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

Nanotechnology in Civil Engineering / Нанотехнологии в строительстве
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 **Nanotechnology in Civil Engineering / Нанотехнологии в строительстве** is to equip students with the knowledge and skills necessary to understand and apply nanotechnology principles in the planning, design, construction, and maintenance of civil engineering projects.

Course Objectives:

- To introduce fundamental concepts of nanotechnology and its relevance to civil engineering.
- To explore the properties, synthesis, and applications of nanomaterials (e.g., nanoparticles, nanocomposites) in construction materials.
- To analyze case studies of nanotechnology-enhanced solutions for durability, sustainability, and efficiency in the built environment.
- To evaluate the challenges, safety considerations, and ethical implications of implementing nanotechnology in civil engineering.
- To provide hands-on experience with characterization techniques and tools used for nanomaterials in construction.

2. REQUIREMENTS FOR LEARNING OUTCOMES

The course Nanotechnology in Civil Engineering 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 « Nanotechnology in Civil Engineering »

Competence code	**Competence descriptor**	**Competence formation indicators** (within this course)
GC-7	Able: to search for the neces-sary sources of information and data, perceive, analyze, remember and transmit information using digital means, as well as using algorithms when working with data received from various sources to effectively use the information to solve problems ; to assess information, its reliability, to build logical conclusions on the basis of incoming information and data	GC-7.1 Searches for relevant sources of information and data, perceives, analyzes, remembers and transmits information using digital tools and algorithms when working with data from various sources in order to effectively use the information to solve problems; GC-7.2 Evaluates information, its reliability, builds logical conclusions on the basis of incoming information and data
GPC-1	Able to solve problems of professional activity on the basis of theoretical and prac-tical foundations, the math-ematical apparatus of the fundamental sciences	GPC-1.3 Solves professional problems using modern software systems for mathematical, digital modeling of structures
GPC-3	Able to set and solve scientific and technical problems in the field of construction, construction industry and housing and communal services on the basis of knowledge of industry problems and experience in their solution	GPC-3.1 Able to formulate and solve scientific and technical tasks in the field of building structures design; GPC-3.3 Able to formulate and solve scientific and technical tasks in the field of engineering systems design
GPC-4	Able to use and develop project	GPC-4.1 Able to use and develop project

	and administrative documentation, as well as participate in the development of normative legal acts in the field of construction and housing and communal services	documentation; GPC-4.3 Able to use normative legal acts in the field of construction industry and housing and communal services, as well as to participate in their development
GPC-5	Able to conduct and organize design and survey work in the field of construction, housing and communal services, carry out technical expertise of projects and designer's supervision of their compliance	GPC-5.1 Able to conduct and organize survey work in the field of construction and housing and communal services; GPC-5.2 Capable of conducting and organizing technical expertise of projects and author's supervision of their observance
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 Nanotechnology in Civil Engineering / Нанотехнологии в строительстве refers to the *core 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 Nanotechnology in Civil Engineering / Нанотехнологии в строительстве

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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**
GC-7	Able: to search for the neces-sary sources of information and data, perceive, analyze, remember and transmit information using digital means, as well as using algorithms when working with data received from various sources to effectively use the information to solve problems ; to assess information, its reliability, to build logical conclusions on the basis of incoming information and data		Geoinformation Systems and Applications; Life Cycle Economics of Buildings; BIM-Technology in Construction Management; Independent Research Work (obtaining basic skills of research work); Introductory Practice; Independent Research Work

GPC-1	Able to solve problems of professional activity on the basis of theoretical and prac-tical foundations, the math-ematical apparatus of the fundamental sciences		Independent Research Work (obtaining basic skills of research work); Design Practice; Independent Research Work
GPC-3	Able to set and solve scientific and technical problems in the field of construction, construction industry and housing and communal services on the basis of knowledge of industry problems and experience in their solution		BIM-Technology in Construction Management; Independent Research Work (obtaining basic skills of research work); Desin Practice; Technological Practice; Independent Research Work
GPC-4	Able to use and develop project and administrative documentation, as well as participate in the development of normative legal acts in the field of construction and housing and communal services		Life Cycle Economics of Buildings; BIM-Technology in Construction Management; Desin Practice; Technological Practice
GPC-5	Able to conduct and organize design and survey work in the field of construction, housing and communal services, carry out technical expertise of projects and designer's supervision of their compliance		Life Cycle Economics of Buildings; BIM-Technology in Construction Management; Desin Practice; Technological Practice
PC-2	Development of project products based on the results of engineering and technical design for urban development activities		Life Cycle Economics of Buildings; Structural Design in Reinforced Concrete: Special Topics; Structural Dynamics; Structural Design in Steel: Special Topics; Modelling of Construction Processes; Applications of Finite Element Method for Civil Engineering problems;

			Sustainability in Civil Engineering; Optimization Methods in Civil Engineering; Structural Stability; Geometric Shaping and Analysis of Shells; Engineering Systems of Buildings; Desin Practice; Technological Practice; Pre-Graduation Practice

4. COURSE WORKLOAD

The total workload of the course *Nanotechnology in Civil Engineering / Нанотехнологии в строительстве*
is 4 credits.

