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
«26» 10 2022

APPROVED
Vice Rector for Academics
_____ Anatolii POLUKHIN
«28» 10 2022

Quality Management System

COURSE TRAINING PROGRAM
on
"Numerical Methods for Structural Design"

Educational and 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	Home-works control works	CP / TP	Form of control
Full-time	5	120/4,0	17	34	-	69	-	-	Graded Test 5st semester
Part-time	-	-	-	-	-	-	-	-	-

Index: ECB - 5 - 192 - 1/22 -3.7

The Course Training Program on "Numerical methods in the calculation of building structures" is developed on the basis of the Educational-Professional Program "Industrial and Civil Engineering" Bachelor Curriculum and Extended Curriculum № CB - 5 - 192 - 1/22, № ECB-5-192-1/22 for training higher education seekers of the Bachelor degree of specialty 192 "Building and Civil Engineering" and corresponding normative documents.

Developed by:

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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.

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«24» 10 2022

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CONTENTS

INTRODUCTION

The Course Training Program of the academic discipline "Numerical Methods for Structural Design" 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 of the discipline is the theoretical and practical basis of the set of knowledge and skills that form the profile of a specialist in the field of industrial and civil construction, enabling design engineers to freely navigate the issues of automating calculations of building structures and structures.

The goal of the academic discipline is the formation of a system of knowledge and skills regarding basic mathematical approaches that will allow solving equations describing the work and state of structures; the study of mathematical formulation and algorithmization of a range of tasks included in the general complex of civil engineer training.

The objectives of the academic discipline are:

- mastering modern mathematical methods that will allow solving equations describing the work and condition of structures;
- mastering the methods of mathematical formulation and algorithmization of a range of tasks when designing structures of buildings and structures.

1.2. Educational outcomes of the academic discipline

As a result of studying the discipline, students of higher education acquire knowledge about the main numerical methods and mathematical models that are widely used in solving problems related to the design and construction of buildings and structures; independently, when solving a specific problem, make a comparative qualitative assessment of existing numerical methods, choose and use the most effective methods in terms of accuracy, labor intensity, and ease of use on a personal computer; justify and analyze the results of mathematical modeling.

1.3. Competencies obtained through the academic discipline

According to the content of the discipline, the student of higher education must acquire the following competencies: know the connection of numerical methods with the automated solution of problems of design, construction and technical operation of buildings and structures; mathematical modeling and elements of theory; methods of solving systems of algebraic equations; basic methods of solving nonlinear algebraic equations and systems of functional nonlinear equations;

approximate functions and formulation of the problem of approximation, interpolation of functions; introduction to mathematical programming methods; the general essence of linear programming problems.

General competences that the educational discipline makes possible to acquire: GC2 – Knowledge and understanding of the subject area and professional activity, GC6 – Ability to independently acquire knowledge by searching, processing and analyzing in-formation from various sources.

Professional competences that the educational discipline makes it possible to acquire: PC1 – Ability to use conceptual scientific and practical knowledge of mathematics, chemistry and physics to solve complex practical problems in construction and civil engineering; 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.

The academic discipline "Numerical Methods for Structural Design" has an interdisciplinary nature and combines courses of professional training disciplines. This discipline is based on the knowledge of such disciplines as "Higher Mathematics", "Physics", "Introduction to Computer-Aided Design", "Fundamentals of Programming" and is the basis for studying the discipline: "Structural Mechanics (Special Course)", " Reinforced Concrete and Stone Structures".

2. PROGRAM OF ACADEMIC DISCIPLINE

2.1. Content of the academic discipline

The educational material of the discipline is structured according to the modular principle and consists of **two educational modules**, namely:

- educational module No. 1 "*Basic methods of solving systems of linear equations. Introduction to the theory of approximate functions and approximate calculations*";
- educational module No. 2 "*Introduction to integral calculations and elements of mathematical physics*", each of which is a logically completed, relatively independent, integral part of the educational discipline, the mastery of which involves conducting a modular control work and analyzing the results of its implementation

2.2. Module structure and integrated requirements for each module

Module № 1 «Basic methods of solving systems of linear equations. Introduction to the theory of approximate functions and approximate calculations»

Integrated requirements for module 1:

To know: the connection between the choice of the calculation scheme and the subsequent solution of the problem using numerical methods; elements of mathematical modeling, formulation of the problem of approximation and interpolation of functions.

Be able to: solve systems of linear algebraic equations; nonlinear algebraic equations and systems of functional nonlinear equations.

Topic 1. Connection of numerical methods with the automated solution of design, construction and technical operation of buildings and structures. Mathematical modeling and elements of theory.

