MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY

Faculty of Architecture, Civil Engineering and Design
Computer Technologies of Airport Construction and Reconstruction Department

AGREED
Dean of the Faculty
_____ Viktor KARPOV
«_8_» ___12___ 2022

APPROVED
Vice Rector for Academics
_____ Anatolii POLUKHIN
«_14_» ___12___ 2022

Quality Management System

COURSE TRAINING PROGRAM
on
«Fundamentals of Computer Modeling»

Educational-Professional Program: «Industrial and Civil Engineering»
Field of study: 19 «Architecture and Construction»
Specialty: 192 «Building and Civil Engineering»

Form of training	Sem.	Total (hours/ ECTS credits))	Lec.	Prac.	Lab.	Self-study	Homeworks control works	CP/ TP	Form of control
Full-time	6	120 / 4,0	17	-	34	69	-	-	Graded Test 6th semester
Part-time	-	-	-	-	-	-	-	-	-

Index: СВ-5-192-1/21-3.10

QMS NAU CTP 10.01.04-01-2022

The Course Training Program on «Fundamentals of Computer Modeling» is developed on the basis of the Educational-Professional Program "Industrial and Civil Engineering", Bachelor Curriculum and Extended Curriculum № CB-5-192-1/21, № ECB-5-192-1/21 for training higher education seekers of the Bachelor degree of specialty 192 "Building and Civil Engineering" and corresponding normative documents.

Developed by:
Professor of the Computer Technologies
of Airport Construction and
Reconstruction Department _____ Maria BARABASH

Lecturer's assistant of the Computer Technologies
of Airport Construction and
Reconstruction Department _____ Andrii TOMASHEVSKYI

Discussed and approved by the Graduate Department for the Specialty 192 "Building and Civil Engineering" (Educational Professional Program "Industrial and Civil Engineering") – Computer Technologies of Airport Construction and Reconstruction Department, Minutes № 12 of "25" 10 2022.

Guarantor of the Educational and
Professional Program _____ Nataliia KOSTYRA

Head of the Department _____ Oleksandr LAPENKO

Vice Rector on International Collaboration and Education

_____ Iryna ZARUBINSKA

«12» 12 2022

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Master copy

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INTRODUCTION

The Course Training Program of the academic discipline 'Fundamentals of Computer Modelling' was developed on the basis of the "Methodological recommendations for the development and execution of the syllabus of educational discipline of full-time and part-time forms of training", approved by rector's order No.249/roz. of 29.04.2021 and relevant regulatory documents.

1. EXPLANATORY NOTE

1.1. Role, goal and objectives of the academic discipline.

The role: this course is a theoretical and practical basis of knowledge and skills that form the specialist who is able to solve complex non-standard problems and engineering / research problems in the field of construction and civil engineering on the basis of a set of scientifical methods of numerical modelling of the stress-strain state of structures. The specialist has knowledge of modern technologies in computer modelling of building structures.

The goal of the academic course is to provide the future specialist in construction with knowledge of the basic computer modelling in generation of design models of building structures using modern software.

The objectives of the academic discipline are:

– to master the practical skills to apply computer modelling methods in generating design models of building structures; to look into the software packages that implement numerical methods for analysis of building structures.

1.2. Educational outcomes of the academic discipline.

PLO1 – Apply basic theories, methods, and principles of mathematical, natural, social, humanistic, and economic sciences, modern models, methods, and decision-making support software to solve complex construction and civil engineering problems.

PLO6 – Apply modern information technologies to solve engineering and management problems of construction and civil engineering.

PLO9 – Design building structures, buildings, structures and engineering networks, taking into account engineering and resource-saving measures, legal, social, environmental, technical and economic indicators, scientific and ethical aspects, and modern requirements of regulatory documentation in the field of architecture and construction, environmental protection and labor safety.

1.3. Competencies obtained through the academic discipline.

GC5 – Ability to use information and communication technologies.

PC5 – Ability to use computer-aided design soft-ware and its specialized application for solving engineering problems of construction and civil engineering.

