(Ф 03.02 – 110)

MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
Faculty of Transport, Management and Logistics
Air Transportation Management Department

AGREED
Dean of Faculty of Transport,
Management and Logistics
_____ Tetiana MOSTENSKA
«06» 09 2023

APPROVED
Vice-Rector for Academics
_____ Anatolii POLUKHIN
«06» 09 2023

Quality Management System
COURSE TRAINING PROGRAM
on
«Mathematical Methods of Modeling and Optimization of Transport Systems and Processes»

Educational Professional Program: «Air Transportation Management»

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

Training Form	Semester	Total (hours/credits ECTS)	Lectures	Practicals	Lab. classes	Self-Study	HW/CGP	TP/CP	Semester Grade
Full-time:	2	150/5	18		36	96	-	TP-2s	examination 2s

Index CM-7-275.04-1/23-2.1.7

Course Training Program on «Mathematical Methods of Modeling and Optimization of Transport Systems and Processes» is developed on the basis of the Educational Professional Program "Air Transportation Management", Master Curriculum and Extended Master Curriculum №CM-7-275.04-1/23, №ECM-7-275.04-1/23 for Speciality 275 «Air Transport Technologies», Specialization 275.04 «Air Transport Technologies» and corresponding normative documents.

Developed by:
Professor
Air Transportation Management Department_____ Andriy GONCHARENKO

Associate professor
Air Transportation Management Department_____ Oleksandr YAKUSHENKO

Discussed and approved by the Graduate Department for Speciality 275 «Air Transport Technologies», Specialization 275.04 «Air Transport Technologies» and Educational Professional Program «Air Transportation Management» - Air Transportation Management Department, Minutes № _17__ of «__05__»____09___2023

Guarantor of Educational Professional Program _____ Andriy.GONCHARENKO

Head of the Department_____ Dmytro SHEVCHUK

Vice-Rector on International
Collaboration and Education
_____ Iryna ZARUBINSKA
«___» _____2023

Document level – 3b
The Planned term between revisions – 1 year
Master copy

CONTENT

page

Introduction 4

1. Explanatory notes 4

1.1. Place, aim, tasks of the discipline 4

1.2. Learning outcomes as results of mastering the discipline 4

1.3. Competences as results of mastering the discipline 4

1.4. Interdisciplinary links 4

2. Academic curriculum of the subject 5

2.1. Content of the subject 5

2.2. Modular structuring and integrated requirements for each module 3. Basic concepts of guidance on the subject 5

2.3. Topic plan 6

2.3. List of examination questions 7

3. Basic concepts of guidance on the subject 7

3.1. Teaching methods 7

3.2. List of references (basic and additional) 7

3.3. Internet resources 7

4. Rating System of knowledge and skills assessment 8

INTRODUCTION

Course Training Program on «Mathematical Methods of Modeling and Optimization of Transport Systems and Processes» is developed based on the "Methodical guidance for development and paperwork of the subject course training program for full and extramural training ", approved by the orders № 249/од dated 29.04.2021 and corresponding normative documents.

1. Explanatory notes

1.1. Place, aim, tasks of the discipline

This subject is the part of the theoretical basis of knowledge and skills for the technical disciplines study for training in the field of transportation.

The aims and goals of discipline teaching are to develop skills of scientific research and their further application in the preparation of master's thesis, in writing scientific articles.

Subject objectives are:

- gaining knowledge on modern approaches to the optimization of logistics processes in air transport;
- mastering modern methods and approaches to creating mathematical models of complex systems and processes;
- mastering modern methods and approaches to optimize complex systems and processes.

1.2. Learning outcomes as results of mastering the discipline

PLO 07. Develop and analyze graphic, mathematical and computer models of transport systems and technologies.

PLO 14. Use specialized software for the analysis, development and improvement of transport systems and technologies, in particular for air transport.

PLO 16. Research theoretical and experimental models for assessing the reliability and efficiency of transport technologies, in particular for air transport.

PLO 17. Apply problem-oriented methods of analysis, synthesis and optimization of computer-integrated information systems for managing aviation transport complexes.

1.3. Competences as results of mastering the discipline

IC The ability of a person to solve complex tasks and problems of the transport industry in the field of professional activity according to a certain type of transport systems and technologies and in the learning process, which involves conducting research and implementing innovations and is characterized by the uncertainty of conditions and requirements.

