

**THE WORKING PROGRAM OF THE DISCIPLINE**

**Name of the discipline:** Geometric Shaping and Analysis of Shells

**Recommended for educational field:** 08.04.01 Civil Engineering

**Specialization (profile):** Civil Engineering and Built Environment .

Mechanics of materials and engineering structures,

Built environment of smart city

## 1. Goals and objectives of the discipline:

**The purpose** of mastering the discipline "Geometric Shaping and Analysis of Shells" / "Geometric Shaping and Analysis of Shells" is to gain knowledge and skills to show the relationship between the shape of the structure, its strength and ergonomics, which characterizes the stages of competence formation and ensures the achievement of the planned results of the development of the educational program.

**The main objective** of the discipline "Geometric Shaping and Analysis of Shells" / "Geometric Shaping and Analysis of Shells" is to train a new generation of young architects and civil engineers who will discover new possibilities of thin-walled structures in connection with the emergence of new materials and software systems for calculation, new forms in the architecture of spatial structures. Each famous spatial structure is unique and their construction can not be made mass. The famous architect and engineer E. Torroja said: "The best structure is the one whose reliability is mainly due to its shape, and not due to the strength of its material. The latter is achieved simply, while the former, on the contrary, with great difficulty. This is the beauty of the search and the satisfaction of discovery."

## 2. Place of discipline in the structure of EP VO:

The discipline "Geometric Shaping and Analysis of Shells" / "Geometric Shaping and Analysis of Shells" refers to the variable part of Block 1 of the curriculum. Its study is based on the material of previous disciplines, and it is also the basis for the study of subsequent disciplines of the curriculum, a list of which is presented in table 1.

### Prior and subsequent disciplines aimed at the formation of competencies

№	Code and name of competence	Preceding disciplines	Subsequent disciplines (groups of disciplines)
General cultural competences			
	GC-1 GC-3	Linear Theory of Elasticity	
General professional competencies			
	GPC-1	Modelling of Construction Processes;	Federal Examination
		Building materials: Special Topics;	Federal Examination
Professional competencies (type of professional activity of a civil engineer)			
	PC-1	Structural Design in Steel: Special Topics; Structural Design in Reinforced Concrete: Special Topics; Structural Design in Steel; Structural Design in Reinforced Concrete	
Vocational Competencies of Specialization Structural mechanics			

## 3. Requirements for the results of mastering the discipline:

*The discipline "Geometric Shaping and Analysis of Shells" is aimed at developing the following competencies in students:*

*GPC-1- Able to solve problems of professional activity based on the use of theoretical and practical foundations, the mathematical apparatus of the fundamental sciences*

*GC-1- Able to carry out a critical analysis of problem situations based on a systematic approach, develop an action strategy*

*GC-3- Able to organize and manage the work of a team, developing a team strategy to achieve a set goal*

*PC-1- Conducting applied research in the field of engineering design for urban planning activities*

As a result of studying the discipline, the student must:

**Know:**

- examples of real buildings, structures, and products outlined on a variety of analytical surfaces,
- the main forms of defining analytical surfaces,
- fundamentals of the classical theory of thin shells,
- achievements of modern architecture in the design and construction of large-span spatial structures,
- methods of cutting or packaging an analytical surface.

**Be able to:**

- find the necessary scientific and technical literature,
- use databases, information and reference systems and search engines to find the necessary information on the geometry, calculation and application of large-span spatial structures,
- produce scale models of projected large-span structures,
- determine analytical surfaces in the structures of machines for various purposes, in the forms of structures proposed by architects, approximate complex surfaces with simpler analytical ones,
- choose a rational shell shape.

**Own:**

- organization of construction production and implementation of author's supervision over the course of construction,
- calculation of thin shells for strength, stability and dynamic effects,
- the use of numerical methods for calculating shells (the finite element method, the variational-difference method, etc.).

**4. Scope of discipline and types of educational work**

The total workload of the discipline is 3 credit units.

