Ministry of Education and Science of Ukraine
Governmental Higher Educational Institution
«National Mining University»

Department of System Analysis and Management

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WORKING PROGRAM OF EDUCATIONAL DISCIPLINE
«Discrete Optimization Methods»
For magisters of specialty 124 "System Analysis"

Dnipro
NMU
2017

Program of educatoinal discipline "Methods of discrete optimization" for masters of specialty 124 "System analysis and management" / T.A. Zheldak, L.S. Koryashkina; National Mining University, system analysis and management. - D.: NMU, 2017. - 13 p.

Considered and approved by the methodical commission on the specialty 124 "System Analysis" on the submission of the department of system analysis and management

CONTENTS

INTRODUCTION

Programme results of the masters in system analysis are defined in the standard of higher education by specialty 124 System Analysis.

In the educational-professional program of the State Higher Educational Institution "NMU" [2.1] distribution of programme learning outcomes has been made according to the organizational forms of the educational process. The discipline "Methods of discrete optimization" includes the following competencies and learning outcomes:

FC1 Ability to develop and analyze mathematical models of natural, technogenic, economic and social objects and processes.

FC4 Ability to form new hypotheses and research tasks in the field of system analysis and decision-making, to choose the appropriate directions for their application.

FC5 Ability to formulate, analyze and synthesize when solving scientific problems at an abstract level.

PRN1 To know and be able to apply in practice methods of system analysis, methods of mathematical and information modeling for constructing and researching models of objects and processes of informatization.

PRN6 Know and be able to apply the methods of evolutionary modeling and genetic optimization methods, inductive modeling methods and mathematical apparatus of fuzzy logic, neural networks, game theory and distributed artificial intelligence, etc.

RNS2 Know and be able to implement highly loaded computing and data processing systems in systems analysis and management tasks, and decision support systems.

RNS3 Be able to build typical mathematical models of objects and processes of system analysis, to use mathematical methods and algorithms for data processing (statistical, algebraic, combinatorial, theoretical-informational, etc.).

In addition of described professional learning outcomes while studying the descipline, the master must master the following general learning outcomes:

3RN3 Be able to process, analyze, systematize scientific and technical information, generalize advanced domestic and foreign experience in system analysis.

ZRN5 Exercise curiosity, risk predisposition, thinking skills, inspiring by new ideas, incarnate them, ignite surrounding by them, combine and experiment

The purpose of discipline "Methods of discrete optimization" is to acquaint students with modern methods of creating control systems and to give students the skills to use the means of analysis and synthesis of such systems, to provide learning outcomes related to the analysis of dynamic systems in accordance with the educational-professional program.

Realization of the goal requires the transformation of the program results of studing into disciplinary, and the selection of the content of the study discipline according to this criterion.

Requirements for the structure of the work program of disciplines are given in [2.5].

1. FIELD OF USE

The work program is intended for:

• realization of a competent approach in shaping the structure and content of discipline;
• internal and external quality control of training specialists;
• accreditation of the educational program in the specialty.

The work program sets:

• scope and terms of teaching discipline;
• designation of physical quantities;
• disciplinary learning outcomes and their level of difficulty;
• Thematic plan and volume distribution according to the organizational forms of the educational process;
• Requirements for the structure and content of individual tasks;
• tasks for independent work of the applicant;
• generalized diagnostic tools, criteria and procedures for assessing the achievements of applicants;
• The composition of the educational and methodological support of the discipline.

2. NORMATIVE REFERENCES

The work program of the discipline is developed on the basis of the following normative documents:

2.1 Educational master program in specialty 124 "System Analysis" / Ministry of Education and Science of Ukraine, National Mining University of Ukraine. - D.: NMU, 2017. - 23 p.

2.2 Resolution of the Cabinet of Ministers of Ukraine dated December 30, 2015, No. 1187 Licensing conditions for the educational activities of educational institutions (Decree of the Cabinet of Ministers of Ukraine of December 30, 2015, No. 1187 "Licensing conditions proceedings for the educational activities of educational institutions".

2.3 Project of the Higher Education Standard of magisters in Specialty 124 system analysis.

2.4 Law of Ukraine "On Higher Education".

2.5 Standard of Higher Education of the State Higher Educational Institution "NMU" Design of the educational process. Dnipropetrovsk: NMU, 2016. - 74 p.

3. THE SCOPE AND TERMS OF TEACHING DISCIPLINE

Total amount - 3 credits ECTS (90 academic hours).
It is taught at the 1st year, in the 1st semester, in the 1st (7 weeks) and the 2nd quarter (8 weeks).

