Federal State Autonomous Educational Institution of Higher Education
"Russian Peoples' Friendship University named after Patrice Lumumba"

Engineering Academy
(name of the main educational unit (POU) - developer of the EP HE)

DISCIPLINE WORK PROGRAM

MODELING OF STRUCTURES AND MATERIALS
(name of discipline/module)

Recommended by MSSN for the following areas of training/specialty:

01.04.02 APPLIED MATHEMATICS AND INFORMATION SCIENCE
(code and name of the area of training/specialty)

The discipline is mastered as part of the implementation of the main professional educational program of higher education (OP HE):

BALLISTIC DESIGN OF SPACE COMPLEXES AND SYSTEMS
(name (profile/specialization) EP HE)

2024G.

1. GOAL OF DISCIPLINE MASTERING

The discipline “Structures & Materials Modeling” is included in the master’s program “Ballistic Design of Space Complexes and Systems” in the direction 01.04.02 “Applied Mathematics and Computer Science” and is studied in the 2nd semester of the 1st year. The discipline is implemented by the Department of the Partner University. The discipline consists of 7 sections and 18 topics and is aimed at studying the fundamental principles of material models, approximation of real behavior, elastic models, elastoplastic models, kinetics and microstructure modeling, analysis of material failure, elastic damage models.

The purpose of mastering the discipline is to develop fundamental knowledge and skills in applying problem solving methods necessary for professional activities, increasing the overall level of students’ literacy in Structures & Materials Modeling. After completing the course, students will be able to discuss the terms elastic-perfectly plastic, kinematic hardening, isotropic hardening, Bauschinger effect, hysteresis loop; identify appropriate failure criteria, relevant to simulation, for structural materials; specify appropriate material properties and constitutive laws for models, which are consistent with the materials and environments being analyzed; assess the significance of simplifying material behavior on the objectives of analyses; assess the need for verification of material models.

2. REQUIREMENTS FOR THE RESULTS OF MASTERING THE DISCIPLINE

Mastering the discipline “Modeling of structures and materials” is aimed at developing the following competencies (parts of competencies) in students:

Table 2.1. List of competencies formed in students when mastering the discipline (results of mastering the discipline)

Cipher	Competence	Indicators of Competency Achievement (within this discipline)
UK-1	Able to critically analyze problem situations based on a systematic approach and develop an action strategy	UK-1.1 Analyzes the task, highlighting its basic components;; UK-1.2 Identifies and ranks the information required to solve the task;; UK-1.3 Searches for information to solve a given problem using various types of requests;; UK-1.4 Offers options for solving a problem, analyzes the possible consequences of their use;;
OPK-2	Able to improve and implement new mathematical methods for solving applied problems	GPC-2.1 Uses the results of applied mathematics to master and adapt new methods for solving problems in the field of professional interests;; OPK-2.2 Implements and improves new methods for solving applied problems in the field of professional activity;; OPK-2.3 Conducts qualitative and quantitative analysis of the resulting solution in order to construct the optimal option.;
OPK-3	Able to develop mathematical models and analyze them when solving problems in the field of professional activity	OPK-3.1 Develops mathematical models in the field of applied mathematics and computer science;; OPK-3.2 Analyzes mathematical models for solving applied problems of professional activity;; GPC-3.3 Develops and analyzes new mathematical models for solving applied problems of professional activity in the field of applied mathematics and computer science.;
PK-3	Capable of participating in scientific research and development of design solutions in the field of ballistics, dynamics and spacecraft flight control	PC-3.1 Knows basic mathematical methods and modern tools in the field of ballistic design of space complexes and systems;; PC-3.2 Has basic knowledge of standards, norms and rules for the development of design solutions in the field of ballistics, dynamics and spacecraft flight control;; PC-3.3 Able to apply mathematical methods and modern information technologies when conducting scientific research and

Cipher	Competence	Indicators of Competency Achievement (within this discipline)
		developing design solutions in the field of ballistics, dynamics and spacecraft flight control.;
PK-5	Able to analyze, including in English, methods for studying ballistic and dynamic characteristics when modeling spacecraft flight trajectories	PC-5.1 Knows proven and applied techniques, including from English-language sources, for studying ballistic and dynamic characteristics when modeling spacecraft flight trajectories;; PC-5.2 Able to develop and modernize methods for studying ballistic and dynamic characteristics when modeling spacecraft flight trajectories;; PC-5.3 Proficient in methods and approaches to the study of ballistic and dynamic characteristics when modeling spacecraft flight trajectories;

3. PLACE OF DISCIPLINE IN THE STRUCTURE OF HE EP

Discipline "Modeling of structures and materials" refers to the mandatory part of block 1 “Disciplines (modules)” of the educational program of higher education.