Type of educational work	Total hours	Semesters			
		5			
<b>Classroom Practice in Obtaining Professional Skills and Professional Experience (Research Practice). lessons (total)</b>	36	36			
Including:	-	-	-	-	-
<i>Lectures</i>	18	18			
<i>Practical lessons (PL)</i>	18	18			
<i>Seminars (S)</i>	-	-			
<i>Laboratory work (LW)</i>	-	-			
<b>Independent work (total)</b>	72	72			
Type of certification test	test				
Total labor intensity	hour	108	108		
	credits	3	3		

**5. Content of the discipline**

**5.1. Contents of discipline sections**

№	The name of the discipline section	Section content (topics)
1.	<b>Classification and forms of spatial structures</b>	- Planar designs. Classification and forms of spatial structures. Signs of static shaping. Kinematic surfaces.
2.	<b>On the design and construction of spatial structures</b>	- Structures working "on the span", rigid shells, regular systems, suspended roofs, transforming systems, air-supporting and air-suspended structures. - Tent structures. Structural concept. Production, transportation and construction of spatial systems.
3.	<b>Shells of revolution</b>	- Spherical shell. Shells in the form of a single-cavity hyperboloid of revolution. Paraboloid and ellipsoid of revolution. Circular torus. - Pseudosphere. Catenoid. Globoid. A drop. The mating surfaces of coaxial cylinder and cone.
4.	<b>Ruled shells of zero Gaussian curvature</b>	- Conical, cylindrical and torso shells. Build torso developments. Replacement of cylinders, cones and torse surfaces folds. Surfaces of the equal slope.
5.	<b>Ruled shells of negative Gaussian curvature</b>	- Hyperbolic paraboloid. Conoids. Cylindroids. 5 types of ruled helicoids. Ruled rotary and spiroid surfaces. Catalan Surfaces.
6.	<b>Cyclic surfaces</b>	- Channel surfaces. Normal cyclic surfaces. Cyclic surfaces with a parallelism plane. Cyclic surfaces with circles in the planes of the bunch.
7.	<b>Kinematic surfaces</b>	- Direct transfer surfaces. Rotative and spiroid surfaces.
8.	<b>Umbrella surfaces and umbrella type surfaces</b>	- Wavy type and wavy surfaces. Corrugated surfaces. Corrugated products. Umbrella domes on the cone. Reinforced concrete, metal, tent umbrella shells.
9.	<b>Minimal surfaces</b>	- Minimal surfaces strung on a rigid support contour. Dome structures made of plastic.
10.	<b>Helicoidal and helical shape shells. Shells in the form of spiral and spiral shape surfaces</b>	- Ordinary screw surfaces. Screw surface variable pitch. Cyclic surface in the cylinder. Helical surfaces with generatrix in the planes of the bunch.
11.	<b>Membrane and cable coatings</b>	- Examples of built structures with membrane and suspended roofs.
12.	<b>Shells in the form of analytically indefinable surfaces</b>	- Overview of the constructed structures. Constructive forms of wildlife and their influence on the development of fundamentally new spatial structures.
13.	<b>Spatial composite structures</b>	- Smooth mating of two surfaces. Transformable structures.
14.	<b>Geometrical shaping of shells</b>	- Manufacturing models that demonstrate the methods of generating the middle surfaces of the shells.

## 5.2. Sections of disciplines and types of classes

No	Discipline section No.	Lecture s.	Practice	Lab. works	Seminars	Independent work of students	Total hour.
1.	<b>Classification and forms of spatial structures</b>	2	1	0	0	5	8
2.	<b>On the design and construction of spatial structures</b>	2	1	0	0	5	8
3.	<b>Shells of revolution</b>	1	2	0	0	5	8
4.	<b>Ruled shells of zero Gaussian curvature</b>	2	2	0	0	6	10
5.	<b>Ruled shells of negative Gaussian curvature</b>	2	2	0	0	6	10
6.	<b>Cyclic surfaces</b>	1	2	0	0	5	8

7.	<b>Kinematic surfaces</b>	1	1	0	0	5	7
8.	<b>Umbrella surfaces and umbrella type surfaces</b>	1	1	0	0	5	7
9.	<b>Minimal surfaces</b>	1	1	0	0	5	7
10.	<b>Helicoidal and helical shape shells. Shells in the form of spiral and spiral shape surfaces</b>	1	1	0	0	5	7
11.	<b>Membrane and cable coatings</b>	1	1	0	0	5	7
12.	<b>Shells in the form of analytically indefinable surfaces</b>	1	1	0	0	5	7
13.	<b>Spatial composite structures</b>	1	1	0	0	5	7
14.	<b>Geometrical shaping of shells</b>	1	1	0	0	5	7

## 6. Laboratory workshop

No laboratory workshop provided.