4. DESIGNATION OF PHYSICAL QUANTITIES

During the teaching of discipline common mathematical notation, which is well-known by the applicants from previous courses, is used.

5. EXPECTED DISCIPLINARY LEARNING OUTCOMES

The code and the content of educational outcomes for an educational-professional program	**Code and content of disciplinary learning outcomes (DRN)**
1	2
PRN1 To know and be able to apply in practice methods of system analysis, methods of mathematical and information modeling for constructing and researching models of objects and processes of informatization.	DRN1-1 Perform a mathematical statement of the problem of combinatorial optimization
	DRN1-2 In accordance with the type of task, to formulate the target function and restriction in the discrete optimization problem
	DRN1-3 To have skills to use exact methods for solving combinatorial optimization problems
PR96 To know and be able to apply evolutionary modeling and genetic optimization methods, inductive modeling techniques and fuzzy logic mathematical apparatus, neural networks, game theory and distributed artificial intelligence, etc.	DRN6-1 To apply a constructive approach for solving combinatorial problems
	DRN6-2 To have skills to use deterministic methods for solving discrete optimization problems
	DRN6-3 To know the instruments of genetic and evolutionary programming
	DRN6-4 To know the instruments of multi-agent and cooperative search in the space of solutions
RNS2 To know and be able to implement highly loaded computing and data processing systems in systems analysis and management tasks, and decision support systems.	DNS2-1 Realize genetic and evolutionary algorithms for solving combinatorial optimization problems
	DNS2-2 Realize algorithms of cooperative multiagent search for solving combinatorial optimization problems
	DNS2-3 To choose the best method for solving the combinatorial optimization problem by efficiency criteria
RNS3 Be able to build typical mathematical models of objects and processes of system analysis, to use mathematical methods and algorithms for data processing (statistical, algebraic, combinatorial, theoretical-informational, etc.).	DNS3-1 Realize algorithms for the exact solution of combinatorial optimization problems
	DNS3-2 Realize algorithms for constructive synthesis of solving problems of combinatorial optimization
	DNS3-3 Realize algorithms of deterministic search for solving combinatorial optimization problems
	DNS3-4 Realize algorithms of stochastic solution of combinatorial optimization problems

6. THEMATIC PLAN AND DISTRIBUTION OF THE VOLUME OF DISCIPLINE BY TYPES OF TRAINING SESSIONS

DRN code	Kind and theme of training sessions	Volume, *hours*		
		aud	CPC	total
1	2	3	4	5
	lectures	**14**	**28**	**42**
DRN1-1	1. Models of combinatorial optimization	1	2	3
DRN1-2	2. Classification of combinatorial optimization methods	1	2	3
DRN6-2	3. Deterministic local search	1	2	3
DRN1-3	4. Stochastic local search	2	4	6
DRN6-3	5. Genetic algorithms	2	4	6
DRN6-3	6. Mimetic algorithms	1	2	3
DRN6-4	7.Optimization of ant colonies	1	2	3
DRN6-2	8. Deformation method in combinatorial optimization	1	2	3
DRN6-1	9. Swarm optimization methods	2	4	6
DRN6-4	10. Bee's algorithms	2	4	6
	Laboratory work	**16**	**32**	**48**
DNS3-1 DNS2-3	1. Solving the problem of combinatorial optimization by one of the precise methods	2	6	8
DNS3-2 DNS2-3	2. Solving the problem of combinatorial optimization by one of the constructive methods	2	4	6
DNS3-3 DNS2-3	3. Solving the problem of combinatorial optimization by one of the methods of deterministic search	2	4	6
DNS3-4 DNS2-3	4. Solving the problem of combinatorial optimization by one of the methods of stochastic search	3	6	9
DNS2-1 DNS2-3	5. Solving the problem of combinatorial optimization using a genetic or mimetic algorithm	2	6	8
DNS2-2 DNS2-3	6. Solving the problem of combinatorial optimization as one of the multi-agent methods of methods	3	6	9
	Control of the laboratory module	2	--	2
	Total	**30**	**60**	**90**
	Lectures (classroom - 1 hour per week)	**14**	**28**	**42**
	Laboratory classes (classroom - 1 hour per week)	**16**	**32**	**48**
	Final (semester) control - differential grade: And semester, 2 quarters			

7. REQUIREMENTS FOR INDIVIDUAL TASKS

When studying the discipline provides for the implementation of an individual task. The task is carried out in accordance with the methodological recommendations [15].

Purpose of the task:

1) generalization of competences acquired during the training;

2) the development of the ability to apply discipline knowledge to implement the algorithms of several discrete optimization methods for solving an individual problem.