GC 07 Ability to conduct research at an appropriate level.

GC 08. The ability to generate new ideas (creativity).

PC 02. The ability to identify and apply promising directions for modeling transport processes, in particular on air transport.

PC 11. The ability to use specialized software to solve complex problems in the field of transport systems and technologies, in particular in aviation transport.

PC 14. The ability to apply modeling and optimization methods to research and increase the efficiency of the functioning of aviation transport systems and their management processes.

1.4. Interdisciplinary links

This discipline is based on knowledge of such discipline as «Supply Chains and Logistics Centers Management», the disciplines complement each other. «Philosophical Problems of Scientific Cognition», «Air Transportation Engineering», Term paper “Mathematical Methods of Modeling and Optimization of Transport Systems and Processes”, "Research Activities in the Field of Air Transportation Management". This discipline is the basis for the study of disciplines: "Pre-Diploma Practice", "Qualification Paper".

2. ACADEMIC CURRICULUM OF THE SUBJECT

2.1. Content of the subject

Training material is structured according to a module principle and consists of **one educational module** «Mathematical methods of optimization and modeling of aviation systems and processes», that is logically complete, relatively independent, holistic part of the subject, learning of which provides module test and analysis of its performance.

A separate second module (educational component) is a term paper (TP), which is performed in the second semester. TP is an important component of consolidation and deepening of theoretical and practical knowledge and skills acquired by students in the process of mastering the educational material of the discipline.

2.2. Modular structuring and integrated requirements for each module

Module 1. "Mathematical methods of optimization and modeling of aviation systems and processes"

Integrated requirements for module №1:

Know modern approaches to the optimization of logistics processes in air transport; methods and approaches to creating mathematical models of complex systems and processes;

Be able to use modern methods and approaches to optimize complex systems and processes.

Topic 1. Introduction. Objects and type of models. Classification of systems and processes models of aviation transport system. Object schematization and description

Objectives and methods of systems and processes modeling. Classification of models. Deterministic and stochastic systems and processes. Continuous in time and space processes, systems with discrete independent variables and quantized states. Deterministic and stochastic models, static and dynamic models. The principle of the "black" box. Model description. Models and methods of assessing the efficiency and reliability of the functioning of aviation transport systems. Regression models of systems and processes

Topic 2. Problems of mathematical optimization of systems and processes in the aviation transportation system. Optimization with constraints

Optimization criteria. Optimization problem: methods of unconditional optimization and optimization methods with constraints. Basic optimization problems of mathematical modeling. Solving problems of mathematical optimization of the object. Constraint optimization methods. Linear modeling: allowable area, constraints, objective function, search for the optimal solution. Features of integer and Boolean modeling. Software for solving linear programming problems.

Topic 3. Unconditional one- and multi-factor nonlinear optimization of systems and processes in the aviation transportation system without constraints

Stepwise method, method of half division, method of golden section. Unconditional multifactor nonlinear optimization without restrictions. Hook and Jeeves's algorithm, gradient methods, the fastest descent method. Study of methods of unconditional nonlinear optimization without restrictions. Software for solving nonlinear optimization problems

Topic 4. Regression and interpolation models

Interpolation models. Basic definitions. Linear interpolation. Interpolation using cubic splines. Bilinear interpolation. Performing interpolation using software. Approximation using the method of least squares. The method of group argument consideration. Performing approximation using software.

Topic 5. Statistical (simulation) modeling of aviation transport system objects

Monte Carlo method. Models of random processes, their characteristics. Statistical simulation errors. Random process distribution parameters. Random variables obtaining.

Topic 6. Mathematical models of systems and processes in the aviation transportation system based on queueing theory and game theory

Theory of queuing. Markov's and semi-Markov's processes. Graph theory and its basic concepts and definitions. Game theory: positional games and normal form games. Games with zero-sum and non-zero-sum. Non-cooperative and cooperative games.

Topic 7. Identification of mathematical models of aviation transport systems and processes

Parametric and structural identification of deterministic and stochastic models of systems with concentrated parameters. Methods of setting experiments to elaborate mathematical models. The concept of experiment planning. Reconciliation of experimental data using analytical relationships. Estimation of adequacy of mathematical models.