## 7. Educational, methodological, and informational support of the discipline

Basic literature:

1. Krivoschapko, S.N., Ivanov, V.N. Encyclopedia of analytical surfaces [Electronic resource] 2015. C. xxx+752~pp. ISBN 9783319117720 URL: <https://search.ebscohost.com/login.aspx?direct=true&db=msn&AN=MR3309742&site=eds-live>

Additional literature:

1. Robinson, Horatio N. Conic sections and analytical geometry: theoretically and practically illustrated / by Horatio N. Robinson [Electronic resource] 1869. 280 c. URL: <http://dlib.rsl.ru/rsl01004000000/rsl01004493000/rsl01004493106/rsl01004493106.pdf>

2. Alexander I. Bobenko. Advances in Discrete Differential Geometry [Electronic resource] 2016. 1 c. ISBN 9783662504468  
URL: <http://www.oapen.org/download/?type=document&docid=100185>

3. Nicholson P. Vol. 1: The principles of architecture: Containing the fundamental rules of the art, in geometry, arithmetic, and mensuration: With the application of these rules to practice: In 3 vol [Electronic resource]. - London: Bohn, 1841.  
URL: <http://dlib.rsl.ru/rsl01004000000/rsl01004430000/rsl01004430454/rsl01004430454.pdf>

4. Krivoschapko S. Forming of velaroidal surfaces on ring plan with two families of sinusoids [Electronic resource]: Abstracts / S. Krivoschapko, S. Shambina // 16th Scientific-Professional Colloquium on Geometry and Graphics. - 2012. - P. 19. – Electronic text data.

5. Wentworth G., Smith D. E. Solid geometry / by George Wentworth and David Eugene Smith [Electronic resource] 463 c.  
URL: <http://dlib.rsl.ru/rsl01004000000/rsl01004457000/rsl01004457534/rsl01004457534.pdf>

6. Krivoschapko S. Classification of cyclic surfaces and geometrical research of canal surfaces [Electronic resource] / S. Krivoschapko, Bock Hyeng C. A. // International Journal of Research and Reviews in Applied Sciences. - 2012. - Vol. 12. – Iss. 3. - P. 360-374. - Electronic text

data.

7. Krivoshapko S. Geometrical research of rare types of cyclic surfaces [Electronic resource] / S. Krivoshapko, Bock Hyeng C. A. // International Journal of Research and Reviews in Applied Sciences. - 2012. - Vol. 12. – Iss. 3. - P. 346-359. - Electronic text data.

8. Krivoshapko S. Two methods of analysis of thin elastic open helicoidal shells [Electronic resource] / S. Krivoshapko, G. GbaguidiAisse // International Journal of Research and Reviews in Applied Sciences. - 2012. - Vol. 12. – Iss. 3. - P. 382-390. - Electronic text data.

Resources of the Internet information and telecommunications network»:

1. EBS RUDN and third-party EBS, to which university students have access based on concluded contracts:

- 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](http://www.studentlibrary.ru)
- EBS" Doe " <http://e.lanbook.com/>

2. Databases and search engines:

- electronic fund of legal and regulatory and 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/>

## 8. Practical exercises (seminars)

No.	Discipline section No.	Subjects of practical classes (seminars)	Labor capacity (hour.)
1.	<b>Classification and forms of spatial structures</b>	Classification and forms of spatial structures. Examples of practical applications of shells in structural engineering.	
2.	<b>On the design and construction of spatial structures</b>	Examples of rigid shells, suspended roofs, transforming systems, air-supporting and air-suspended structures, tent structures in structural engineering.	
3.	<b>Shells of revolution</b>	Examples of shells of revolution.	
4.	<b>Ruled shells of zero Gaussian curvature</b>	Examples of ruled shells of zero Gaussian curvature (conical, cylindrical and torse shells).	
5.	<b>Ruled shells of negative Gaussian curvature</b>	Examples of ruled shells of negative Gaussian curvature (hyperbolic paraboloid, conoids, cylindroids, helicoids).	
6.	<b>Cyclic surfaces</b>	Examples of cyclic surfaces (channel surfaces, normal cyclic surfaces, cyclic surfaces with a parallelism plane, cyclic surfaces with circles in the planes of the bunch).	
7.	<b>Kinematic surfaces</b>	Examples of kinematic surfaces (direct transfer surfaces, rotative and spiroid surfaces).	
8.	<b>Umbrella surfaces and</b>	Examples of umbrella surfaces (wavy surfaces, corrugated surfaces, umbrella domes on the cone).	

