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

**Engineering Academy**
(educational division (faculty/institute/academy) as programme developer)

**Department of Construction Technology and Structural Materials**
(department realizing the PhD program)

# COURSE SYLLABUS

**Advanced Structural Mechanic**
(course title)

Scientific specialty:

**2.1.9. Structural mechanics**
(scientific speciality code and title)

The course instruction is implemented within the PhD programmes:

**Structural mechanics**
(PhD program title)

2024 г.

## 1. DISCIPLINE (MODULE) GOAL

The objective of mastering the discipline «Advanced Structural Mechanic» is to gain knowledge, 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 and also preparation for the candidate's examinations and obtaining knowledge, skills and experience in the field of construction.

## 2. REQUIREMENTS FOR LEARNING OUTCOMES

Mastering the discipline “Structural Mechanics” is aimed at preparing for passing candidate exams, as well as mastering the following competencies:

- knowledge of the methodology of theoretical and experimental research in the field of construction;

– mastery of the culture of scientific research in the field of construction, including the use of the latest information and communication technologies;

- mastery of methods for developing scientific and methodological foundations for research, improvement, theoretical, experimental and feasibility studies for the use of various technical solutions and technologies in construction;

- knowledge of linear and nonlinear mechanics of structures and structures, physical and mathematical models, analytical and numerical methods for their calculation, including calculation of structures and structures for reliability under extreme operating conditions.

## 3. WORKLOAD OF THE DISCIPLINE AND TYPES OF ACTIVITIES

The overall workload of the discipline «Advanced Structural Mechanic» is 3 credit units (108 academic hours).

| **Types of activities** | | **Total ac. hrs.** | **Semesters** |
|---|---|---|---|
| | | | 3 |
| *Classroom activities (total), including:* | | 60 | 60 |
| в том числе: | | | |
| Lectures (LC) | | 30 | 30 |
| Laboratory activities (LA) | | – | – |
| Practical lessons/Seminars (PC) | | 30 | 30 |
| *Independent work* | | 48 | 48 |
| *Intermediate certification (test with assessment/exam)* | | – | – |
| Overall workload | ac. hrs. | 108 | 108 |
| | credits | 3 | 3 |

## 4. DISCIPLINE CONTENTS

| **Name of the discipline section** | **Contents of the section (topic)** | **Type of study work** |
|---|---|---|
| Section 1. Finite element analysis of structures | Topic 1.1. Linear theory of spatial trusses and properties of rod elements. Linear theory of spatial frames and properties of frame elements.<br>Topic 1.2. Linear theory of plates and properties of finite elements of plates. Linear theory of folded plates and finite element properties of folded plates.<br>Topic 1.3. Systems of linear equations: structure, solution, accuracy. Accuracy control using adaptive methods.<br>Topic 1.4. Database, algorithms and interfaces for finite element applications on computers. | LC, PC |

| | | |
|---|---|---|
| | Examples of practical application of the method in construction. | |
| Section 2. Structural dynamics | Topic 2.1. Linear and nonlinear equations of motion for load-bearing systems. Spatial and temporal discretization of dynamic boundary value problems. Methods for solving linear and nonlinear problems.<br>Topic 2.2. Modal analysis by finite element method. Time history analysis using finite element method.<br>Topic 2.3. Constructed structures with wind and wave excitation. Objects under construction subject to transport loads and ground vibrations. Structures susceptible to earthquakes. Computer models for dynamic analysis. | LC, PC |
| Section 3. Structural stability | Topic 3.1. Structural stability concepts: singularity, instability, imperfection, load disturbance. Linear and nonlinear formulations of stability problems.<br>Topic 3.2. Second-order stress analysis of plane frames. Second-order stability analysis of plane frames.<br>Topic 3.3. First-order theory of cosmic reference systems with uniform and inhomogeneous torsion. Second-order stress analysis of space frames. Second-order stability analysis of spatial frames (torsional-flexural deformation).<br>Topic 3.4. Theory of bifurcations and continuation of the load path. Buckling of thin plates. Introduction to deflection of arches and shells. Computer implementation and testing of all methods. | LC, PC |
| Section 4. Nonlinear structural analysis | Topic 4.1. Geometrically nonlinear theory of elasticity. Theory of plasticity, fracture and destruction, nonlinear constituent laws.<br>Topic 4.2. Geometrically nonlinear theory of spatial trusses: formulation, finite elements. Nonlinear load-displacement behavior, limit points (through, bifurcation). Incremental-iterative methods for solving nonlinear quasi-static problems.<br>Topic 4.3. Geometrically nonlinear frame theory: formulation, finite elements, nonlinear. Load-displacement behavior, limit points (end-to-end, bifurcation).<br>Topic 4.4. Physically nonlinear behavior of trusses and frames, only tension elements. Computer models and interfaces for nonlinear analysis of trusses and frames. Examples of practical applications in structural engineering. | LC, PC |

