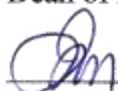


MINISTRY of EDUCATION and SCIENCE of UKRAINE
National Aviation University
 Aerospace Faculty
 Airport Technologies Department

AGREED

Dean of Aerospace Faculty

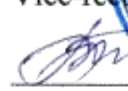


Mykola KULYK

« 10 » 05 2023

APPROVED

Vice-rector for Academics



*Anatoli POLUKHIN

« 10 » 05 2023



Quality Management System

COURSE TRAINING PROGRAM

on

«Mathematical Methods for Modeling Systems and Processes»

Educational Professional Program: Maintenance and Repair of Aircrafts and Engines

Educational Professional Program: Airport Technologies and Technical Equipment

Field of study: 27 Transport

Specialty: 272 Aviation Transport

Form of training	Semester	Total (hours / ECTS credits)	Lectures	Practicals	Laboratory classes	Self-study	HW/ CGW/ CW	TP/ CP	Form of semester control
Full-time	1	105/3,5	17	–	17	71	CGW-1		Graded Test 1s

Index: ECM-1-272-1/22-2.1.2

Index: ECM-1-272-2/22-2.1.2

Index: ECM-1-272-2fs/22-2.1.2



The Course Training Program on «Mathematical Methods for Modeling Systems and Processes» was developed on the the basis of Educational Professional Programs «Maintenance and Repair of Aircrafts and Engines», «Airport Technologies and Technical Equipment», and Curriculums CM-1-272-1/22, CM-1-272-2/22, CM-1-272-2fs/22, ECM-1-272-1/22, ECM-1-272-2/22, ECM-1-272-2fs/22 for the «Master» educational degree seekers training for the Specialty 272 «Aviation Transport» and corresponding normative documents


Developed by:

Professor of
Airport Technologies Department


Oleksandr TAMARGAZIN

Discussed and approved by the Graduate Department for the Educational Professional Program «Airport Technologies and Technical Equipment», the Specialty 272 «Aviation Transport» – Department of Airport Technologies, Minutes № 3 of "21" 04 2023.

Guarantor of
Educational Professional Program


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Oleksandr TAMARGAZIN

Discussed and approved by the Graduate Department for the Educational Pro-fessional Program «Maintenance and repair of aircrafts and engines» - Department of Airport Technologies, Minutes № 3 of "27" 04 2023.

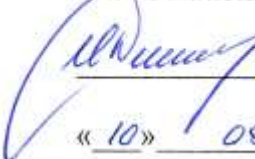
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«10» 05 2023

Document level – 3b


The planned term between revisions – 1 year

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INTRODUCTION

Course Training Program (CTP) of discipline «Mathematical Methods for Modeling Systems and Processes» is developed in accordance with the «Methodical recommendations for the development and design of the Course Training Program of the discipline of full-time and part-time forms of education», approved by the rector's order dated 29/04/2021 No. 249/od, and correspondent normative documents.

1. EXPLANATORY NOTES

1.1. Place, objectives, tasks of the subject

This educational discipline is the theoretical basis of totality of knowledge and outcomes, that forms the profile of specialist in the field of the airport technologies and technical equipment.

Purpose of teaching of the discipline is the systematization of knowledge and skills in creating of mathematical models of systems and processes occur in these systems and processes.

Tasks of learning the discipline are:

- learning of knowledge of mathematical modeling and processes occur in these systems and processes;
- learning of the methods of conducting of experiments using mathematical models of systems and processes occur in these systems and processes, making decisions with their improvement.

1.2. Learning outcomes the subject makes it possible to achieve

At the end of the course, the student will be able to:

EPP «Airport technologies and technical equipment»

PTO02. To apply modern methods of scientific research, organisation and planning of the experiments, digital technologies, methods of data analysis to solve complex problems in the field of airport operation and operation of aviation ground equipment and airport equipment.

PTO09. To develop and to analyse physical, mathematical and computer models related to the creation, operation, maintenance and repair of aviation ground handling facilities and airport equipment.

PTO15. To search necessary data in scientific literature, databases and other sources, to analyze, to evaluate and to use these data.

EPP «Maintenance and repair of aircrafts and engines»

PTO01. Specialized conceptual knowledge includes modern scientific achievements in the field of aviation transport and is the basis for original thinking and conducting of research. To apply modern methods of scientific research, organization and planning of experiment, digital technologies, methods of data analysis to solve complex problems of aviation transport.