Topic 8. Methods for optimal decision-making in the functioning of the aviation transportation system. Graph theory

Utilizing the Bayesian method in decision-making. General problem formulation. Bayes' theorem and

formula. Information required for optimization using the Bayesian method. Accounting for losses from incorrect forecasts and the probability of problem occurrence. Risk minimization method. Graph theory, its basic concepts, definitions, and problems. Definition of a graph. Solving graph theory problems using software.

Module №2 (educational component) "Term paper"

Term paper (TP) is performed in the second semester, in accordance with the approved methodological recommendations.

Name of the term paper is "Mathematical methods of optimization and modeling of aviation systems and processes"

The purpose of the TP is to create a mathematical model of the process and its optimization.

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

The time required to perform the TP is 30 hours of self-study work.

2.3. Topic plan

№ пор	*Topics title (thematic section)*	Обсяг навчальних занять (год.) Денна форма навчання			
		Total	**Lectures**	**Practicals**	**Self-study**
1	*2*	*3*	4	5	6
Module №1 «Mathematical methods of optimization and modeling of aviation systems and processes»					
		2 семестр			
1.1	Introduction. Objects and type of models. Classification of systems and processes models of aviation transport system. Object schematization and description	***13***	*2*	2 2	7
1.2	Problems of mathematical optimization of systems and processes in the aviation transportation system. Optimization with constraints	***13***	*2*	2 2	7
1.3	Unconditional one- and multi-factor nonlinear optimization of systems and processes in the aviation transportation system without constraints	***13***	*2*	2 2	7
1.4	Regression and interpolation models	***13***	*2*	2 2	7
1.5	Statistical (simulation) modeling of aviation transport system objects	***13***	*2*	2 2	7
1.6	Mathematical models of systems and processes in the aviation transportation system based on queueing theory and game theory	***14***	*2*	2 2	8
1.7	Identification of mathematical models of aviation transport systems and processes	***14***	*2*	2 2	8
1.8	Methods for optimal decision-making in the functioning of the aviation transportation system. Graph theory.	***18***	2 2	2 2 2	8
1.9	Module test 1	***9***	-	2	7
	Total by the module №1	***120***	***18***	**36**	**66**
Module №2 «Term paper»					
2.1	Mathematical methods of optimization and modeling of aviation systems and processes	**30**	**-**	**-**	**30**
	Total by the module №2	***30***	**-**	**-**	**30**
	Total by the Subject	**150**	**18**	**36**	**`96**

2.3. List of examination questions

The list of questions and the content of the tasks for the examination are developed by the leading teachers and approved by the minutes of the department meeting and delivered to the students.

3. BASIC CONCEPTS OF GUIDANCE ON THE SUBJECT

3.1. Teaching methods

Problem-oriented learning, which involves formulating and solving a problem during lectures, solving situational problems at seminars, practical classes, laboratory work, researching a problem during the independent work of students of higher education. Practice-oriented training through various types of practices at enterprises, institutions and organizations of various forms of ownership on the basis of contracts on the completion of practice, the organization of which is carried out according to the principle of continuity. Performance of practical and laboratory work in production conditions. The implementation of these methods is carried out through various approaches, including conducting lectures, demonstrations, independent problem-solving, working with educational literature, analysis and problem-solving

3.2. List of references (basic and additional)

Basic literature

3.2.1. Mathematical Methods of Modeling and Optimization of Transport Systems and Processes: manual / D. Shevchuk, O.Yakushenko, A. Mirzoyev, O.Sokolova, V. Akmaldinova. – K.: NAU, 2021. – 112 p.

3.2.2. Конспект лекцій з Математичні методи моделювання та оптимізації транспортних систем і процесів / [Електронний ресурс]. - Режим доступу: https://bit.ly/3N0XTLa

3.2.3. Лабораторний практикум з Математичні методи моделювання та оптимізації транспортних систем і процесів (укр.) / [Електронний ресурс]. - Режим доступу: https://bit.ly/43eXVEN

3.2.4. Лабораторний практикум з Математичні методи моделювання та оптимізації транспортних систем і процесів (англ.) / [Електронний ресурс]. - Режим доступу: https://bit.ly/3ozYUAv

3.2.5. Давідіч Ю. О. Конспект лекцій з дисципліни «Моделювання транспортних систем» (для магістрів усіх форм навчання спеціальності 275 – Транспортні технології) / Ю. О. Давідіч, Г. І. Фалецька; Харків. нац. ун-т. міськ. госп-ва ім. О. М. Бекетова. – Харків : ХНУМГ ім. О. М. Бекетова, 2019. – 71 с.