1.4. Interdisciplinary links.

This course is based on the knowledge of such courses as 'Higher Mathematics', 'Computer Science', 'Strength of Materials', 'Building Mechanics', 'Introduction to CAD', and is the basis for the study of further courses, namely: 'Computer technology for design of airport buildings and structures', 'Integrated technologies for design of buildings'.

2. PROGRAM OF THE ACADEMIC DISCIPLINE.

2.1. Content of the academic discipline

The training material of the course is structured on a modular basis and consists of one training module, namely:

educational module 1 'Fundamentals of computer modelling' is logically complete, relatively independent, integral part of the course; the mastering of the course involves a modular test and evaluation of its results.

2.2. Modular structure and integrated requirements for each module

Module 1 'Fundamentals of Computer Modelling'

Integrated requirements for the module 1: after mastering the training material, the student should:

To know:

- the fundamentals of finite element method;
- basic principles and rules for development of adequate design models for buildings and structures;
- basic information on advanced software packages that implement the finite element method for analysis of buildings and structures;
- tools and basic concepts of LIRA-SAPR program;
- the process of generating computer model of the object in LIRA-SAPR.

Be able to:

- to generate design model for static analysis of beam, arch, truss, 2D frame, slab, thick-walled cylinder, wall-beam in LIRA-SAPR;
- to compute geometric properties of the section with Cross-section Design Toolkit module;
- to generate design model for static/dynamic analysis of the frame in LIRA-SAPR;
- to obtain and evaluate the output data from analysis of 3D design model of the structure in LIRA-SAPR;
- to evaluate the output data.

Topic 1. Computer technology in complex and system automation of design process.

Introduction. Computer technologies for the design, construction, reconstruction and maintenance of airport buildings and structures. Development of methods for analysis of buildings and structures: from graph-analytical techniques to computer models. Review, possible development of computer modelling technologies.

Topic 2. Introduction to LIRA-SAPR software.

Software tools for computer technology in analysis and design of structures. Preparing for model generation in LIRA-SAPR. Generating new project to carry out analysis and define its name. Defining directories, units of measurement.

Topic 3. General theoretical fundamentals of the finite element method (FEM).

Fundamentals of FEM. Application of FEM in analysis of buildings and structures. Library of finite elements. Static and dynamic analyses. Physical and geometric nonlinearity.

Topic 4. Techniques for generating design models.

Generation of design model. Types of elements, boundary conditions, hinges, stiffness. Load application. Carrying out analysis. Generating design model and computing displacements and internal forces in a single-span beam in LIRA-SAPR.

Topic 5. Idealization of the object when generating computer model.

Abstraction, selecting the object properties that are important for analysis. Idealization, defining the values of object properties accepted for analysis. Techniques, tools and methods of working with LIRA-SAPR.

Topic 6. Principles for generating design of the bar system for the FEM analysis.

Generating design model of the truss and determining forces in LIRA-SAPR. Generating design model of the frame and determining the forces in LIRA-SAPR.

Topic 7. Computer implementation. Software packages are the basis of computer modelling tools.

Review of software packages LIRA-SAPR, MONOMAKH-SAPR, SAPFIR. Other software packages for the FEA. Generating design model of the frame of an industrial building and determining the forces in LIRA-SAPR. Generating design model of the arch and determining the forces in LIRA-SAPR.

Topic 8. Software tools for computer technology of analysis and design of structures.

Basic modelling. Computing geometric properties of the section with Cross-section Design Toolkit module.

Topic 9. Loads applied to the elements of design model.

Types of loads. Static, dynamic loads. Nodal and distributed loads. Uniform and non-uniform loads. Methods to edit loads.

Topic 10. Auto-generated documents with analysis results.

The concept of analysis results. Tools for generating documentation with analysis results of the stress-strain state. Documentation of analysis results in LIRA-SAPR.

Topic 11. General functioning of LIRA-SAPR software.