Connection of numerical methods with the automated solution of design, construction and technical operation of buildings and structures. The main groups of construction problems that lead to the use of numerical methods. The connection between the choice of the calculation scheme and the subsequent solution of the problem using numerical methods. Elements of mathematical modeling.

Topic 2. Methods of solving systems of linear algebraic equations. Gaussian algorithm with principal element sampling. Iteration methods.

Systems of linear algebraic equations. The concept of conditioning of a system of linear algebraic equations. Gauss method for solving systems of linear algebraic equations. Gauss method with principal element sampling. Kramer's method. Simple iteration method for solving systems of linear algebraic equations. Seidel's method. Classification of errors that arise when solving nonlinear and systems of linear algebraic equations. Elements of the theory of errors.

Topic 3. Basic methods of solving nonlinear algebraic equations and systems of functional nonlinear equations. Separation of the root of a nonlinear equation. Refinement of the root of the equation. Simple iteration method. Using the method of halving, the method of chords and tangents to clarify the roots.

Topic 4. Approximate functions. Setting the problem of approximation, interpolation of functions. Lagrange interpolation polynomial. Error estimation. Setting the problem of approximation, interpolation and smoothing of functions. Using polynomials to represent a function. Lagrange interpolation polynomial. The assessment is incorrect. Determination of parameters of empirical formulas. The method of least squares. Linear and parabolic alignment. Local smoothing of experimental data.

Module №2 «Introduction to integral calculations and elements of mathematical physics»

Integrated requirements for module 2:

To know: methods of approximate integration and methods of mathematical programming;

Be able to: solve problems of linear programming of the transport type, using the method of potentials, and apply them when solving similar problems in the construction industry.

Topic 1. Approximate integration. The practical necessity of approximate integration formulas.

Formulas of rectangles, trapezoids and Simpson. Quadrature formulas of Gauss.

Multiple integrals. Quadrature formulas. Method of uncertain coefficients. Newton-Cotes quadratic formulas. Orthogonal polynomials. Practical evaluation of quadrature error.

Topic 2. Multidimensional problems. Monte Carlo method.

General idea of the method. Approximate calculation of integrals by the Monte Carlo method. Convergence acceleration of the Monte Carlo method. Random and quasi-random numbers. Development of quasi-random numbers.

Topic 3. **Introduction to mathematical programming methods**. The general essence of linear programming problems.

Constraint system and objective function. Formulation of the problem of mathematical programming. Geometric interpretation of linear programming problems. Simplex method. Basic concepts. The sequence of actions in the implementation of the simplex method taking into account the artificial basis.

Topic 4. Transport problem and its varieties. The method of potentials for solving the transport problem.

Conversion of one-time substitution. Problems of linear programming of transport type. The method of potentials.

2.3. Thematic plan.

№	Topic	Academic hours							
		Full-time study				Part-time study			
		Total	Lecture	Practice	Self-study	Total	Lecture	Practice	Self-study
1	2	3	4	5	6	7	8	9	10
Module №1 «Introduction to the theory of approximate functions and approximate calculations»									
1.1	Connection of numerical methods with the automated solution of design, construction and technical operation of buildings and structures. Mathematical modeling and elements of theory.	**5 semester**				**6 semester**			
		8	2	2	4	-	-	-	-
1.2	Solution of the system of linear algebraic equations by the inverse matrix method, the Gauss method with the sampling of the main element, the Kramer method.	6	-	2	4	-	-	-	-
1.3	Methods of solving systems of algebraic equations. Gaussian algorithm with sampling of the main element. Iteration methods.	8	2	2	4	-	-	-	-
1.4	Solution of systems of linear algebraic equations by iterative methods.	6	-	2	4	-	-	-	-
1.5	Basic methods of solving nonlinear algebraic equations and systems of functional nonlinear	8	2	2	4	-	-	-	-

1	2	3	4	5	6	7	8	9	10
	equations.								
1.6	Approximate methods of solving nonlinear algebraic equations	6	-	2	4	-	-	-	-
1.7	Approximate functions. Formulation of the problem of approximation and interpolation of functions. Error estimation.	8	2	2	4	-	-	-	-
1.8	Lagrange interpolation polynomial. The method of least squares.	6	2	2	4	-	-	-	-
1.9	Module Test №1	6	-	2	4	-	-	-	-
Total for module №1		64	10	18	36	-	-	-	-
Module №2. "Introduction to integral calculus and elements of mathematical physics"									
2.1	Approximate integration. The practical necessity of approximate integration formulas.	8	2	2	4	-	-	-	-
2.2	Approximate calculation of definite integrals	6	-	2	4	-	-	-	-
2.3	Multidimensional problems. Monte Carlo method. General idea of the method.	8	2	2	4	-	-	-	-
2.4	Solving problems by the finite difference method	6	-	2	4	-	-	-	-
2.5	Introduction to mathematical programming methods. The general essence of linear programming problems.	8	2	2	4	-	-	-	-
2.6	Solving problems using the finite element method	6	-	2	4	-	-	-	-
2.7	Transport problem and its varieties. The method of potentials for solving the transport problem.	8	1	2	5	-	-	-	-
2.8	Module Test №2	6	-	2	4	-	-	-	-
2.9	Performance of control (home) work	-	-	-	-	-	-	-	-
2.10	Final semester test (FST)	-	-	-	-	-	-	-	-
Total for module №2		**56**	**7**	**16**	**33**	-	-	-	-
Total For Academic Discipline		**120**	**17**	**34**	**69**	-	-	-	-