3) the determination of the strengths and weaknesses of the methods, the limitation when applying to this class of discrete optimization tasks.

Given the task to carry out the following operations:

1) compile a mathematical model of the problem for an individual variant;

2) implement in an arbitrary language three algorithms for finding an extreme solution to a problem;

3) determine whether the solution is optimal, compare the methods with accuracy, complexity and available limitations.

When evaluating the task, account shall be taken of:

- methods used;
- correctness and completeness of solving tasks;
- literacy, conciseness and logical sequence of presentation;
- skills in using computer tools for solving problems;
- correct execution of the explanatory note and its timely submission;
- Independence of performance (diagnose's during protection).

8. TASKS FOR INDEPENDENT WORK OF THE STUDENT

The main tasks for independent work include:

- preliminary processing of information provision for each topic;
- preparation for ongoing control - solving tasks of self-control on each topic;
- performance of individual tasks;
- preparation for the protection of individual tasks;
- preparation for the final (semester) control.

9. FORM OF FINAL CONTROL, DIAGNOSTIC TOOLS, CRITERIA AND PROCEDURES OF EVALUATION

9.1 Form of final control

The form of final control is a differentiated credit.

An assessment of the level of the formation of disciplinary competencies in the form of a differentiated score can also be made without the participation of a student based on the results of current control.

9.2 Forms of current control

Determination of the level of the formation of disciplinary learning outcomes during the current control is carried out for:

• a certain section of the work program of discipline;
• laboratory work (inspection and protection);

9.3 Diagnostic tools

9.3.1 Generalized diagnostic tools

Diagnostic tools are presented in the form of theoretical questions and concretized tasks with numerical input data and are designed to assess the student's ability:

- differentiate, integrate and unify knowledge;
- apply rules, methods, principles, laws in specific situations;
- interpret circuits, graphs, diagrams;
- analyze and evaluate the facts, events and predict the expected results from the decisions made;
- to present material on paper Logically, consistently, with the requirements of the current standards.

9.3.2 Specified diagnostic tools

The concretized diagnostic tools that are directly used for control measures during lectures are formed on the basis of generalized numerical or other concretization of generalized means in the form of closed and open type tests.

9.4 Criteria and procedures of evaluation

9.4.1 Lecture material

The evaluation of the results of the accomplished tasks is carried out by comparing them with the standards - samples of correct and complete answers by identifying the level of the formation of competencies based on the analysis of the student's response, using the coefficient of assimilation as a percentage that adapts the value of the assessment to the ECTS scale:

$$P_i = a / m \ (\%),$$

where - a number of correct answers or performed essential operations of decision standards; m is the total number of questions or essential operations of the decision benchmark.

The results of the students' achievements (as a percentage) obtained from the described scheme are presented in the estimations of the ECTS and the national scale:

Marks, %	Grade
National Differentiated Scale	

90-100	Excellent
74-89	Good
60–73	Satisfactory
1-59	Fail
ECTS Scale	
90-100	A
82-89	B
74-81	C
64–73	D
60–63	E
35-59	Fx
1-34	F

If the level of student achievement below 60% is fixed or if the student does not appear on control measure, then he is rated "Fx" and "unsatisfactory". In such cases, the student is obliged to further master this topic of classes and undergo a re-evaluation of his learning outcomes.

9.4.2 Laboratory work

Each laboratory work is evaluated by the quality of the report by means of the coefficient of assimilation or by the expert method, when the maximum assessment is made subject to the following conditions:

- compliance with the report on the implementation of laboratory work methodological recommendations;
- correctness of execution
- possession of theoretical knowledge on which the subject of research is based;
- possession of experimental research methods;
- general and professional literacy, conciseness and logical sequence of material presentation;
- compliance of the report with the current standards.
- availability of references to sources of information;
- independence of execution (it turns out during protection).

The level of achievements based on the results of a complex of laboratory work by discipline is defined as the average value of the results of the current control of each.

During the expertise, the evaluation for laboratory work is determined by the percentage of the correct steps of the algorithm for its implementation.

Integral assessment of achievements in all laboratory work is accepted (student's level of achievement is not less than 60% or at least 60 points) only if all the laboratory work provided by the program of the discipline is performed and evaluated.

9.4.3 Integral level of student achievement in discipline

The integral level of student achievement in the mastering of discipline material as a whole is calculated as the weighted mean of the level of formation of competences in lecture, practical and laboratory classes:

$$IP = \sum_{i=1}^{n} \frac{(P_i \times T_i)}{T}, \%,$$

where - n number of types of training sessions;

P_i – the level of achievements for the i-th type of occupation, %;

T_i – volume of the i-th type of studies;

T – total volume of discipline.