Generating a design model of the slab and determining the max deflection of the slab from a certain load, considering its dead weight in LIRA-SAPR.

Topic 12. Design combinations of forces (DCF). Design combinations of loads (DCL).

Rules to define design combinations of forces (DCF). Classification of DCF. Parameters of DCF. Load factors. Sign variability of loads. Logical bindings between loads. DCF coefficients. Generating design model of a continuous beam. Computing the most unfavourable combination of forces for each span.

Topic 13. Analysis protocol.

Possible errors and warnings during analysis procedure. Geometric variability in analysis. Methods of fixing errors, control over analysis. Evaluation of analysis results. Analysis of a thick-walled cylinder (2D problem of the theory of elasticity) in LIRA-SAPR.

Topic 14. Nonlinear analysis of structures.

The concept of load history, step-type method of nonlinear analysis. Generating geometric design model of the wall-beam and determining components of the displacement tensor in LIRA-SAPR. Stability analysis of the frame in LIRA-SAPR. Diagram of internal forces, buckling mode, effective length of compressed bars in the frame.

Topic 15. Dynamic analysis of structures.

Natural mode shapes and natural frequencies of vibrations. Internal forces in the structure during the movement of the system by its own mode shapes.

2.3. Thematic plan.

No.	Topic	Academic hours							
		Full-time study				Part-time study			
		Total	Lectures	Lab. works	Self-study	**Total**	Lectures	Lab. works	Self-study
1	2	3	4	5	6	7	8	9	10
Module No. 1 'Basics of computer modelling'									
		6th semester							
1.1	Computer technology in complex and system automation of design	8	2	2	4	-	-	-	-
1.2	Introduction to LIRA-SAPR	7	-	2	5	-	-	-	-
1.3	Fundamentals of the finite element method (FEM)	8	2	2	4		-	-	-
1.4	Techniques of model creation	7	-	2	5	-	-	-	-
1.5	Idealization of an object for the model creation	8	2	2	4	-	-	-	-
1.6	Creation of a model of the bar system for FEA	9	2	2	5	-	-	-	-
1.7	Computer implementation. Software packages are the basic tools in computer modelling	8	2	2	4	-	-	-	-
1.8	Software tools for computer technology in analysis and design of structures	6	-	2	4	-	-	-	-
1.9	Loads applied to the elements of design model	7	-	2	5	-	-	-	-
1.10.	Software tools for computer technology in analysis and design of structures	8	2	2	4	-	-	-	-
1.11.	Auto-generation of analysis results	7	-	2	5	-	-	-	-
1.12.	Principal functionality of LIRA-SAPR software	6	-	2	4	-	-	-	-
1.13.	Design combinations of forces (DCF). Design combinations of loads (DCL)	8	2	2	4	-	-	-	-
1.14.	Analysis protocol	6	-	2	4	-	-	-	-
1.15.	Special features of nonlinear structural analysis	8	2	2	4	-	-	-	-
1.16.	Special features of dynamic structural analysis	6	-	2	4	-	-	-	-
1.17.	Modular test 1	3	1	2	-	-	-	-	-
Total for Module 1		**120**	**17**	**34**	**69**	**-**	**-**	**-**	**-**
Total for Academic Discipline		**120**	**17**	**34**	**69**	**-**	**-**	**-**	**-**

2.4. Questions to prepare for the final test.

The list of questions and the tasks for preparation for the final test are developed in accordance with the course schedule, approved at the meeting of the department and provided to the students.

3. TRAINING MATERIALS FOR THE DISCIPLINE

3.1. Training methods

The following teaching-training methods are used in the course study:

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

These methods are implemented in lectures, demonstrations, independent problem solving, work with educational literature, analysis and evaluation of problems in structural mechanics with the help of computer tools.

3.2. Recommended literature

Basic literature

3.2.1. Барабаш М. С. Основи комп'ютерного моделювання / М. С. Барабаш, П. М. Кір'язєв, О. І. Лапенко, М. А. Ромашкіна // Навчальний посібник. – К.: НАУ, 2018. – 492 с.

