(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 the Faculty of Transport,
Management and Logistics

_____ Tetiana MOSTENSKA
«27» 09 2021

APPROVED
Vice-Rector for Academics

_____ Anatolii POLUKHIN
«7» 10 2021

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

Educational and 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-7-275-1/21-2.1.7

QMS NAU CTP 19.01-01-2021

Course Training Program on «Mathematical Methods of Modeling and Optimization of Transport Systems and Processes» is developed on the basis of the Educational and Professional Program "Air Transportation Management", Master Curriculum and Extended Master Curriculum №CM-7-275-1/21, №ECM-7-275/21 for Speciality 275 «Air Transport Technologies», Specialization 275.04 «Air Transport Technologies» and corresponding normative documents.

Developed by:
Associate Professor of
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 and Professional Program «Air Transportation Management» - Air Transportation Management Department, Minutes № 15 of « 31 » 08 2021

Guarantor of Educational and
Professional Program _____ Iryna VYSOTSKA

Head of the Department _____ Dmytro SHEVCHUK

Vice-Rector on International
Collaboration and Education
_____ Iryna ZARUBINSKA
« 7 » 10 2021

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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 № 246/од dated 29.04.2021 and corresponding normative documents.

1. Explanatory notes

1.1. Place, aim, tasks of the subject

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

- Develop new and improve existing transport systems and technologies, define development goals, existing constraints, efficiency criteria and field of use;
- Develop and analyze graphical, mathematical and computer models of transport systems and technologies;
- Manage complex technological and production processes of transport systems and technologies, including unpredictable and those that require new strategic approaches;
- Use specialized software for analysis, development and improvement of transport systems and technologies;
- Analyze scientific recommendations and justify the feasibility of modern methods of controlling the movement of vehicles (aircraft).

1.3. Competences as results of mastering the discipline

- Ability to search, process and analyze information from various sources;
- Ability to develop and manage projects;
- Ability to conduct research at the appropriate level;
- Ability to conduct research within a narrow specialization, identify problems, set goals and solve them using appropriate research methods;
- Ability to identify and apply promising aproachs of modeling of transport processes;
- Ability to use modern technologies of transport and forwarding activities;
- Ability to manage supply chains and logistics centers;
- Ability to manage traffic flows;
- Ability to use specialized software to solve complex problems in the field of transport systems and technologies;
- Ability to apply modeling and optimization methods to study and improve the efficiency of aviation transport systems and their management processes.

1.4. Interdisciplinary links

This discipline is based on knowledge of such discipline as "Supply Chain Management and Logistics Centers" and is the basis for the study of disciplines: "Undergraduate Practice", "Unified State Qualification Exam", "Qualification Work".

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 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 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. Schematization and description of the object.

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. Regression models of systems and processes

Topic 2. Statistical (simulation) modeling

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

Topic 3. Identification of mathematical models of 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 4. Neural networks

Mathematical modeling of biological neural networks. Neuron, a layer of neurons, the structure of a network as a whole. Types of networks. Network training. The problem of overlearning and its solution. Software for work with the artificial neural network.

Topic 5. Mathematical models based on queuing theory

Theory of queuing. Markov's and semi-Markov's processes. Graph theory and its basic concepts and definitions. Game theory.

Topic 6. Problems of mathematical optimization of the object. 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 7. Unconditional one- and multifactor nonlinear optimization without restrictions

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 8. Bayesian method and method of risk minimization

Methods of pattern recognition. Bayes' theorem and formula. Information required for Bayesian optimization. The main dependencies. Taking into account losses from incorrect forecast and the probability of its occurrence. Risk minimization method. Mathematical modeling of natural selection. Basic terms. Search for the optimum of a multidimensional function using genetic algorithms. Software for working with genetic algorithms.

