(Ф 03.02 – 92)

MINISTRY OF EDUCATION AND SCIENCE N OF UKRAINE
National Aviation University
Faculty of Transport, Management and Logistics
Air Transportation Management Department

AGREED
Dean of the Faculty of Transport,
Management and Logistics
_____ T.Mostenska
«24» 06 2021

APPROVED
Vice-Rector for Academic Affairs
_____ A. Polukhin
«25» 06 2021

Quality Management System

COURSE TRAINING PROGRAM
on
"OPERATIONS RESEARCH ON TRANSPORT"

Educational Professional Programs: «Air Transportation Management»
«Multimodal transport and logstics»
«Onboard support of air passenger transportation»

Field of Study: 27 «Transport»
Speciality: 275 «Air Transport Technologies»
Specialization: 275.04 «Air Transport Technologies»

Training Form	Semester	Total (hours/ECTS credits)	Lectures	Laboratory Classes	Self-study	HW/CGP	Semester Grade
Full-time	4,5	210/7,0	34	68	108	CGP - 4 s	Graded Test 4s Examination 5s

Index: CB-7-275-1/21-2.1.12
CB-7-275-3/21-2.1.12
CB-7-275-4/21-2.1.12

Course Training Program on "Operations Research on Transport" is developed on the basis of Educational Professional Programs «Air Transportation Management», «Multimodal Transport and Logistics», «Onboard Support of Air Passenger Transportation», Bachelor Curriculum and Bachelor Extended Curriculum №СВ-7-275-1/21, №СВ-7-275-3/21, №СВ-7-275-4/21, №ЕСВ-7-275-1/21, № ЕСВ -7-275-3/21, № ЕСВ-7-275-4/21 for Speciality 275 «Air Transport Technologies», Specialization 275.04 «Air Transport Technologies» and corresponding normative documents.

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Contents

INTRODUCTION

The Course Training Program of the subject "Operations research on transport" is developed based on the "Methodical guidance for the subject course training program", approved by the order № 249/од, of 29.04.2021 and corresponding normative documents.

1. EXPLANATORY NOTE

1.1. Place, objectives, tasks of the subject.

This training course is the theoretical basis and practical body of knowledge and skills that form the air transport profile of a specialist in the field of knowledge and systematization of knowledge about the functioning of transport systems. Students' mastering of the discipline "Operations Research on Transport" makes it possible to clearly understand the structure of processes in transport systems in terms of the theory of operations research and to find solutions of problems that arise during functioning and which are related to the peculiarities of transportation systems construction and their effective development.

The **objective** of teaching is to ensure a sufficient level of competence of the experts in the scientific justification and adoption of the best management decisions for the organization of traffic and transport management using of mathematical models and modern computers

The **tasks** of the discipline study are:

- mastering the basic concepts and approaches of research of operations,
- mastering the methods of operations research, their practical use;
- mastering the basic principles and techniques of mathematical modeling of operations, the principles of selection of mathematical and software for the practical realization of problems;
- formation of skills for modeling and solving specific tasks for professional activities.

1.2. Learning outcomes the subject makes it possible to achieve.

As a result of mastering the discipline "Operations Research on Transport" students must be formed the following **competencies:**

- ability to critically analyze and solve practical problems in the field of air transport and related industries to provide their own solutions subject to technical, regulatory, commercial, political, social and environmental constraints
- ability to select and evaluate the effectiveness of modern methods and components of programs needed to solve fundamental engineering problems in the field of transportation and transport logistics;
- ability to develop and use mathematical and computer models of transport systems and processes for scientific and practical research.

1.3. Competences the subject makes it possible to acquire.

- Ability to analyze and predict the parameters and performance of transport systems and technologies, taking into account the impact of the external environment;
- Ability to organize international transportation;
- Ability to use modern information technologies, automated control systems and geographic information systems in the organization of the transportation process;
- Ability to identify insurance cases on air transport, to develop a system of measures to prevent and eliminate them;
- Ability to use professionally profiled knowledge and practical skills of technology, organization and management of air passenger transportation to solve engineering problems in production;
- Ability to design transport (transport-production, transport-warehousing) systems and their individual elements. Ability to develop and use appropriate software to automate transport systems and processes.

1.4. Interdisciplinary connections.

The discipline "Operations research on transport" is based on knowledge of such disciplines as: "Basic theory of transport systems " "Higher Mathematics", "Theory of Probability and Mathematical Statistics" and is the basis for the studying such disciplines as: "Air cargo transportation"," Air passenger transportation”, “Methods of Scientific Research”.