As part of the educational program of higher education, students also master other disciplines and/or practices that contribute to achieving the planned results of mastering the discipline “Modeling of Structures and Materials.”

Table 3.1. List of components of EP HE that contribute to achieving the planned results of mastering the discipline

Cipher	Name of competency	Previous disciplines/modules, practices*	Subsequent disciplines/modules, practices*
UK-1	Able to critically analyze problem situations based on a systematic approach and develop an action strategy	*Machine Learning and Big Data Mining***; *From Data Acquisition to Data Treatment***; Cross-Cultural Training; Programming; Databases;	System Design; Dynamics and Control of Space Systems; Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Practical Training and Research in Dynamics and Control of Space Systems (online from RUDN Mission Control Center) / Research work; Technological Training; Pre-Graduation Internship in Industry;
OPK-2	Able to improve and implement new mathematical methods for solving applied problems	*Programming;*	System Design; On-board Energy; Dynamics and Control of Space Systems; Pre-Graduation Internship in Industry; Technological Training;
OPK-3	Able to develop mathematical models and analyze them when solving	*Programming;*	Pre-Graduation Internship in Industry; Technological Training; System Design;

Cipher	Name of competency	Previous disciplines/modules, practices*	Subsequent disciplines/modules, practices*
	problems in the field of professional activity		On-board Energy; Dynamics and Control of Space Systems; Project "Drone Systems Engineering. Part 2";
PK-3	Capable of participating in scientific research and development of design solutions in the field of ballistics, dynamics and spacecraft flight control	*Applied Mechanics and Engineering***; *Systems Engineering***;	Pre-Graduation Internship in Industry; Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Practical Training and Research in Dynamics and Control of Space Systems (online from RUDN Mission Control Center) / Research work; Technological Training; System Design; On-board Energy; Dynamics and Control of Space Systems; Project "Drone Systems Engineering. Part 2";
PK-5	Able to analyze, including in English, methods for studying ballistic and dynamic characteristics when modeling spacecraft flight trajectories	*English Language;* *Applied Mechanics and Engineering***; *Systems Engineering***; *Russian as a Foreign Language;*	Pre-Graduation Internship in Industry; Practical Training in Receiving Remote Sensing Data from Satellites and its Interpretation (online from RUDN Mission Control Center) / Research; Practical Training and Research in Dynamics and Control of Space Systems (online from RUDN Mission Control Center) / Research work; Technological Training; System Design; On-board Energy; Dynamics and Control of Space Systems;

* - to be filled out in accordance with the competency matrix and SUP EP VO

** - elective disciplines/practices

4. SCOPE OF DISCIPLINE AND TYPES OF STUDY WORK

The total labor intensity of the "Structures & Materials Modeling" discipline is "5" credit units.

Table 4.1. Types of educational work by periods of mastering the educational program of higher education for full-time study.

Type of educational work	**TOTAL,**ac.ch.		**Semester(s)**
			2
Contact work, ac.ch.	*90*		*90*
Lectures (LK)	36		36
Laboratory work (LR)	18		18
Practical/seminar sessions (SZ)	36		36
Independent work of students, ac.ch.	*54*		*54*
Control (exam/test with assessment), academic degree.	*36*		*36*
Total labor intensity of the discipline	**ac.ch.**	***180***	*180*
	credit units	***5***	*5*