2.4. Tasks for control (home) work (CHW).

The purpose of performing control (homework) work is to teach students to work independently with educational, reference, scientific and normative literature in order to consolidate and deepen the theoretical knowledge and skills acquired by the student in the process of assimilating the educational material, acquiring skills of independent development connection of engineering calculations of continuous structures.

The specific goal is the ability to independently implement numerical methods to solve a number of basic problems that arise in the design or research processes in construction. Execution, design and protection of the control work is carried out by the student individually in accordance with methodical recommendations.

The list of questions and the content of tasks for preparation for the final test are developed by the leading teacher of the department in accordance with the work program, approved at the meeting of the department and brought to the attention of students.

2.5. List of questions for preparing for the final test.

The list of questions and the content of tasks for preparation for the final test, developed in accordance with the work program, is approved at the department meeting and brought to the attention of students.

3. TRAINING MATERIALS FOR THE DISCIPLINE

3.1. Teaching methods

The following teaching methods are used when studying an academic discipline:

– explanatory and illustrative method;

– the problem statement method;

– reproductive method;

- research method

The implementation of these methods is carried out during lectures, practical classes, independent work, work with educational literature, solving problems on the calculation of building structures.

3.2. Recommended literature

Basic literature

3.2.1. Чисельні методи: Навчальний посібник. / Волонтир Л.О, Зелінська О.В., Потапова Н.А., Чіков І.А., Вінницький національний аграрний університет. – Вінниця: ВНАУ, 2020 – 322 с.

3.2.2.Чисельні методи розв’язання прикладних задач: навч. посіб. / О. А. Гончаров, Л. В. Васильєва, А. М. Юнда. – Суми : Сумський державний університет, 2020. – 142 с.

3.2.3. Методи обчислень: Частина 1. Чисельні методи алгебри [Електронний ресурс] : навч. посіб. /КПІ ім. Ігоря Сікорського ; уклад.: В. В. Третиник, Н. Д. Любашенко. – Електронні текстові дані (1 файл: 2,94 Мбайт). – Київ : КПІ ім. Ігоря Сікорського, 2019. – 138 с.

3.2.4. Чисельні методи в розрахунках будівельних конструкцій: Лабораторний практикум. / уклад.: С.М. Скребнєва, І.Л. Машков, І.А. Яковенко – К.: НАУ, 2015. – 52 с.

Additional literature

3.2.5. Чисельні методи : навчальний посібник / О. К. Колесницький, І. Р. Арсенюк, В. І. Месюра. – Вінниця : ВНТУ, 2017. – 130 с.

3.2.6. Мусіяка В.Г. Основи чисельних методів механіки: Підручник. – К.: Вища освіта, 2004. – 240 с.

3.2.7. Денисюк В. П. Чисельні методи: Текст лекцій. – К.: НАУ, 2003. – 76 с.

3.3. Internet information resourse

3.3.1. http://iap.nau.edu.ua/index.php/kafedry/komp-yuternikh-tekhnologij-budivnitstva

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

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

4. RATING SYSTEM OF KNOWLEDGE AND SKILLS ASSESSMENT

4.1. Evaluation of individual types of educational work performed by the student is carried out in points according to the table.4.1.

Table 4.1

Kind of Academic Activities	Max scores		Kind of Academic Activities	Max scores	
	Full-time education	Part-time education		Full-time education	Part-time education
5 semestr					
Module № 1 «Introduction to the theory of approximate functions and approximate calculations»			Module № 2 «Introduction to integral calculations and elements of mathematical physics»		
Kind of Academic Activities	values	values	Kind of Academic Activities	values	values
Practice	40	-	Practice	36	-
-	-	-	Performance of control (homework) work	-	-
For carrying out a module test a student must receive not less than	24	-	*For carrying out a module test a student must receive not less than*	22	-
Carrying out a module test №1	12	-	Carrying out a module test №2	12	-
			Final semester test	-	-
Total for module №1	52	-	**Total for module №2**	48	100
Total for module №1, №2				**100**	**100**
Total for academic discipline				**100**	

A Semester Grade is determined (in points and in the National Scale) as a result of performing all kinds of educational work during the semester.