2. COURSE TRAINING PROGRAM ON THE SUBJECT

2.1. The subject content.

Training material is structured according to module principle and consists of **one educational module, Module № 1 «Linear and nonlinear programming problems»**

Module №2 «Network Models. Dynamic programming», that are logically complete, relatively independent, holistic part of the subject, learning of which provides module test and analysis of its performance.

2.2. Modular structuring and integrated requirements for each module.

Module №1 «Linear and nonlinear programming problems»

Integrated requirements of module №1:

Know:

- main directions of operations research in transport systems;
- the role of operations research in the management of transport systems;
- the main stages of mathematical modeling of operations;
- the basic concepts of the mathematical programming theory;
- formulation of linear programming (LP) problem;
- graphical and simplex methods for solving LP problems;
- duality theory for LP problems;
- the transport problem, the concept of the basic and optimal plan of the transport problem,
- methods of construction the starting solutionn, the concept of the cycle, the algorithm of the method of multipliers;
- variants of a transport model;
- assignment model, algorithm of the Hungarian method;
- basic concepts of nonlinear programming;
- classical optimization methods.

A student has to be able to do the following:

- to orientate himself without assistance and operate with the concepts of the mathematical programming theory at the research of processes in transport systems;
- to construct models of linear programming problems;
- to find the optimal solution of LP problems graphically, by a simplex method and by artificial basis method;
- to construct the duel problem for primal LP problem;
- to apply the algorithm of the Gomori to solve integer problems;
- to determine the starting solution.for transportation problem by north-west corner and least cost methods;
- to find the solution of the transportation problem by method of multipliers;
- to find the solution of the LP assignment problem by the hungarian method.
- to construct nonlinear models of mathematical programming;
- to use the method of Lagrange multipliers to connect optimization problems, to identify the largest and highest values of functions in a closed domain.

Theme 1. Operations research problems on transport. Classification of optimization problems.

The subject of research of operations in transport systems. Basic concepts and principles of operations research in transport systems. Mathematical models of operations research. Classification of optimization problems.

Theme 2. Linear programming problems (LPP). Methods for solving LP problems.

Construction of LPP models. Forms of LPP records. Graphical LPP interpretation. Graphic solution of LPP. Properties of LPP solutions. Simplex method algorithm. Finding basic solutions. Corner points.

Feasible and basic solutions. LPP in canonical form. Converting LPP into the canonical form. The optimal plan. Jordan-Gauss method. Artificial basis method. Solving LPP in Excel and by means of TORA

Theme 3. Duality in LPP.

The concept of duality in linear programming. Construction of a dual problem. A dual simplex method for solving the LP problem. Economic interpretation of duality.

Theme 4. Integer Linear Programming Models.

Formulation of the problem. Cutting method. Algorithm of the Gomori method.

Theme 5. Transportation Model.

Definition of the Transportation Model **(**TM). Properties of a balanced TM. Properties of basic solutions of the TM. Determination of the Starting Solution (north-west corner and least cost methods, Vogel method). Multipliers method algorithm. Criterion of optimality of TM. Examples of the problems that can be solved by TM.

Theme 6. Nontraditional Transportation Models.

Inventory management, equipment distribution. TM on the network. TM with the criterion of time, with obligatory transportations, with non-homogeneous cargo. TM with limited capacity. Solving transport problem in Excel and by means of TORA. Assignment model. Algorithm of the Hungarian method, Mack algorithm.

Theme 7. N**onlinear programming models.**

The general model of nonlinear programming. Graphical method for solving nonlinear models with two variables. The classic problem of nonlinear programming. Lagrange multiplier method.

Theme 8. Application of linear and nonlinear programming in aviation.

Examples of the use of linear and nonlinear programming models in modern scientific research on the aviation industry.

Module №2 «Network models. Dynamic programming».

Integrated requirements of module №2:

Know:

- contents and sphere of transport networks use;
- basic concepts of graph theory;
- Dijkstra and Ford algorithms to determine the shortest routes;
- Ford-Falkerson algorithm to determine the maximal flow on network;
- critical path method;
- basic concepts of dynamic programming (DP);
- general DP model;
- principle of optimality and Bellman equation;
- three basic elements of the DP model.

A student has to be able to do the following:

- to use Ford and Dijkstra algorithms to find the shortest path;
- to apply Ford-Falkerson algorithm to find the maximum flow;
- to construct a time schedule;
- to calculate the basic parameters of the network schedule;
- to solve the problem of optimal distribution of funds for reconstruction and modernization between several objects;
- to solve problems of equipment replacement, cargo loading, work-force size model.