5. CONTENT OF DISCIPLINE

Table 5.1. Contents of the discipline (module) by type of academic work

Section number	Name of the discipline section	Contents of the section (topic)		Type of educational work*
Section 1	Introduction	1.1	Need for and requirements of material models	LC, LR, SZ
		1.2	Approximation of real behavior	LC, LR, SZ
Section 2	Elastic models	2.1	Linear and non-linear elasticity	LC, LR, SZ
		2.2	Anisotropy	LC, LR, SZ
Section 3	Elastoplastic models	3.1	Yield criteria	LC, LR, SZ
		3.2	Plastic flow models	LC, LR, SZ
		3.3	Associated plasticity	LC, LR, SZ
		3.4	Rheology	LC, LR, SZ
		3.5	Concrete plasticity model	LC, LR, SZ
Section 4	Kinetics and microstructure modeling	4.1	Simulation of hydration kinetics	LC, LR, SZ
		4.2	Thermodynamic stability in the pore structure	LC, LR, SZ
		4.3	Modeling the hardened properties of the microstructure	LC, LR, SZ
Section 5	Analysis of material failure	5.1	Loss of stability	LC, LR, SZ
		5.2	Diffusion and local failure	LC, LR, SZ
Section 6	Elastic damage models	6.1	Degradation of stiffness due to progressive damage	LC, LR, SZ
		6.2	Scalar damage factor	LC, LR, SZ
Section 7	Incorporation into analysis	7.1	Incorporation into general stress space	LC, LR, SZ
		7.2	Approximations on implementation into analysis software	LC, LR, SZ

* - to be filled out only for full-time education: LC – lectures; LR – laboratory work; SZ – practical/seminar classes.

6. MATERIAL AND TECHNICAL SUPPORT OF DISCIPLINE

Table 6.1. Material and technical support of the discipline

Audience type	Auditorium equipment	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
Lecture	An auditorium for conducting lecture-type classes, equipped with a set of specialized	

Audience type	Auditorium equipment	Specialized educational/laboratory equipment, software and materials for mastering the discipline (if necessary)
	furniture; board (screen) and technical means of multimedia presentations.	
Computer class	A computer class for conducting classes, group and individual consultations, ongoing monitoring and intermediate certification, equipped with personal computers ([Parameter] pcs.), a whiteboard (screen) and technical means for multimedia presentations.	
Seminar	An auditorium for conducting seminar-type classes, group and individual consultations, ongoing monitoring and intermediate certification, equipped with a set of specialized furniture and technical means for multimedia presentations.	
For independent work	An auditorium for independent work by students (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with access to EIOS.	

* - the audience for independent work of students is MANDATORY!

7. EDUCATIONAL, METHODOLOGICAL AND INFORMATIONAL SUPPORT OF DISCIPLINE

Main literature:

1. “An Introduction to the Use of Material Models in FE”, Nawal K Prinja and Anup K Puri, NAFEMS

2. “Materials Science and Engineering An Introduction”, William D. Callister, Jnr.

3. “Modeling of Concrete Performance – Hydration and Microstructure”, K. Maekawa

4. “Numerical Modeling of Concrete Cracking”, G. Hofstetter and G. Meschke

Additional literature:

1. “Nonlinear Finite Element Analysis of Solids and Structures”, Crisfield MA, John Wiley & Sons.

2. “Constitutive Modeling of High Performance Concrete”, Fédération Internationale du Béton (fib) – State of the art report.

Resources of the information and telecommunications network “Internet”:

1. EBS of RUDN University and third-party EBS, to which university students have access based on concluded agreements

- Electronic library system of RUDN - EBS RUDN http://lib.rudn.ru/MegaPro/Web
- EBS “University Library Online” http://www.biblioclub.ru
- EBS Yurayt http://www.biblio-online.ru
- EBS “Student Consultant” www.studentlibrary.ru
- EBS “Trinity Bridge”

2. Databases and search engines

- electronic fund of legal and regulatory 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/

Educational and methodological materials for students' independent work when mastering a discipline/module:*

1. A course of lectures on the discipline "Modeling of structures and materials."

* - all educational and methodological materials for students' independent work are posted in accordance with the current procedure on the discipline page in TUIS!

8. ASSESSMENT MATERIALS AND POINT-RATING SYSTEM FOR ASSESSING THE LEVEL OF COMPETENCIES FOR A DISCIPLINE

Evaluation materials and point-rating system* for assessing the level of development of competencies (parts of competencies) based on the results of mastering the discipline"Modeling of structures and materials" are presented in the Appendix to this Work Program of the discipline.

* - OM and BRS are formed on the basis of the requirements of the relevant local regulatory act of RUDN University.

DEVELOPER:

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