Achievements of a student in mastering a certain discipline in general can not be evaluated positively if from any planned control measure in this discipline the student has not received a positive assessment.

If the level according to the results of any current control measure is higher than 60%, then by national scale it is rated "credited".

If the level according to the results of any current control measure is lower than 60%, then the discipline is rated "Fx" and, if below 35%, then "F". By the national scale in this case, the "unrecorded" score is displayed.

10 COMPOSITION OF THE COMPLEX OF EDUCATIONAL AND METHODICAL PROVISION OF DISCIPLINE

Complex of teaching and methodological support of discipline, should be located on the site of the Department of System Analysis and Management and must contain:

1) work program of discipline;
2) educational content (informational support of lectures);
3) task and methodical provision of laboratory work;
4) materials of methodical support of independent work of the student concerning:
– preliminary processing of information provision of lectures;
– solving self-control tasks for each topic
– performance of an individual task;
– preparation for the protection of individual tasks;
6) generalized tasks for ongoing control level of formation of disciplinary competencies in the form of typical situational exercises with examples of solutions.;
7) task for post-certification monitoring level of formation of disciplinary competencies.

11 RECOMMENDED LITERATURE

11.1 Basic

1. Voloshin A. F. Sequential analysis of options in problems of research of complex systems : monograph / A. F. Voloshin, V. I. Kudin. – K. : edition- polygraphic center "Kiev university ", 2015.

2. Glybovets M. M. Evolutionary algorithms: book / M. M. Glybovets, N. M. Gulyaeva. – K. : НаУКМА, 2013.

3. Gary M. Computing machines and hard-to-solve problems / M. Gary, D. Johnson. – M. : World, 1982.

4. Papadimitriou X. Combinatorial optimization. Algorithms and complexity / X. Papadimitriou, K. Stajglitz. – M. : World, 1985.

5. Sergienko I. V. Classification of applied methods of combinatorial optimization / I. B. Sergienko, L. F. Gulyanitsky, S. I. Sirenko // Cybernetics and Systems Analysis. – 2009. – № 5. – p. 71–83.

6. Sergienko I. V. Discrete optimization problems / I. V. Sergienko, V. P. Shilo. – K. : Scientific thought, 2003.

7. Subbotin S. O. Non-iterative, evolu- tionary and multi-agent methods for the synthesis of non-regular and neu- romorezhnyh models: monograph / S. O. Subbotin, A. O. Oliynik, O. O. Oliynik; under par. Ed.. S. O. Subbotin. – Zaporizhzhia: ЗНТУ, 2009.

11.2 Support

8. Dorigo M. Ant colony optimization theory: A survey / M. Dorigo, C. Blum // Theoretical Computer Science. – 2005. – 344. – P. 243–278.

9. Handbook of Combinatorial Optimization / eds. P. Pardalos, D.-Z. Du, R. L. Graham. – 2nd ed. – Heidelberg : Springer. – 2013, XXI.

10. Handbook of Memetic Algorithms / eds. F. Neri, C. Cotta, P. Moscato. – Berlin, Heidelberg : Springer-Verlag, 2012.

11. Hoos H. H. Stochastic Local Search: Foundations and Applications / H. H. Hoos, T. Stьtzle. – San Francisco : Morgan Kaufmann Publ., 2005.

12. A comprehensive survey: artificial bee colony (ABC) algorithm and applications / D . Karaboga, B. Gorkemli, C. Ozturk, N. Karaboga // Artificial Intelligence Review. – 2014. – 42(1). – P. 21–57.

13. Lourenзo H. R. Iterated local search / H. R. Lourenзo, O. Martin, T. Stьtzle // Handbook of Metaheuristics: International Series in Operations Research & Management Science, vol. 57 (Eds. F. Glover and G. Kochenberger). – Norwell, MA : Kluwer Academic Publishers, 2002. – P. 321–353.

14. Pintea C.-M. Advances in Bio-inspired Computing for Combinatorial Optimization Problems / C.-M. Pintea. – Heidelberg : Springer, 2014

15. Talbi E.-G. Metaheuristics: from design to implementation / E.-G. Talbi. – Hoboken, New Jersey : John Wiley & Sons, Inc., 2009.

16. Nikolić M. Empirical study of the bee colony optimization (BCO) algorithm / M. Nikolić, D. Teodorović // Expert Systems with Applications. – 2013. – 40(11). – P. 4609–4620.

Educational edition

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Published
at the State Higher Educational Institution
«National Mining University».
Certificate of entry to State register ДК № 1842 from 11.06.2004
49005, Dnipro, Javornitsky av., 19.