Theme 1. Optimal network models.

Definition of graphs, types of graphs. Shortest-Route Problem. Ford and Dijkstra's algorithms. Maximum flow on transport systems. Ford-Falkerson algorithm. Network model as a LPP. The problem of the distribution of workers.

Theme 2. Time ordering problems (Johnson’s algorithm).

The problem of scheduling. Formulation of the scheduling problem. Criteria for scheduling effectiveness. Downtime minimization. Time ordering problems. Johnson's algorithm (cases of two and three tools). Examples of the use of scheduling problems and scheduling theory in the management of civil aviation objects. Scheduling flights.

Theme 3. Methods of the planning, scheduling, and control of projects.

The essence and types of calendar network plans. The process of network planning. Project network construction. Critical path method (CPM). Calculation of the network schedule parameters. Construction of the time schedule.

Theme 4. Solve network problems in Excel and with TORA.

Solving the problems of finding the shortest path, finding the maximum flow in transport systems, finding the critical path of the project. Construction of a time schedule.

Theme 5. Dynamic programming models. General characteristics.

General characteristics of dynamic programming problems. Geometric and economic essence. The principle of optimality and the Bellman equation.

Theme 6. The simplest DP problems.

The use of **DP** to solve applied problems: to minimize fuel consumption by aircraft, the optimal distribution of investment, the replacement of equipment, cargo loading, the task of workforce planning.

Theme 7. Probabilistic dynamic programming.

Investment problem. Increasing the likelihood of achieving the goal.

Theme 8 Application of network and dynamic programming methods in aviation.

Examples of the use of network and dynamic programming in modern scientific research on the aviation industry.

2.3. Training schedule of the subject.

№ пор	Theme	Total, hours			
		Total	Lectures	Laboratories	Self -study
1	2	3	4	5	6
Module №1 «Linear and nonlinear programming problems»					
		4 semester			
1.1	Operations research problems on transport. Classification of optimization problems.	**11**	2	2 2	5
1.2	Linear programming problems. Methods for solving LP problems.	**11**	2	2 2	5
1.3	Duality for LP problem solution.	**11**	2	2 2	5
1.4	Integer Linear Programming Models.	**11**	2	2 2	5
1.5	Transportation problem.	**11**	2	2 2	5
1.6	Nontraditional transportation models. Assignment model (the hungarian method).	**11**	2	2 2	5
1.7	Nonlinear programming models.	**11**	2	2 2	5
1.8	Application of linear and nonlinear programming in aviation.	**12**	2 1	2 2	5

1.9	Calculation and graphic test.	**10**	-	-	10
1.10	Module test №1	**6**	-	2	4
Total for the module №1		**105**	**17**	**34**	**54**
Module №2 «Network models. Dynamic programming»					
2.1	Optimal network models.	**5 semester** **12**	2	2 2	6
2.2	Time ordering problems (Johnson’s algorithms).	**12**	2	2 2	6
2.3	Methods of the planning, scheduling, and comrol of projects (CPM, PERT).	**12**	2	2 2	6
2.4	Solve network problems in Excel and with TORA	**12**	2	2 2	6
2.5	Dynamic programming models. General characteristics.	**12**	2	2 2	6
2.6	The simplest DP problems.	**12**	2	2 2	6
2.7	Probabilistic dynamic programming.	**12**	2	2 2	6
2.8	Application of network and dynamic programming methods in aviation.	**13**	2 1	2 2	6
2.9	Module test №2	**8**	-	2	6
2.10	Control (home) test №2 (Part-time)	**-**	-	-	-
Total for the module №2		**10 5**	**17**	**34**	**54**
Total for the subject		**21 0**	**34**	**68**	**108**

2.4. Calculation and graphic paper.

Calculation and graphi c paper (CGP) of the discipline is performed in order to consolidate and deepen the theoretical and practical knowledge and skills acquired in the process of mastering the educational material of the discipline in the field of air transport, which are used in the study of many disciplines of the curriculum with basic and complete higher education.

The purpose of the CGP is for students to acquire skills in constructing mathematical models and solving applied optimization problems. The tasks differ in their variants.

To successfully complete the calculation and graphic paper the student must **know** the methods of solving optimization problems of linear and nonlinear programming, dynamic programming, network problems; **be able** to build mathematical models, analyze and solve applied optimization problems.

Execution, registration and defence of CGP is carried out by the student individually according to methodical recommendations.