PTO02. To solve complex problems of creation, operation, maintenance, repair and utilization of aviation transport objects, including related fields, engineering sciences, physics, ecology and economy.


PTO04. To develop and to implement new technical solutions and to apply new technologies.

PTO05. To apply universal and specialized life cycle management (PLM), automated design (CAD), manufacturing (CAM) and engineering research (CAE) systems in professional activities.

PTO07. To organize and to manage the work of the primary production, design or research division in the field of aviation transport, to evaluate the effectiveness and efficiency of the activities of the staff and the division.

PTO08. To develop and to analyze physical, mathematical and computer models related to the creation, operation, maintenance and repair of aviation transport objects.

PTO10. To develop technical regulations, to take part in their development and to organize

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technological processes in the field of aviation transport, to provide production safety.

PTO11. To use the principles and methods of system analysis in scientific and technical activities, to analyze cause-and-effect links between significant factors and technical-economic characteristics.

PTO15. To control quality of maintenance and repair of aircrafts, to comply the state requirements of airworthiness and ensuring of flight safety during the operation of aviation equipment.

PTO16. To provide the safety of operation (including ecological), storage, maintenance of aviation equipment and technological equipment, safe working conditions of personnel.

PTO17. To analyze the technical and economic efficiency of the operation of aircraft and technological processes, to participate in the development of recommendations for improving the operational and technical characteristics of the operation of aviation equipment.

PTO18. To develop models allow forecasting the change of the technical condition of aviation equipment objects, monitoring the parameters of the efficiency of its technical operation on the basis of modern analytical methods and complex models.

PTO19. To develop organizational and technical, regulatory and methodical documentation of the technical operation of aircrafts.

EPP «Management of aviation transport systems and complexes»

PTO02. To apply modern methods of scientific research, organization and planning of experiment, digital technologies, methods of data analysis to solve complex problems of aviation transport.

PTO03. To solve complex problems of creation, operation, maintenance, repair and utilization of aviation transport objects, including related fields, engineering sciences, physics, ecology and economics.

PTO05. To develop and to implement new technical solutions and to apply new technologies.

PTO06. To apply universal and specialized life cycle management (PLM), automated design (CAD), manufacturing (CAM) and engineering research (CAE) systems in professional activities.

PTO07. To develop and to implement the latest technologies in the field of aviation transport security.

PTO08. To organize and to manage the work of the primary production, design or research division in the field of aviation transport, to evaluate the effectiveness and efficiency of the activities of the staff and the division.

PTO09. To develop and to analyze physical, mathematical and computer models are related to the creation, operation, maintenance and repair of aviation transport objects.

PTO16. To determine the properties and characteristics, to calculate the parameters of aviation transport objects.

PTO17. To develop and to optimize the parameters of aviation transport objects and systems and technological processes, including the using of automated computer design for the production of units, aggregates and systems of aviation transport objects.

1.3. Competences the subject makes it possible to acquire

As a result of discipline studying, the student must acquire the following **competencies**:

EPP «Airport technologies and technical equipment»


GC01. Knowledge and understanding of the subject area and understanding of professional activities.

GC03. Skills of using of information and communication technologies.

GC04. Ability to conduct research at the appropriate level.

GC05. Ability to search, to process and to analyze information of various sources.

GC06. Ability to identify, to set and to solve problems.

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GC07. Ability to make informed decisions.

GC09. Ability to evaluate and to ensure the quality of the performed works.

PC01. Ability to develop and to implement scientific and applied projects in the field of airport operation and operation of aviation equipment and airport equipment.

PC02. Ability to apply a systematic approach to solving engineering interdisciplinary problems in the field of airport operation and operation of aviation ground equipment and airport equipment.

PC04. Ability to integrate knowledge and to solve complex scientific and industrial problems in the field of airport operation and operation of aviation ground equipment and airport equipment, taking into account the wider interdisciplinary engineering context.

PC06. Ability to implement modern technologies, to research, to analyze and to improve technological processes in the field of airport operation and operation of aviation ground equipment and airport equipment.

EPP «Maintenance and repair of aircrafts and engines»

GC03. Skills of using of information and communication technologies.

GC04. Ability to conduct research at an appropriate level.

GC05. Ability to search, to process and to analyze information of various sources.

GC07. Ability to make informed decisions.