## 5. EQUIPMENT REQUIREMENTS AND TECHNOLOGY SUPPORT

| Room Type | Room Equipment | Specialized educational / laboratory equipment, software and materials for mastering the discipline |
|---|---|---|
| Class for Seminars, Lectures | Room for seminar-type classes, equipped with a set of specialized furniture, board (screen) and technical / multimedia gadgets | Not necessary |
| Self-Work Class | Room for self-working (can be used for lecture and seminars activities), equipped with a set of specialized furniture, board (screen) and technical / multimedia gadgets and computers with an access to EIPES | Not necessary |
| Computer class | Computer class for conducting classes, group and individual consultations, ongoing monitoring and intermediate certification, equipped with personal computers (9 pcs.), a whiteboard (screen) and technical means for multimedia presentations. | RUDN University software: Plaxis 2D Suit (Network license). Plaxis Professional (version 8) + Plaxis Dynamics Modul + PlaxFlow (version 1) - Education Registration number 90-07-019-00261-3<br>MS-office corporate, Registration code: 86626883<br>Parent program: 86493330<br>Status: Active |

## 6. METHODOLOGICAL SUPPORT AND LEARNING MATERIALS

*Main readings:*

1. Krivoshapko S.N. Structural mechanics: lectures, seminars, calculation and graphic works [Electronic resource]: Textbook for universities / S.N. Krivoshapko. - 2nd ed. reworked and additional ; Electronic text data. - M.: Yurayt, 2011. - 391 p. - System requirements: Windows XP and higher. - ISBN 978-5-9916-1375-0: 229.00. Access mode: http://lib.rudn.ru/MegaPro/UserEntry?Action=Rudn_FindDoc&id=359565&idb=0

2. Shambina S.L. Structural mechanics [Text/electronic resource]: Lecture notes. / S.L. Shambina. - Electronic text data. - M.: Publishing house RUDN, 2015. - 48 p. : ill. - ISBN 978-5-209-06779-5: 42.15. Access mode: http://lib.rudn.ru/MegaPro/UserEntry?Action=Rudn_FindDoc&id=447028&idb=0

3. Tukhfatullin, B. A. Numerical methods for calculating building structures. Finite element method: textbook. manual for academic undergraduates / B. A. Tukhfatullin. — 2nd ed., rev. and additional - Moscow: Yurayt Publishing House, 2019. - 157 p. — (Series: Bachelor. Academic course). — ISBN 978-5-534-08899-1. — Access mode: HYPERLINK https://biblio-online.ru/bcode/442338

*Additional readings:*

1. Петров, В.В. Нелинейная инкрементальная строительная механика/ В.В. Петров. - Москва: Инфра-Инженерия, 2014. - 480 с. - ISBN 978-5-9729-0076-3; То же [Электронный ресурс]. - URL: http://biblioclub.ru/index.php?page=book&id=234783

2. Голушко, С.К. Прямые и обратные задачи механики упругих композитных пластин и оболочек вращения / С.К. Голушко, Ю.В. Немировский. - Москва :

Физматлит, 2008. - 429 с. - ISBN 978-5-9221-0948-2 ; То же [Электронный ресурс]. - URL: http://biblioclub.ru/index.php?page=book&id=68839
3. Димитриенко, Ю.И. Нелинейная механика сплошной среды: учебное пособие / Ю.И. Димитриенко. - Москва : Физматлит, 2009. - 624 с. - ISBN 978-5-9221-1110-2 ; То же [Электронный ресурс]. - URL: http://biblioclub.ru/index.php?
Радин, В.П. Метод конечных элементов в динамических задачах сопротивления материалов / 4. В.П. Радин, Ю.Н. Самогин, В.П. Чирков. - Москва: Физматлит, 2013. - 314 с. : схем., табл. - Библиогр. в кн. - ISBN 978-5-9221-1485-1 ; То же [Электронный ресурс]. - URL: http://biblioclub.ru/index.php?page=book&id=275558

*Internet sourses:*

ELS RUDN University and third party EBS, to which university students have accessbased signed contracts:

- RUDN Electronic Library System, http://lib.rudn.ru/MegaPro/Web ;
- ELS University Library Online, http://www.biblioclub.ru ;
- EBS Urayt, http://www.biblio-online.ru ;
- ELS Student Consultant, http://www.studentlibrary.ru ;
- EBS Lan, http://e.lanbook.com ;
- EBS Trinity Bridge http://www.trmost.ru

Databases and search engines:

- Electronic fund of legal and normative-technical documentation, http://docs.cntd.ru ;
- Yandex search system https:// www .yandex.ru ;
- Google search system https://www.google.com ;
- Reference database Scopus , http://www.elsevierscience.ru/products/scopus

*Educational and methodological materials for students' self-work studying the discipline / module:*

A course of lectures on the discipline «Advanced Structural Mechanic».

## 7. ASSESSMENT TOOLKIT AND GRADING SYSTEM FOR EVALUATION OF PHD STUDENTS' COMPETENCES LEVEL AS COURSE RESULTS

Assessment toolkit and a grading system to evaluate the level of competences (competences in part) formation as the course results are specified in the Appendix to the course syllabus.

**DEVELOPERS:**

Professor A.P. Svintsov

**HEAD OF THE DEPARTMENT**

Director of the department S.B. Yazyev