3.2.2. Барабаш М. С. Комп'ютерні технології проєктування металевих конструкцій / М. С. Барабаш, С. В. Козлов, Д. В. Медведенко // Навчальний посібник. – К.: НАУ, 2012. – 572 с.

3.2.3. Барабаш М. С. Комп'ютерне моделювання процесів життєвого циклу об'єктів будівництва: Монографія (рос. мова) / М. С. Барабаш. – Київ.: Вид-во «Сталь», 2014. – 301 с.

3.2.4. Барабаш М. С. Нелінійна будівельна механіка з ПК ЛІРА-САПР / М. С. Барабаш, М. М. Сорока, М. Г. Сур'янінов // Монографія. – Одеса: Екологія, 2018. – 248 с.

3.2.5 Городецкий О. С. Комп'ютерні моделі конструкцій (рос.мова) / О. С. Городецкий, І. Д. Євзєров. – [2-е изд., доп.]. – Київ :Вид-во «ФАКТ», 2007. – 394 с.

Additional literature

3.2.6 LIRA-SAPR 2013. Manual / [D. A. Gorodetsky, M. S. Barabash, R. Y. Vodopjyanov, etc.]; edited by academician of RAACS A. S. Gorodetsky. – M., 2013. – 376 p.

3.2.7. A. S. Gorodetsky. Computer modelling in problems of structural mechanics: manual / A. S. Gorodetsky, M. S. Barabash, V. N. Sidorov. – M.: Publisher ABC, 2016. – 338.

3.2.8 M. S. Barabash. SAPFIR and LIRA-SAPR software forms the basis of domestic BIM technologies. M. S. Barabash, O. I. Palienko, D. V. Medvedenko. – 2nd ed. – M.: Yuright, 2013. – 366 c.

3.3. Internet information resources

3.3.1. http://er.nau.edu.ua/handle/NAU/24905

3.3.2. http://www.lib.nau.edu.ua/main/

3.3.3. Методичні розробки кафедри (в електронному вигляді).

4. RATING SYSTEM OF KNOWLEDGE AND SKILLS ASSESSMENT

4.1. Evaluation of certain types of work done by students of the points made in accordance with Tables.4.1.

Table 4.1

Kind of Academic Activities	Maximum Grade	
	Full-time study	**Part-time study**
	6th semester	-
Module 1 'Fundamentals of computer modelling'		
Laboratory works	70	-
For carrying out a module test a student must receive not less than	*42*	-
Final test paper for module 1	30	-
Total for Module 1	**100**	**-**
Total for Academic Discipline	**100**	

A Semester Grade is determined (in points and on a national scale) according to results of all types of educational work during the term.

4.2. A student is considered to have passed the module if both his/her Current Module Grade and Module Test Grade are positive.

4.3. The Semester Module Grade is calculated as the sum of the Total Module Grades.

4.4. The Semester Module Grade and the Graded Test together make up a Total Semester Grade which is calculated according to the National Scale and the ECTS Scale.

4.5. The Total Semester Grade in points, the National Scale and the ECTS Scale is written into a student's record book, for example: ***92/Ex/A, 87/Good/B, 79/Good/C, 68/Sat/D, 65/Sat./E***, etc.

4.6. The Total Semester Grade of the subject is determined as the arithmetic average grade of the total semester grades in points (for the fourth semester for this subject) with its further transfer into the National Scale and ECTS Scale. The indicated Total Semester Grade of the subject is entered in the Diploma Supplement.