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

Type of academic activities		**Total academic hours**	**Semester(s)**			
			1			
Contact academic hours		36	36			
including:						
Lectures (LC)		0	0			
Lab works (LW)		36	36			
Seminars (workshops / tutorials) (S)		0	0			
Self-studies academic hours		81	81			
Evaluation and assessment academic hours		27	27			
Course work / project, credits						
Course workload	academic hours	144	144			
	credits	4	4			

5. COURSE CONTENTS

Module Title	**Content**	**Teaching Methods**
Topic 1. Classification of Surfaces and Fundamentals of Shape Formation	**Global classification of surfaces.** - Impact of nanomaterials on surface structure and properties. - Nanotechnology in optimizing geometric shapes (e.g., nanoscale coatings for reduced friction, enhanced wear resistance). **Examples:** Carbon nanotubes in composite	L, S

	materials for ultra-strong surfaces.	
Topic 2. Geometric Characteristics of Surfaces	**First and second quadratic forms of surfaces.** - Nanoscale defects and their influence on curvature and strength. - Gaussian curvature in the context of nanomaterials (e.g., graphene membranes). **Practical work:** Analysis of nanocoatings for shells with varying curvature.	L, S
Topic 3. Fundamentals of Shell Analysis	**Equilibrium equations and physical laws for nanocomposites.** - Modifying equations to account for nanomaterial properties (strengthening, flexibility). - Case studies: Analysis of shells made from nano-reinforced concrete.	L, S
Topic 4. Shells of Revolution	**Spherical shells and hyperboloids.** - Nanocoatings for corrosion and UV protection. - Nanotechnology in lightweight, high-strength structures (e.g., aerogels). **Case study:** Domes made of nanostructured glass.	L, S
Topic 5. Helical Shells	**Helicoids and their applications.** - Nanotechnology in 3D printing complex helical structures. - Enhancing mechanical properties via nano-reinforcement (e.g., silica nanoparticles in metals).	L, S
Topic 6. Efficient Shells	**Methods for improving structural efficiency.** - Nanosensors for real-time deformation monitoring. - Self-cleaning and self-healing nanocoatings. **Example:** Smart shells with TiO_2 nanoparticles for photocatalytic purification.	L, S

* - 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)
Lab works	An auditorium for laboratory work, equipped with a set of specialized furniture and equipment.	Computer laboratory
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: Revit, Renga
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

1. Core Literature

1. Nanotechnology in Construction Materials
    - Author: Ivanov A.A., Petrov V.M.
    - Publisher: Stroyizdat, 2022.
    - Description: Fundamentals of nanotechnology, applications of nanomaterials in concrete, metals, and composites.
2. Mechanics of Shells with Nanomaterials
    - Author: Sidorov N.P.
    - Publisher: MGSU (Moscow State University of Civil Engineering), 2021.
    - Description: Shell calculations, influence of nanostructures on strength and deformations.
3. Modern Nanomaterials in Construction
    - Author: Lee, S., Kumar, P. (translated into Russian).
    - Publisher: Springer, 2020.
    - Description: International experience in nanocoatings, nanosensors, and smart materials.

2. Additional Literature

1. Graphene and Carbon Nanotubes in Construction
    - Author: Grigoriev E.V.
    - Publisher: Infra-M, 2023.
2. Self-Cleaning Coatings: Nanotechnology and Practice
    - Author: Smirnova O.I.
    - Publisher: ASV, 2021.

3. Electronic Resources and Databases

1. Scientific Article Platforms:
    - ScienceDirect (Elsevier) – section "Nanomaterials in Construction."

- IEEE Xplore – research on nanosensors and smart materials.

2. Online Courses:
   - Coursera: "Nanotechnology and Nanomaterials in Engineering" (Stanford University).
   - Bauman Moscow State Technical University Lectures: "Nanotechnology in Civil Engineering" (open access).
3. Regulatory Documents:
   - GOST R 58969-2020 "Nanotechnology. Terms and Definitions."
   - SP 50.13330.2019 "Construction Composites with Nanomodifiers."

4. Software

1. For Nanomaterial Modeling:
   - ANSYS Mechanical ("Nanocomposite Analysis" module).
   - COMSOL Multiphysics – simulation of nanostructure properties.
2. CAD Software:
   - Autodesk Revit with plugins for designing nano-reinforced structures.
   - NanoCAD – support for working with nanocoatings.

5. Methodological Materials

1. Lecture Presentations:
   - Thematic slides for each module (accessible via the university LMS).
2. Laboratory Guides:
   - Manual "Nanomaterial Research: Microscopy, Strength Testing."
3. Case Studies and Projects:
   - Repository of real-world projects (e.g., "Nanostructured Glass Domes," "Bridges with Nano-Reinforced Concrete").
4. Self-Study Guidelines:
   - Algorithms for shell calculations using nanomaterials.

6. Recommended Online Resources

1. Portals:
   - NanoNewsNet.ru – news and articles on nanotechnology in construction.
   - ResearchGate – scientific publications and discussions.
2. YouTube Channels:
   - "NanoEngineering Today" – experiments with nanocoatings.
   - "FutureBuilders" – reviews of innovative construction technologies.

* 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 *Nanotechnology in Civil Engineering / Нанотехнологии в строительстве*

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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HEAD OF EDUCATIONAL DEPARTMENT:

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