Federal State Autonomous Educational Institution of Higher Education
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA NAMED AFTER PATRICE LUMUMBA
RUDN University

Academy of Engineering
educational division (faculty/institute/academy) as higher education programme developer

COURSE SYLLABUS

Applications of Finite Element Method for Civil Engineering problems
course title

Recommended by the Didactic Council for the Education Field of:

08.04.01 Civil Engineering
field of studies / speciality code and title

The course instruction is implemented within the professional education programme of higher education:

Civil Engineering and Built Environment
higher education programme profile/specialisation title

2025

1. COURSE GOAL(s)

The goal of the course Applications of Finite Element Method for Civil Engineering problems is to gain knowledge, skills, skills and experience in the field of calculation of structures and structures that characterize the stages of competence formation and ensure the achievement of the planned results of the development of the educational program.

The main objectives of the discipline Applications of Finite Element Method for Civil Engineering problems are the following. FEM in the calculations of building structures is an experimental and theoretical science, where experimental data and theoretical studies are widely used. Various structures and structures, the design and construction of which is engaged in the engineer, must be de-signed for strength, rigidity, stability. This discipline teaches the student the correct selection of finite elements and their sizes for solving specific construction problems using the method of forces or displacements

2. REQUIREMENTS FOR LEARNING OUTCOMES

The course Applications of Finite Element Method for Civil Engineering problems implementation is aimed at the development of the following competences (competences in part):

Table 2.1. List of competences that students acquire during the course «Applications of Finite Element Method for Civil Engineering problems»

Competence code	**Competence descriptor**	**Competence formation indicators** (within this course)
PC-2	Development of project products based on the results of engineering and technical design for urban development activities	PC-2.1 Capable of performing engineering and technical design and developing design products for building structures, grounds and foundations; PC-2.2 Able to perform engineering and technical design and develop design products for engineering systems and engineering structures

3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

The course Applications of Finite Element Method for Civil Engineering problems refers to the *elective component* of (B1) block of the higher educational programme curriculum.

Within the higher education programme students also master other disciplines (modules) and / or internships that contribute to the achievement of the expected learning outcomes as results of the course Applications of Finite Element Method for Civil Engineering problems.

Table 3.1. The list of the higher education programme components that contribute to the achievement of the expected learning outcomes as the internship results.

Competence code	**Competence descriptor**	**Previous courses / modules, internships**	**Subsequent courses / modules, internships**
PC-2	Development of project products based on the results of engineering and technical design for urban development activities	Digital technologies in construction; Structural Design in Steel; Nanotechnology in Civil Engineering; Structural Design in Reinforced Concrete: Special Topics; Structural Dynamics; Structural Design in Reinforced Concrete; Building materials:	Desin Practice; Technological Practice; Pre-Graduation Practice

		Special Topics; Structural Design in Steel: Special Topics; Modelling of Construction Processes	

4. COURSE WORKLOAD

The total workload of the course Applications of Finite Element Method for Civil Engineering problems is 3 credits.

Table 4.1. Academic activities types by periods of the higher education programme

Type of academic activities		**Total academic hours**	**Semester(s)**			
			3			
Contact academic hours		36	36			
including:						
Lectures (LC)		18	18			
Lab works (LW)		0	0			
Seminars (workshops / tutorials) (S)		18	18			
Self-studies academic hours		45	45			
Evaluation and assessment academic hours		27	27			
Course work / project, credits			1			
Course workload	academic hours	108	108			
	credits	3	3			

5. COURSE CONTENTS

Modules	**Contents (topics)**	**Academic activities types ***
Section 1. Plane Stress and Plane Strain Theory	Topic 1.1 Plane stress and plan strain approximations. Coordinate systems. Displacement of material points. State of strain. State of stress. Stress equilibrium at a point. Topic 1.2 Constitutive equations. Boundary conditions. Differential form of the governing equations. Weighted residual method. Integral form of the governing equations.	LC, S
Section 2. Introduction to the finite element method	Topic 2.1 Finite element concept. Description of finite element shape. Quadrilateral elements. Triangular elements. Interpolation of variables in finite elements. Topic 2.1 Differentiation of functions in finite elements: Differentiation of shape functions. Differentiation of behavioral variables Topic 2.1 Integration of functions in finite elements: Integration over quadrilateral elements; Integration	LC, S

Modules	Contents (topics)	Academic activities types *
	over triangular elements. Topic 2.1 Numerical integration. One-dimensional Gauss integration: Gauss integration in quadrilaterals; Gauss integration in triangles	
Section 3. Potential energy and approximate analysis	This section will enable the student to: a) Develop the expressions for strain energy, work done and potential energy for beam and bar problems b) Understand and apply the concept of minimum potential energy. c) Understand the Rayleigh-Ritz method as an introduction to the finite element method	LC, S
Section 4. Finite element formulation and application of bar elements	This section will enable the student to: a) Recognize the displacement field and shape functions used in the formulation of a bar finite element. b) Derive the stiffness matrix as well as load vector due to various load conditions acting on a bar element. c) Perform a finite element analysis for a complete bar problem in order to evaluate displacements and stresses along the length of the bar. d) Judge on the accuracy of a specific bar element mesh used to solve a certain bar problem	LC, S
Section 5. Introduction to theory of elasticity	This section will enable the student to understand the basic equilibrium and kinematic equations, the constitutive relations as well as the potential energy expression for 2-D plane stress and plane strain elasticity problems	LC, S
Section 6. Shape functions for 2-D problems	This section will enable the student to: a) Recognize various types of elements used to solve 2-D plane problems. b) Recognize the natural coordinate systems, the shape functions used in various 2-D plane elements. c) Evaluate the Jacobian expression for various 2-D plane elements	LC, S
Section 7. Finite element formulation and application by constant stress triangular (CST) element	This section will enable the student to: a) Derive the stiffness matrix as well as the load vector due to various load conditions acting on a CST element. b) Know how to handle the effect of inclined boundaries. c) Perform finite element analysis of 2-D problems using CST elements.	LC, S
Section 8. Practical consideration in modelling	This section will enable the student to: a) Recognize some basic considerations when laying out a finite element mesh including element size and grading.	LC, S