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 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 systems and processes»					
1.1	Introduction. Objects and type of models. Classification of systems and processes. Schematization and description of the object.	***2 семестр***			
		13	*2*	2 2	7
1.2	Statistical (simulation) modeling	***13***	*2*	2 2	7
1.3	Identification of mathematical models of systems and processes	***13***	*2*	2 2	7
1.4	Neural networks	***13***	*2*	2 2	7
1.5	Mathematical models based on queuing theory	***13***	*2*	2 2	7
1.6	Problems of mathematical optimization of the object. Optimization with constraints	***14***	*2*	2 2	8
1.7	Unconditional one- and multifactor nonlinear optimization without restrictions	***14***	*2*	2 2	8
1.8	Bayesian method and method of risk minimization	***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 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

The following teaching methods in subject guidance are:

- explanatory and illustrative method;
- method of problem presentation;
- reproductive method;
- research method.

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

3.2. List of references (basic and additional)

Basic literature

3.2.1 Li, C., Xing, Y., He, F., & Cheng, D. (2018). A Strategic Learning Algorithm for State-based Games. ArXiv.

3.2.2. Billings S.A. (2019), Nonlinear System Identification: NARMAX Methods in the Time, Frequency, and Spatio-Temporal Domains, Wiley.

3.2.3. Thomas Kuhn . Stanford Encyclopedia of Philosophy. 13 August 2010. Retrieved 15 January 2019.

3.2.4. Thornton, Chris. "Machine Learning Lecture". Retrieved 2019-02-06.

3.2.5. Pyke, G. H. (2015). "Optimal Foraging Theory: A Critical Review". Annual Review of Ecology and Systematics. 15: 523–575.

3.2.6. Васильєв В.В., Квач Ю.М., Киркач К.В. Математичні методи моделювання та оптимізації систем і процесів: Навч. посібник. – К.: НАУ, 2012. – 270 с.

3.2.7. Основи теорії і методів оптимізації: Навчальний посібник. Черкаси: Брама-Україна, 2015. – 608 с.

3.2.8. Оптимізаційні методи та моделі.: Підручник. – К., 2014. – 372 с.

Additional Literature

3.2.4. Інформатика, основи системології та програмування: лабораторний практикум/ МОН України; Національний авіаційний університет; Городній О. В., Труш О. І., Чижевський Й. Ф., уклад. – Київ: НАУ-друк, 2015. – 48 с.– CD

3.3 Internet Information resources

3.3.1 Сайт розробника Matlab (MathWorks.) / [Електронний ресурс]. - Режим доступу: www.matlab.com

3.3.2 Авторські керівництва та довідкові матеріали по роботі з продуктами MathWorks [Електронний ресурс]. - Режим доступу: http://matlab.exponenta.ru

3.3.3 Сайт розробника Mathcad / [Електронний ресурс]. - Режим доступу: www.mathcad.com

3.3.4 Керівництва та довідкові матеріали по роботі з MathCAD / [Електронний ресурс]. - Режим доступу: http://old.exponenta.ru/soft/mathcad/Users Guide/0.asp

3.3.5. Форум, присвячений роботі у MathCAD / [Електронний ресурс]. - Режим доступу: http://www.cyberforum.ru/mathcad

3.3.6. Сторінка сайту МФТІ, присвячена математичному моделюванню транспортних потоків / [Електронний ресурс]. - Режим доступу: https://mipt.ru/education/chair/computational_mathematics/upload/22b/Book-arpglktefbb.pdf

3.3.7. Сайт та бібліотека, присвячені проблемам логістики / [Електронний ресурс]. - Режим доступу: https://logists.by/

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 semester	
Module №1 «Mathematical methods of optimization and modeling of systems and processes»	
Carrying out labs (7g x 8)	56 (total)
For admission to complete module test №1, a student must receive not less than	*34 points*
Module test №1	24
Total for the Module №1	**80**
Semester Examination	**20**
Total for the subject	**100**
	Module №2 "Term Paper"
Kind of Academic Work	Maximum Grade Values
Carrying out of the TP	60
TP defending	40
Carrying out and defending of the 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				