The time required to perform the CGP is 10 hours of self-work

3. BASIC CONCEPTS OF GUIDANCE ON THE SUBJECT

3.1. Teaching methods.

In the teaching of the discipline "Operations research on transport ", it is proposed the use of such forms and methods of learning as

- lecture-visualization,

- elements of problem lecture,
- elements of dialogue with the audience (lectures - conversations),
- elements of "brain attack",
- workshops-discussions within the framework of practical occupations,
- business games, presentations.

The implementation of these methods are carried out during lectures, demonstrations, self-study, work with the educational material, analysis and solving problems in the study of operations research.

3.2. List of references (basic and additional).

Basic literature

3.2.1. Крюков М.М., Кравець Т.В., Крижановська Т.В., Коновалюк В.С., Семененко Т.М. Дослідження операцій у транспортних системах у прикладах і задачах. Навч. посіб.для студ. вищ. навч.закл. – К.: ДЕТУТ, 2014. – 199 с.

Additional recommended sources

3.2.2. Козаченко Д.М., Вернигора Р. В., Малашкін В. В Основи дослідження операцій у транспортних системах: приклади та задачі. – Дніпропетр. нац. ун-т залізн. трансп. ім. акад. В. Лазаряна – Дніпропетровськ, 2015. – 280 с.

3.3. Internet Information resources

3.3.1. http://e-books.ksavm.senet.ru/Books/physics/akulich-i.m.-matematicheskoe-programmirovanie-v-primerah-i-zadachah.pdf

3.3.2. https://tvims.files.wordpress.com/2012/01/d182d0b0d185d0b0-d185-d0b0-d0b2d0b2d0b5d0b4d0b5d0bdd0b8d0b5-d0b2-d0b8d181d181d0bbd0b5d0b4d0bed0b2d0b0d0bdd0b8d0b5-d0bed0bfd0b5d180.pdf

3.3.3. http://eadnurt.diit.edu.ua/bitstream/123456789/8967/1/Kozachenko_textbook.pdf

3.3.4. https://www.scribd.com/doc/316680593/Operations-Research-Hamdy-Taha-pdf

4. RATING SYSTEM OF KNOWLEDGE AND SKILLS ASSESSMENT

4.1. Assessment of certain kinds of student academic work is carried out in accordance with table 4.1.

Table 4.1

Kind of Academic Work	Max Grade Values
4-5 semester	
Module №1 «Linear and nonlinear programming problems»	
Kind of Academic Work	*points*
Carrying out labs (8б x 8)	64 (total)
Carrying out and defence calculation and graphic test.	16
Control (home) test № 1 (Part-time)	–
For admission to complete module test №1, a student must receive not less than	*48*
Final semester test (Part-time)	-
Module test №1	20
Total for the Module №1	**100**
Total for the subject	**100**
5-6 semester	
Module №2 «Network models. Dynamic programming»	
Kind of Academic Work	*points*
Carrying out labs (8б x 8)	64 (total)
For admission to complete module test №2, a student must receive not less than	*38*
Module test №2	16

Total for the Module №2	**80**
Semester exam	**20**
Total for the subject	**100**

4.2. The Total Semester Grade is entered into the Examination Register and into a student’s record book in values, National Scale grades, and ECTS Scale grades.

4.3. The Total Semester Grade is entered into a student’s record book, for example: ***92/Ex/A, 87/Good/B, 79/Good/C, 68/Sat/D, 65/Sat/E,*** etc.

4.4. The Total Grade for the subject is equal to the average grade from Total Semester Grades with its further transformation into national scale and ECTS system.

The credit rating is determined (in points and on a national scale) based on the results of all types of educational work during the semester.

(Ф 03.02 – 02)

АРКУШ ОЗНАЙОМЛЕННЯ З ДОКУМЕНТОМ

№ пор.	Прізвище, ім’я, по батькові	Підпис ознайомленої особи	Дата ознайом-лення	Примітки

(Ф 03.02 – 04)

АРКУШ РЕЄСТРАЦІЇ РЕВІЗІЇ

№ пор.	Прізвище, ім’я, по батькові	Дата ревізії	Підпис	Висновок щодо адекватності

(Ф 03.02 – 03)

АРКУШ ОБЛІКУ ЗМІН

№ зміни	№ листа (сторінки)				Підпис особи, яка внесла зміну	Дата внесення зміни	Дата введен-ня зміни
	Зміненого	Заміненого	Нового	Анульо-ваного			

(Ф 03.02 – 32)

УЗГОДЖЕННЯ ЗМІН

	Підпис	Ініціали, прізвище	Посада	Дата
Розробник				
Узгоджено				
Узгоджено				
Узгоджено				