Modules	Contents (topics)	Academic activities types *
	b) Know how to number a finite element mesh in order to optimize the computer storage and the running time	

* - to be filled in only for full -time training: LC - lectures; LW - lab work; S - seminars.

6. CLASSROOM EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Table 6.1. Classroom equipment and technology support requirements

Type of academic activities	Classroom equipment	Specialized educational / laboratory equipment, software and materials for course study (if necessary)
Lectures	An auditorium for conducting lectures, equipped with a set of specialized furniture; a blackboard (screen) and technical means for multi-media presentations.	
Seminars	A classroom for conducting seminars, group and individual consultations, current and midterm assessment; equipped with a set of specialised furniture and technical means for multimedia presentations.	
Computer Labs	A classroom for conducting classes, group and individual consultations, current and mid-term assessment, equipped with personal computers (in the amount of 14 pcs), a board (screen) and technical means of multimedia presentations.	Software: SCAD Office, Lira, Ansys
Self-studies	A classroom for independent work of students (can be used for seminars and consultations), equipped with a set of specialised furniture and computers with access to the electronic information and educational environment	

7. RESOURCES RECOMMENDED FOR INTERNSHIP

Main readings:

1. Advanced Finite Element Method in Structural Engineering. 2019. Publisher: Springer Berlin Heidelberg. ISBN: 978-3-642-00316-5

2. Norrie, D.H. A first course in the finite element method. 3(2)1987. 162–163 p. ISBN:0534552986.

3. Cook, R.D., Malkus, D.S., Plesha, M.E., Witt, R.J. Cook, Malkus, Plesha, Witt - Concepts and Application of Finite Element Analysis - 4a. ed. - J. Wiley - 2022 – 733 2022.

Additional readings:

1. Algorithms for Solving the Parametric Self-Adjoint 2D Elliptic Boundary-Value Problem Using High-Accuracy Finite Element Method [Text] = Algorithms for solving the Parametric Self-Adjoint elliptic boundary value problem in a two-dimensional domain by the high-order finite element method
// Bulletin of the Peoples ' Friendship University of Russia: Mathematics. Computer science. Physics. - 2017. - no. T. 25 (1). - C. 36-55. http://dx.doi.org/10.22363/2312-9735-2017-25-1

2. Gusev Alexander Alexandrovich. Finite Element Method of High-Order Accuracy for solving Two-Dimensional Elliptic Boundary-Value Problems of Two and Three Identical Atoms in a Line : article in English / A. A. Gusev // Bulletin of the Russian University of Friendship of Peoples: Mathematics. Computer science. Physics. - 2018. - no. t. 26 (3). - p. 226-243. http://journals.rudn.ru/miph/article/view/18988/16003
3. Solution of the Boundary-Value Problem for a Systems of ODEs of Large Dimension: Benchmark Calculations in the Framework of Kantorovich Method [Text] = Solution of boundary-value problems for systems of ODES of large dimension: reference calculations within the framework of the Kantorovich method. Computer science. Physics. - 2016. - No. 3. - p. 31-37. http://journals.rudn.ru/miph/article/view/13387/12817

Internet sources:

1. Electronic libraries (EL) of RUDN University and other institutions, to which university students have access on the basis of concluded agreements:
   - RUDN Electronic Library System (RUDN ELS) http://lib.rudn.ru/MegaPro/Web
   - EL "University Library Online" http://www.biblioclub.ru
   - EL "Yurayt" http://www.biblio-online.ru
   - EL "Student Consultant" www.studentlibrary.ru
   - EL "Lan" http://e.lanbook.com/
   - EL "Trinity Bridge"
2. Databases and search engines:
   - electronic foundation of legal and normative-technical documentation http://docs.cntd.ru/
   - Yandex search engine https:// www .yandex.ru/
   - Google search engine https://www.google.ru/
   - Scopus abstract database http://www.elsevierscience.ru/products/scopus/

The training toolkit and guidelines for a student:

1. Collection of lectures on the course Applications of Finite Element Method for Civil Engineering problems.

* The training toolkit and guidelines for the course are placed on the internship page in the university telecommunication training and information system under the set procedure..

8. ASSESSMENT TOOLKIT AND GRADING SYSTEM* FOR EVALUATION OF STUDENTS' COMPETENCES LEVEL AS INTERNSHIP RESULTS

The assessment toolkit and the grading system* to evaluate the level of competences (competences in part) formation as the course Applications of Finite Element Method for Civil Engineering problems results are specified in the Appendix to the internship syllabus.

* The assessment toolkit and the grading system are formed on the basis of the requirements of the relevant local normative act of RUDN University (regulations / order).

DEVELOPERS:

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position in the education department	*signature*	*Last name and first name*

HEAD OF EDUCATIONAL DEPARTMENT:

Head of the Department		*Yazyev Serdar Batyrovich*
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