GC09. The ability to evaluate and to ensure the quality of the performed works.

PC01. Ability to develop and to implement scientific and applied projects in the field of aviation transport.

PC02. The ability to use the system approach to solving of engineering interdisciplinary problems in the field of aviation transport.

PC05. The ability to manage technological processes in the field of aviation transport, which are complex, unpredictable and require new strategic approaches.

PC06. Ability to implement modern technologies, to research, to analyze and to improve technological processes of aviation transport.

PC08. Ability to plan, to organize and to carry out scientific research in the field of aviation transport.

PC09. The ability to apply modern methods of modeling and experimental research of objects and technological processes of aviation transport.

PC12. The ability to develop production programs for technical maintenance, service, repair and other services in the operation of aviation equipment based on fundamental and special knowledge.

PC13. The ability to carry out technological calculations of the enterprise in order to determine the needs of personnel, production and technical base, materials, spare parts.

PC18. The ability to develop plans, programs and methods of research, practical recommendations for the use of research results.


PC19. Ability to develop of organizational and technical, regulatory and methodological documentation for technical operation and repair of aircrafts and aircraft engines.

1.4. Interdisciplinary connections

This discipline is based on the knowledge obtained during the preparation for the educational degree «Bachelor» and is the basis for the study of further disciplines, namely:

EPP «Airport technologies and technical equipment»

«Business Foreign Language», «Information Technologies for Providing Maintenance Processes for Aviation Equipment», «Mathematical Modeling of Airport Technological Processes», «Operation of Aviation Ground Equipment and Airport Equipment», passing of Research Activities

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in the Field of Airport Technologies and Pre-diploma practice.

EPP «Maintenance and repair of aircrafts and engines»

«Information Technologies for Providing of Processes of Maintenance and Repair of Aircrafts and Engines», passing of Research Activities in the Field of Maintenance and Repair of Aircrafts and Engines and Pre-diploma practice.

2. COURSE TRAINING PROGRAM ON THE SUBJECT

2.1. The subject content

The educational material of the discipline is structured according to the modular principle and consists of one educational **module №1**, «Mathematical Methods for Modeling Systems and Processes», which is a logically complete, independent, integral part of the educational discipline, the mastery of it provides a modular control work and analyzing the results of its implementation.

2.2. Modular structuring and integrated requirements for each module

Module №1 «Mathematical Methods for Modeling Systems and Processes»

Module №1 integrated requirements:

To know:

– acquirement of knowledge of mathematical modeling and processes occur in these systems and processes;

– acquirement of the methods of conducting of experiments using mathematical models of systems and processes occur in these systems and processes, making decisions with their improvement

To be able:

– correctly set modeling tasks and organization of work on the implementation and use of models on the basis of mastering of the methods of system analysis;

– to create mathematical models of systems and processes that take place in these systems and processes;

– to conduct research using mathematical models built in specialized application program packages;

– to analyze the results of mathematical modeling in order to forecast the state and improve the objects are modeled;

– to make decisions based on modeling results.

Module 1. «Mathematical Methods for Modeling Systems and Processes»

Topic 1.1. General provisions and definitions of mathematical modeling of systems and – correctly set modeling tasks and organization of work on the implementation and use of models on the basis of mastering of the methods of system analysis;

– to create mathematical models of systems and processes that take place in these systems and processes;

– to conduct research of using of mathematical models are built in specialized application program packages;


– to analyze the results of mathematical modeling in order to forecast the state and to improve the modeled objects;

– to make decisions based on processes modelling results.

The subject of the theory of decision-making. Modeling in economy and industry. Types of models. Classification of operations of problems research. Examples of problems of research operations. Brief historical reference.

Topic 1.2. Basic properties of linear programming problems.

The general problem of linear programming. Two standard forms of linear programming

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problems. The canonical form of the basic problem of linear programming. Geometric interpretation of linear programming problems. Basic analytical properties of linear programming problems. A graphical method of solving of linear programming problems.

Topic 1.3. A simplex method of solving of linear programming problems.

The idea of the simplex method. Algorithm for finding of reference plan. Algebra of the simplex method. Simplex tables. Artificial basis method (M-method). Alternative optimum and fixation in linear programming problems.

Topic 1.4. Duality and sensitivity analysis.