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

"NUMERICAL METHODS FOR STRUCTURAL DESIGN»
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	5
ECTS credits / hours	4,0/ 120
Language of training	English
What will be studied (subject of study)	Mathematical formulation and algorithmization of a range of tasks included in the general complex of civil engineer training.
Why is it interesting / necessary to study (goal)	The goal of teaching the discipline is the formation of a system of knowledge and skills about basic mathematical approaches that will allow solving equations describing the work and condition of building structures.
Why can you learn (learning outcomes)	The student of higher education acquires knowledge of basic numerical methods and mathematical models that have been widely used in solving problems related to the design of buildings and structures.
How to use the acquired knowledge and skills (competencies)	General competences that the educational discipline makes possible to acquire: GC2 – Knowledge and understanding of the subject area and professional activity, GC6 – Ability to independently acquire knowledge by searching, processing and analyzing in-formation from various sources. Professional competences that the educational discipline makes it possible to acquire: PC1 – Ability to use conceptual scientific and practical knowledge of mathematics, chemistry and physics to solve complex practical problems in construction and civil engineering; PC5 – Ability to use computer-aided design software and its specialized application for solving engineering problems of construction and civil engineering.
Educational logistics	Content of the discipline: Introduction to the theory of approximate functions and approximate calculations. Connection of numerical methods with the automated solution of design, construction and technical operation of buildings and structures. Mathematical modeling and elements of theory. Methods of solving systems of algebraic equations. Gaussian algorithm with principal element sampling. Iteration methods. Basic methods of solving nonlinear algebraic equations and systems of functional nonlinear equations. Approximate functions. Setting the problem of approximation, interpolation. Lagrange interpolation polynomial. Determination of parameters of empirical formulas. The method of least squares. Linear and parabolic alignment. Local smoothing of experimental data. Approximate integration. The practical necessity of approximate integration formulas. Formulas of rectangles, trapezoids and Simpson. Quadrature formulas of Gauss. Multiple integrals. Introduction to mathematical programming methods. The general essence of linear programming problems. Formulation of a mathematical programming problem. Geometric interpretation of linear programming problems. Simplex method. Calculation methods of construction structures and structures. Finite difference method. Finite difference method for two-dimensional domains. Variational and variational-difference methods. Variational principles. Energy space. The Ritz method. The Bubnov-Galyorkin method. Main and natural boundary conditions. The Treftz method. Finite element method. Calculation of rod systems. Solving problems of the plane-stressed state of an elastic body. Calculation of thin plates. The method of finite elements in the calculation of arrays.

	Types of classes: lectures, practical classes **Teaching methods**: explanatory and illustrative method, problem presentation method, reproductive and research methods. **Forms of education**: full-time, part-time	
Prerequisites	"Higher mathematics", "Physics", "Informatics"	
Porekvizyty	"Construction mechanics", "Mechanics of a rigid deformed body", "Basics of programming", "Reinforced concrete and stone structures".	
Information support from the repository and fund of NTL NAU	Denysyuk V. P. Numerical metods: Lecture. – K.: NAU, 2003. – 76 p. Kalayda O. F. Numerical metods (basis of the calculate mathematics): Tuto-rial. - K.: Publishing House - Printing Center "Kyiv University", 2000. – 249 p. Numerical methods in the calculation of building structures: Laboratory practice. / comp.: S.M. Skrebneva, I.L. Mashkov, I.A. Yakovenko – K.: NAU, 2015. – 52 p. Musyaka V.G. Fundamentals of numerical methods of mechanics: Textbook. - K.: Higher education, 2004. – 240 p.	
Location and logistic	http://www.lib.nau.edu.ua	
Semester control, examination methods	tests, module test	
Department	Computer technologies of airport construction and reconstruction	
Faculty	Archictecture, civil engineering and design	
Professors		**Skrebneva Svitlana Mykolayivna** **Position: associate professor** **Scientific degree: candidate of technical sciences** **Academic rank: associate professor** **Teacher profile: (http://iap.nau.edu.ua/index.php/prepod-ktb)** **Phone: 044-406-74-24** **E-mail: 3879643@npp.nau.edu.ua** **Workplace: building 5, 5.510**
		**KRAYUSHKINA KATERYNA** **Position:** Associate Professor **Scientific degree:** Candidates of Sciences **Academic title:** Associate Professor **Profile:** http://iap.nau.edu.ua/index.php/prepod-ktb **Phone:** 044-406-72-89 **E-mail:** kateryna.krayushkina@npp.nau.edu.ua **Room:** 5.307
Originality of academic discipline	Author's course	
Link to discipline		