(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

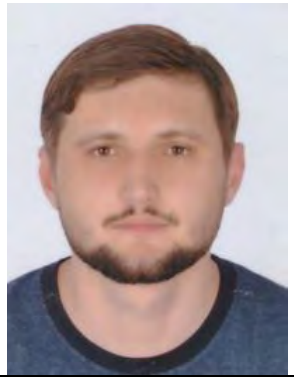
№ зміни	№ листа (сторінки)				Підпис особи, яка внесла зміну	Дата внесення зміни	Дата введення зміни
	Зміненого	Заміненого	Нового	Анульо-ваного			

(Ф 03.02 – 32)

УЗГОДЖЕННЯ ЗМІН

	Підпис	Ініціали, прізвище	Посада	Дата
Розробник				
Узгоджено				
Узгоджено				
Узгоджено				

	Syllabus of the academic discipline **«FUNDAMENTALS OF COMPUTER MODELING»** **Educational and professional program:** **«Industrial and Civil Engineering»,** **Field of study: 19 «Architecture and Construction»** **Specialty: 192 «Building and Civil Engineering»**
Level of higher education	First (Bachelor)
Discipline status	Academic discipline of the selective component
Course	3
Semester	6
ECTS credits / hours	4,0 / 120
Language of training	English
What will be studied (subject of study)	Computer modeling of buildings and structures, finite element method.
Why is it interesting / necessary to study (goal)	The goal of the academic course is to provide the future specialist in construction with knowledge of the basic computer modelling in generation of design models of building structures using modern software.
Why can you learn (learning outcomes)	To be able to apply basic theories, methods and principles of mathematical, natural, humanities/social/economic sciences, modern models, methods and software to support decision-making process to solve complex problems in construction and civil engineering; to apply modern information technology to solve engineering and management problems in construction and civil engineering; to design building structures, engineering networks and technological processes in construction with account of engineering and resource-saving measures, legal, social, environmental, technical and economic indicators, scientific and ethical aspects, and modern requirements of regulatory documents, time and other limitations in the field of architecture and construction, environmental protection and labor protection.
How to use the acquired knowledge and skills (competencies)	The acquired knowledge and skills will allow students to use computer-aided design systems and special software to solve engineering problems in construction and civil engineering.
Educational logistics	**Contents:** Computer technologies of design, construction, reconstruction and technical operation of buildings and airport structures. The essence of the finite element method (FEM). Application of FEM in analysis of buildings and structures. Finite element library. Static and dynamic analyses. Physical and geometric nonlinearity. Creation of a design model, abstraction and idealization. Loads acting on the elements of the design model. Concept of construction calculation results. Calculating of design combinations of forces. Analysis of calculation results. Concept of loading history, step method of non-linear analysis. Concept of eigenforms and eigenfrequencies of oscillations. **Classroom sessions:** lectures, practicals. **Teaching methods:** problem lectures, online. **Form of training:** full-part
Prerequisites	Knowledge of the basics of higher mathematics, informatics, strength

	of materials, structural mechanics, CAD systems.
Postrequisites	'Computer technology for design of airport buildings and structures', 'Integrated technologies for design of buildings'.
Information support from the repository and fund of NTB NAU	1. M. S. Barabash. Fundamentals of computer modelling / M. S. Barabash, P. M. Kirjyazev, O. I. Lapenko, M. A. Romashkina // Study guide. – K.: NAU, 2018. – 492 p. 2. M. S. Barabash. Computer technologies for design of steel structures / M. S. Barabash, S. V. Kozlov, D. V. Medvedenko // Study guide. – K.: NAU, 2012. – 572 p.
Location and logistics	projection equipment
Semester control, examination methods	tests, modular test
Department	Computer technologies of airport construction and reconstruction
Faculty	Architecture, civil engineering and design
Professor	 **БАРАБАШ МАРІЯ СЕРГІЇВНА** **Position:** Professor **Scientific degree:** Doctor of Sciences **Academic title:** Professor **Tel.:** 406-74-25 **E-mail:** mariia.barabash@npp.nau.edu.ua **Room:**5.510  **ТОМАШЕВСЬКИЙ АНДРІЙ ВОЛОДИМИРОВИЧ** **Position:** Lecturer's Assistant **Tel.:** 406-74-25 **E-mail:** andrii.tomashevskyi@npp.nau.edu.ua **Room:**5.510
Originality of academic discipline	Author's course
Link to discipline	