization, the principle of integration, the principle of three-level consideration and the principle of formalization.

Meaningful tasks of operations research: optimal planning of the range of products of the enterprise of the IT industry; optimal use of resources of the IT industry; optimal purchase of computer equipment by the enterprise of the IT industry; problems about a cheap diet, about a cheap diet of animals, about a cheap technological mix and others.

Study of technology for solving linear programming problems based on their geometric interpretation.

	problems.		linear programming problems	
Topic 4 Lecture 5	Analytical apparatus for linear programming	Laboratory Workshop 5	Properties of reference plans of a dual pair of linear programming problems.	Study of technology for solving linear programming problems on based on the theorem on the existence of a reference solution.
Topic 5 Lecture 6-7	Finite methods for solving linear programming problems.	Laboratory Workshop 6-7	The first and second algorithms of the method of sequential improvement of the plan.	Study of the technology of solving linear programming problems by the first and second algorithm of the method of sequential improvement plan.
Topic 6 Lectures 8-9	The problem of choosing the initial reference plan, methods of its solution.	Laboratory Workshop 8-9	The first and second algorithms of the M-method for solving linear programming problems	Study of modern software for solving linear programming problems.
Topic 7 Lecture 10	Modern computer program for linear programming.	Laboratory Workshop 10	Modern software for solving linear programming problems	Study of modern software for solving linear programming problems.
Topic 8 Lecture 11	Duality theory in linear programming.	Laboratory Workshop 11	Investigation of the properties of solutions of a dual pair of linear programming problems.	Study of the analytical apparatus of linear programming.
Topic 9 Lecture 12	Post-optimization analysis of operations research tasks.	Laboratory Workshop 12	Numerical experiments on post-optimization analysis of meaningful problems of operations research	Study of modern technologies of post-optimization analysis of operations research problems
Topic 10 Lecture 13	Research of operations with the use of transport tasks.	Laboratory Workshop 13	Modeling of operations by transport tasks.	Study of technologies for modeling operations with transport problems.

Topic 11 Lecture 14-15	Methods of solving transport problems.	Laboratory Workshop 14-15	Method of potentials for solving closed transport problems.		Study of technologies for solving closed transport problems.
Topic 12 Lecture 16	Methods of parametric programming	Laboratory Workshop 16	Research of stability of problems of research of operations		Study of technologies for studying the stability of linear programming problems.

PART 2

Lecture 1	The subject of optimization methods. The concept and definition of optimization theory. Examples of optimization problems. Classification of optimization methods.	Laboratory work 1-2	Development of general programs for one-dimensional search methods	Self-Study	Extremum of a function of one variable. Unimodal functions and their properties.
Lecture 2	One-dimensional search methods. Sven's method. Dichotomy method. The method of dividing a segment in half.	Laboratory work 3-4	Sven's method. Dichotomy method. The method of dividing a segment in half.		Uniform search method. Fibonacci method.
Lecture 3	One-dimensional search methods. The method of the golden ratio. Step adaptation method.	Laboratory work 5-6	The method of the golden ratio. Step adaptation method. Fibonacci method.		Methods of interpolation and approximation. Methods of quadratic and cubic interpolation
Lecture 4	Multidimensional search methods. First order methods. Cauchy method.	Laboratory work 7-8	Numerical finding of gradient and hessian. Cauchy method programming.		Hesse matrix. Properties of conjugate vectors
Lecture 5	Gradient methods. Methods of the connected direction. Fletcher-Reeves and Polak-Ribery methods.	Laboratory work 9-10	Fletcher-Reeves and Polak-Ribery method programming.		First order optimality condition. The condition of optimality of the second order.
Lecture 6	Newton's method. Quasi-Newtonian methods	Laboratory work 11-12	Second-order programming methods		Marquardt's method Rafson's method

Lecture 7	Direct search methods. Simplex method. Deformed polygon method	Laboratory work 13-14	Deformed polygon method programming	David-Fletcher-Powell method. Broyden-Goldfarb-Shanno method
Lecture 8	Basic theoretical positions. Weyl's method. Genetic algorithms.	Laboratory work 15-16	Програмування методу Вейля та генетичні алгоритми.	Particle swarm method Random search methods.