	<b>umbrella type surfaces</b>		
9.	<b>Minimal surfaces</b>	Examples of minimal surfaces in structural engineering.	
10.	<b>Helicoidal and helical shape shells. Shells in the form of spiral and spiral shape surfaces</b>	Examples of screw surfaces in structural engineering.	
11.	<b>Membrane and cable coatings</b>	Examples of built structures with membrane and suspended roofs.	
12.	<b>Shells in the form of analytically indefinable surfaces</b>	Examples of constructed shell structures.	
13.	<b>Spatial composite structures</b>	Examples of mating of two surfaces and transformable structures.	
14.	<b>Geometrical shaping of shells</b>	Methods of generating the middle surfaces of the shells.	

### 9. Material and technical support of the discipline:

<b>Auditorium with a list of logistics</b>	<b>Location</b>
<p><b>Lecture room</b> - Specialized room number 298 - "Modeling of large-span building structures"</p> <p>Equipment and furniture:  - a set of specialized furniture;  - chalk board;  - projection screen;  - multimedia projector EPSON EMP-X5.</p>	Moscow, st. Ordzhonikidze, 3
<p>Classroom for independent work-Computer class No. 352  A set of specialized furniture; technical means: PolyVision Webster TSL 610 interactive whiteboard, Toshiba TLP XC3000 multimedia projector, Draper Luma 178x178 roll-up wall screen, Pirit Codex 1226 computer - 1 pc., GENIUS SP-i350 sound amplification equipment-1 pc., Xerox 3125-1 pc. printer, Epson 10V Photo scanner-1 pc., HP DesignJet 130+ NR (A1) plotter-1 pc., Pirit Doctrina computers-9 pcs., ViewSonic 22" LCD monitor VA2216w-9 pcs., 19" NEC monitor-1 pc., chalk board.</p> <p>Plaxis 2D Suit (Network license). Plaxis Professional (version 8) + Plaxis Dynamics Modul + PlaxFlow (version 1) - Education, 25 seats-registration number 90-07-019-00261-3 (2008),  Abaqus, 20 seats-registration number 90-07-019-00317-7 (2010),  MS-office corporate. (RUDN Software) - Registration Code: 86626883  Parent Program: 86493330  Status: Active</p>	Moscow, st. Ordzhonikidze, 3

## 10. Information support of the discipline

### a) software

Specialized software for conducting lectures and practical classes, completing coursework and independent work of students:

RUDN University software: Plaxis 2D Suit (Network license). Plaxis Professional (version 8) + Plaxis Dinamics Modul + PlaxFlow (version 1) - Education Registration number 90-07-019-00261-3

MS-office corporate, Registration code: 86626883

Parent program: 86493330

Status: Active).

### b) databases, reference and search systems

- electronic fund 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/>

- Site of the Ministry of Construction and Housing and Communal Services of the Russian Federation <http://www.minstroyrf.ru/>

- Electronic library system 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](http://www.studentlibrary.ru)

- EBS "Doe" <http://e.lanbook.com/>

## 11. Educational and methodological support of the discipline:

Methodological guidelines for students on the development of the discipline (module)

Lectures are delivered in classrooms equipped with technical training facilities and video projectors.

Lectures should be presented in the form of PowerPoint presentations.

Laboratory work is carried out in a laboratory fully equipped for laboratory work.

Practical classes are held in classrooms equipped with technical training facilities. Practical tasks are analyzed, as well as examples of solving computational and graphical tasks.

Control measures consist of two control works (for 2 ak. one hour each), exam at the end of the semester.

Methodological recommendations for the student are posted in the TUIS.

### 12. Fund of assessment tools for intermediate certification of students in the discipline (module)

Materials for assessing the level of mastering the educational material of the discipline "Geometric Shaping and Analysis of Shells", including a list of competencies indicating the stages of their formation, a description of indicators and criteria for evaluating competencies at various stages of their formation, a description of the assessment scales, typical control tasks or other materials necessary to assess knowledge, skills, skills and (or) experience of activity, characterizing the stages of the formation of competencies in the process of mastering the educational program, methodological materials that determine the procedures for assessing knowledge, skills, skills and (or) experience of activities that characterize the stages of the formation of competencies are developed in full and are available for students on the discipline page in TUIS RUDN.

The program is compiled in accordance with the requirements of the ES HE in the RUDN.



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