Definition of a dual (conjugate) problem. Correlation between optimal solutions of direct and dual problems. Economic interpretation of duality. Dual simplex method. Matrix representation of simplex calculations. Sensitivity analysis of the optimal solution.

Topic 1.5. Transport problem.

Formulation of the transport problem and features of its structure. Finding of reference plans of the transport problem. The method of potentials for finding of solutions of the transport problem. Alternative optimum and degeneracy in transport problems. The transport problem with the limitation of capacity. Economic analysis of transport problems. Transport problem according to the criterion of time. Application of transport models for solving of some economic problems.

Topic 1.6. Integer linear programming.

Characteristics of integer programming problems and methods of solving. Formulation of the problem of integer linear programming. The Gomori method. The method of branches and boundaries. Additive algorithm for problems with boolean variables.

Topic 1.7. Nonlinear programming.

General formulation of the problem. Graphical method. Classic methods of optimization. Convex programming. Quadratic programming. Nonlinear problems with separable functions. Fractional linear programming problems. Multi-criteria optimization problems.

Topic 1.8. Dynamic programming.

Dynamic programming method. Some economic problems are solved by dynamic programming methods. General statement of the problem of dynamic programming. The principle of optimality.

Topic 1.9. Stochastic programming.

Formulation of stochastic problems. Methods of solving of stochastic programming problems. Probabilistic dynamic programming.

Topic 1.10. Deterministic models of inventory management.

Generalized inventory management model. The classic problem of the economic order size. The problem of economic order placement with price gaps. Model of production processes.

Topic 1.11. Mass service systems (MSS).

Markov processes. Flow of events. Formulation of the problem, characteristics and classification of MSS. Models of birth and death. Some simple MSS.

Topic 1.12. Methods of network planning.

Basic concepts. Critical path method. Network minimization. The problem of finding of the shortest path. Consideration of cost factors during implementing of network schedule.

Topic 1.13. Theory of games and decision-making.

Classification of decision-making conditions. Hierarchy analysis method. Decision-making under conditions of risk. Decision-making in conditions of uncertainty. Basic concepts of game theory. Methods of solving of antagonistic matrix games.

2.3. Training schedule of the subject

№ ser.	Name of topic	Classes Workload (hours)			
		Full-time education			
		Total	Lectures	Laboratory classes	Self-study
1	2	3	4	5	6
1.1	General positions and definitions of mathematical modeling of systems and processes.	7	2	–	5
1.2.	Using of the MS Excel table editor to solve optimization problems	4	–	2	2
1.3	Basic properties of linear programming problems. A simplex method of solving of linear programming problems	7	2	–	5
1.4	Construction of economic and mathematical models and determination of their optimal plans	4	–	2	2
1.5	Duality and sensitivity analysis	7	2	–	5
1.6	Solving problems of the transport type	4	–	2	2
1.7	Transport problem	7	2	–	5
1.8	Finding a solution of the transport problem with prohibitions	4	–	2	2
1.9	Integer linear programming	7	2	–	5
1.10	Dynamic programming	4	–	2	2
1.11	Technical departments of the special transport division of the airport	7	2	–	5
1.12	Models of network planning	4	–	2	2
1.13	Stochastic programming. Deterministic models of inventory management.	7	2	–	5
1.14	Network planning models	4	–	2	2
1.15	Mass service systems. Methods of network planning	7	2	–	5
1.16	Tasks of games theory	4	–	2	2
1.17	Theory of games and decision making	5	1	–	4
1.18	Execution of Calculation and Graphic Work	10	–	–	10
1.19	Module Test № 1	2	–	1	1
Total on the Module № 1		105	17	17	71
Total on the 1st semester		105	17	17	71
Total on the discipline		105	17	17	71


2.4. Calculation and Graphic Work

Calculation and Graphic Work (CGW) of the discipline is carried out with the purpose of consolidating and improving of the theoretical knowledge and skills are acquired by the student in the process of mastering the educational material of the discipline in the field of mathematical modeling of technological and technical systems and processes related to aviation transport.

The task of CGW is to build a mathematical model of the system of operation of aviation equipment at the airport.

Execution, registration and defending of the CGW is carried out by the student in an individual manner in accordance with methodical recommendations.

Required time to complete the CGW is up to 10 hours of self-study.

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2.5. List of questions for the exam

The list of questions and the content of tasks for the exam preparation are developed by the leading lecturer of the department in accordance with the Course Training Program, approved by the department and informed to the attention of the students.