RECOMMENDED READING

Compulsory

1. Taha H., Lavrov, Ye.A., (2020) Introduction to Operations Research. Moscow: "Williams"
2. Perkhun, L.P., Shendrik V.V. (2017) Mathematical methods of additional operations. / Sumi, Sumy State University
3. Siniglazov, V.M., Zelenkov, O.A., (2018) Mathematical methods of optimization: Navch. posibn. Sh.I. Askerov, Nat. Aviation University, Kiev: Osvita Ukrainy.
4. Godlevsky M.D. Lisitsky, V.L., Stratienko. N.K. (2016) Operations research: problem solving and options for typical calculations: textbook Kharkiv: NTU "KhPI"
5. Lysytskiy V.L. (2006) Automation of operational research based on personal computers. Tutorial. Kharkov: NTU "KhPI"
6. Lisenko, O.I., Alekseeva. I. V.(2016) (Preliminary operations. Lecture notes. Kiev: NTUU "KPI"
7. Severin V.P., Nikulina O.M.(2013) Methods of one-dimensional search: on the course "Optimization methods". Kharkov. NTU "KhPI"
8. Severin V.P. (2012) Methods of one-dimensional search: ucheb.-method. manual for the course "Optimization Methods". Kharkov NTU "KhPI"
9. Severin V.P.(2012) Methods of multidimensional unconditional minimization of studies. allowance. Kharkov. NTU "KhPI"
10. Domnin I.F., Severin V.P., Nikulina E.N. (2014) Numerical methods of analysis and synthesis in radio electronics: textbook. Kharkov. NTU «KhPI»,
11. Andrunyk V.A., Vysotska V.A., Pasichnyk V.V., Chirun L.B., Chirun L.V. (2020) Numerical methods in computer science: textbook - Lviv: Publishing House "New World - 2000"
12. Siniglazov V.M., Zelenkov O.A., , Askerov Sh. I. (2018) Mathematical methods of optimization: textbook. manual Nat. Aviation University Kyiv: Education of Ukraine

Recommended

1. Garcia Marquez Fausto Pedro, Lew Benjamin. (2021) Introduction to internet of Things in Management science and operations research implented Retryeved from: studies. [http:// WWW.spinger.com](http://WWW.spinger.com)> book
2. Larionov Yu.T., Levikin V.M., Khazhmuratov P.V.(2005) Preliminary operations in information systems. Kharkiv. : Company "SMIT".
3. Luenberger. D.G. Linear and nonlinear programming. Retryeved from: [http:// WWW.link.springer.com](http://WWW.link.springer.com)> book 2021y
4. Gerald J. Libetman, Frederick S. Hillier.(2003) Operathions reseach. Retryeved from [http:// WWW.flipkard.com](http://WWW.flipkard.com).> introduct 2019
5. Zaychenko Yu.P. Preliminary operations. 6 - te vidannya Kiev .: Vidavnichy dim "Word".
6. Knowledge portal. Global intellectual resource Retryeved from: <http://statistica.ru/branches-maths/chislennyye-metody-resheniya-uravneniy>.
7. Bundy B. (1984) Optimization methods. Introductory course. – Edward Arnold, 1984.
8. Knowledge Portal. Global intellectual resource. Retryeved from: <http://statistica.ru/branches-maths/chislennyye-metody-resheniya-uravneniy>.
9. National open University Retryeved from: <http://www.intuit.ru/studies/courses>.
10. Wikiversity. Retryeved from: <https://ru.wikiversity.org/wiki>.
11. Retryeved from: <http://math.semestr.ru/optim/optim-examples.php>.
12. Himmelblau D.(1972) Applied nonlinear programming. McGraw-Hill,
13. Lysenko O.I., Tachinina O.M., Alekseeva I.V.(2017) Mathematical methods of modeling and optimization. Киев: НАУ.
14. Lazarev Y.F.(2013) Handbook of MATLAB / Electronic textbook for course and diploma design. Kiev: NTUU "KPI".

Academic integrity

Students are expected to adhere to the Code of Ethics of Academic Relations and Integrity” of NTU “KhPI”.

The content of this syllabus is consistent with the course program.