3.2.6. Н. В. Богданова, О. В. Богданов, Математичне моделювання систем і процесів. – Київ : КПІ ім. Ігоря Сікорського, 2021. – 85 с.

3.2.7. Козаченко Д. М. Основи дослідження операцій у транспортних системах: приклади та задачі: навч. посіб. для ВНЗ / Д. М. Козаченко, Р. В. Вернигора, В. В. Малашкін ; Дніпропетр. нац. ун-т залізн. трансп. ім. В. Лазаряна. - Київ : ПрофКнига, 2019. – 277 с.

Additional Literature

3.2.8. Shevchuk D., Yakushenko O., Pomytkina L., Medynskyi D., Shevchenko Y. (2021) Neural Network Model for Predicting the Performance of a Transport Task. In: Mottaeva A. (eds) Proceedings of the XIII International Scientific Conference on Architecture and Construction 2020. Lecture Notes in Civil Engineering, vol 130. pp 271-278 Springer, Singapore. https://doi.org/10.1007/978-981-33-6208-6_27

3.2.9. Якушенко О.С., Шевчук Д.О., Мединський Д.В. Нейромережева модель для прогнозування часу на виконання транспортної задачі// Наукоємні технології, т. 49, № 1. –2021. –С.33-38.

3.3 Internet Information resources

3.3.1. Matlab developer site (MathWorks.) / [Electronic resource]. - Access mode: www.matlab.com

3.3.2. Mathcad developer website / [Electronic resource]. - Access mode: www.mathcad.com

3.3.3. Site and library dedicated to logistics problems / [Electronic resource]. - Access mode: https://logists.by/

3.3.4. NAU Bulletin / [Electronic resource]. – Access mode: http://jrnl.nau. edu.ua/index.php/visnik

3.3.5. Visnyk "KHAI" / [Electronic resource]. – Access mode: https://www.citefactor.org/journal/index/11253/aerospace-technic-and-technology

3.3.6. Aviation / [Electronic resource]. – Access mode: https://journals.vgtu.lt/index.php/Aviation

3.3.7. Eastern European journal of advanced technologies / [Electronic resource]. – Access mode: http://journals.uran.ua/eejet

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	Maximum Grade Values
	Module №1
2 семестри	
Module №1 «Mathematical methods of optimization and modeling of systems and processes»	
Види навчальної роботи	бали
Carrying out labs (7g x 8)	56 (total)
For admission to complete module test №1, a student must receive not less than	*34 балів*
Module test №1	24
Total for the Module №1	**80**
Semester Examination	**20**
Total for the subject	**100**

Модуль №2	
Вид навчальної роботи	Max кількість балів
	Денна та заочна форма навчання
Carrying out TP	60
TP defending	40
Carrying out and defending TP	**100**

4.2. Completed kinds of academic activities are credited to the student, if he received a positive rating.

4.3. The sum of rating assessments received by the student for certain types of completed education work is the current module rating assessment, which is entered in the module control paper.

4.4. The final modular rating obtained by the student based on the results of fulfilment and defense of the TP in grades, in the national scale and ECTS scale is entered in the module control, as well as in the study card, individual student curriculum and the Diploma Appendix, for example: **92 / Excellent / A, 87 / Good / B, 79 / Good / C, 68 / Satisf./D, 65 / Satisf./E**, etc.

4.5. 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.

4.6. 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.

4.7. The final rating of the discipline is equal to the final semester rating. The specified final rating assessment for the discipline is entered in the Diploma Appendix.

(Ф 03.02 – 01)

АРКУШ ПОШИРЕННЯ ДОКУМЕНТА

№ прим.	Куди передано (підрозділ)	Дата видачі	П.І.Б. отримувача	Підпис отримувача	Примітки

(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 введення зміни
	Зміненого	Заміненого	Нового	Анульо-ваного			

(Ф 03.02 – 32)

УЗГОДЖЕННЯ ЗМІН

	Підпис	Ініціали, прізвище	Посада	Дата
Розробник				
Узгоджено				
Узгоджено				
Узгоджено				