3. BASIC CONCEPTS OF GUIDANCE ON THE SUBJECT

3.1. Teaching methods

The following educational methods are used during studying the discipline:

- explanatory-illustrative method;
- method of problem exposition;
- reproductive method;
- research method.

These methods realization is provided during lectures, demonstrations, individual tasks solution, reading of educational literature, analysis and resolution of conflict situations during the planning of technological processes at the airport.

3.2. List of references

Basic references

3.2.1. Математичні методи дослідження операцій. Лінійне програмування. Частина 1: навчальний посібник / А. А. Яровий, Л. М. Ваховська, Л. В. Крилик. – Вінниця: ВНТУ, 2020 – 86 с.

3.2.2. Основи дослідження операцій у транспортних системах: приклади та задачі: навчальний посібник для ВНЗ / Д. М. Козаченко, Р. В. Вернигора, В. В. Малашкін; Дніпропетр. нац. ун-т залізн. трансп. ім. акад. В. Лазаряна. – Дніпропетровськ, 2015 – 277 с.

3.2.3. Hamdy A. Taha Operations Research: An Introduction, University of Arkansas, Fayetteville, 2007, 838 p.

Additional references

3.2.4. Карагодова О.О. Дослідження операцій: навч. посіб. / О. О. Карагодова, В. Р. Кігель, В. Д. Рожок. – К.: ЦУЛ, 2007 – 256 с.

3.2.5. Зайченко Ю. П. Дослідження операцій: підручник / Зайченко Ю. П. – К.: ВД «Слово», 2006 – 816 с.

3.2.6. Катренко А. В. Дослідження операцій: підручник / А. В. Катренко. – Львів: «Магнолія Плюс», 2004 – 549 с.

3.2.7. Наконечний С. І. Математичне програмування: навч. посіб. / С. І. Наконечний, С. С. Савіна. – К.: КНЕУ, 2003 – 452 с.

3.3. Information sources on the Internet

3.3.1. <https://www.mathworks.com>

3.3.2. <https://www.maplesoft.com>

4. RATING SYSTEM OF KNOWLEDGE AND SKILLS ASSESSMENT

4.1. The current grading of knowledge and skills acquired by the student is carried out according to 5-point system, *rating grade* is given: 1, 2, 3, 4, 5.

4.2. The *current module rating grade* is determined as the average value of the sum of the *rating grades* of all types of classes and control, provided by the educational work program (lectures, laboratory works and practical works, homeworks, TP, CP, testing, module test, graded test and exam, etc.).

4.3. The correspondence of the *current module rating grade* to the minimum value of the student's knowledge mark according to the 100-point scale of the European Credit Transfer System (ECTS) is established according to Table 1 (column 2).

Table 4.1

Current Module Grade	Minimal Grade Value of ECTS	Incentive Points	Total Grade of ECTS	Grade	Index
5	90	0-10	90 - 100	Excellent	A
4,5 - 4,9	82	0-10	82 - 89	Good	B
4,0 - 4,4	75	0-10	75 - 81	Good	C
3,5 - 3,9	67	0-10	67 - 74	Satisfactory	D
3,0 - 3,4	60	0-10	60 - 66	Satisfactory	E
2,5 - 2,9	35	0	35 - 59	Unsatisfactory	FX
1,0 - 2,4	1	0	1- 34	Unsatisfactory	F

4.4 The sum of incentive points according to table 2, which characterize the student's attitude to studying of the discipline (no more than 10 points), is added to the minimum value of the ECTS grade.

Table 4.2

№ ser.	Incentive Criterion	Points
1	Absence of missed classes	0 - 3
2	Activity during classes	0 - 3
3	Defending of works in time	0 - 2
4	Correct behavior	0 - 2

4.5. The sum of the minimal ECTS grade and incentive points are the *Total (Module, Semester) Grade*, which is entered in the module test report, study card, individual curriculum of the student, record book and diploma supplement, for example, as follows: **92 / Excellent / A, 87 / Good / B, 79 / Good / C, 68 / Sat./D, 65 / Sat./E**, etc.



(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 ознайомлення	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	Анульованого			

(Ф 03.02 – 32)

УЗГОДЖЕННЯ ЗМІН

	Підпис	Ініціали, прізвище	Посада	Дата
Розробник				
Узгоджено				
Узгоджено				
Узгоджено				