Federal State Autonomous Educational Institution for 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

Methodology of Scientific Research
course title

Recommended by the Didactic Council for the Education Field of:

15.04.05 Design and technological support of machine-building industries
field of studies / speciality code and title

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

Designing energy machines
higher education programme profile/specialisation title

2024

1. COURSE GOAL(s)

The discipline "Methodology of Scientific Research" is included in the master's program "Design of power plants" in the direction of 15.04.05 "Design and technological support of machine-building industries" and is studied in the 3rd semester of the 2nd year. The discipline is implemented by the Basic Department of Mechanical Engineering Technologies. The discipline consists of 12 sections and 42 topics and is aimed at studying the essence of scientific research, preparing for setting tasks and conducting scientific research and its application in the field of mechanical engineering.

2. REQUIREMENTS TO LEARNING OUTCOMES

The course 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

Competence code	**Competence descriptor**	**Competence formation indicators** (within this course)
GPC-1.	Can formulate the goals and objectives of research in the field of design and technological training of machine-building industries, identify priorities for solving problems, select and create criteria for evaluating research	GPC-1.1. Applies modern physical and mathematical methods in engineering and research practice; conducts preliminary preparation for research and a priori analysis of available information; GPC-1.2. Draws up a plan and analyzes the results of the experiment; theoretical aspects of experimental research and the basic principles of preparation, planning, conducting and analyzing a scientific experiment; GPC-1.3. Conducts scientific experiments, evaluates research results, compares new experimental data with data from accepted models to verify their adequacy and, if necessary, suggests changes to improve models.
GPC-2.	Can develop modern research methods, evaluate and present the results of the work performed	GPC-2.1. Applies in practice the knowledge of the current state of science in domestic and global mechanical engineering; GPC-2.2. Solves scientific, technical, organizational and economic problems of design and technological support of machine-building industries; GPC-2.3. Performs mathematical modeling of processes, tools and systems of machine-building industries using modern research technologies.
GPC-4.	Capable of preparing scientific and technical reports and reviews based on the results of research and design work in the field of mechanical engineering	GPC-4.1. Organizes and makes plans for the scientific work of the team, evaluates the scientific activities of researchers, analyzes the level of their knowledge; GPC-4.2. He is able to issue scientific and technical reports and reviews based on the results of completed research and design work in the field of mechanical engineering.

Competence code	Competence descriptor	Competence formation indicators (within this course)
PC-3.	Using the results and well-known scientific methods and methods to solve new scientific and technical problems, problem-oriented methods of analysis, synthesis and optimization of design and technological support for energy production	PC-3.1 Analyzes new scientific problems of the relevant field of knowledge; PC-3.2. Applies methods of conducting experiments, compiles their description, formulates conclusions; PC-3.3. Forms new problem-oriented areas of scientific research and development.

3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

The course refers to the variable component of (B1) block of the higher educational programme curriculum.

Within the higher education programme students also master other (modules) and / or internships that contribute to the achievement of the expected learning outcomes as results of the course study.

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

Competence code	Competence descriptor	Previous courses/modules	Subsequent courses/modules
GPC-1.	Can formulate the goals and objectives of research in the field of design and technological training of machine-building industries, identify priorities for solving problems, select and create criteria for evaluating research	History and methodology of science in mechanical engineering; Modern problems of science and production in energy engineering;	
GPC-2.	Can develop modern research methods, evaluate and present the results of the work performed	CAE systems in mechanical engineering; History and methodology of science in mechanical engineering; Mathematical modeling of thermal processes; Nanotechnology in mechanical engineering; New construction materials; Physical modeling in mechanical engineering;	
GPC-4.	Capable of preparing scientific and technical reports and reviews based		

Competence code	Competence descriptor	Previous courses/modules	Subsequent courses/modules
	on the results of research and design work in the field of mechanical engineering		
PC-3.	Using the results and well-known scientific methods and methods to solve new scientific and technical problems, problem-oriented methods of analysis, synthesis and optimization of design and technological support for energy production	Research work (obtaining primary research skills); Modern problems of science and production in energy engineering;	Research work;

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total workload of the course “Methodology of Scientific Research” is 3 credit units.

Table 4.1. Types of academic activities during the periods of higher education programme mastering

Type of academic activities		**TOTAL,** ac. hrs.	**Semesters/ training modules**
			3
Contact academic hours		*36*	*36*
Lectures (LC)		18	18
Lab work (LW)		-	-
Seminars (workshops/tutorials) (S)		18	18
Self-studies		*45*	*45*
Evaluation and assessment (exam/passing/failing grade)		*27*	*27*
Course workload	academic hours	**108**	**108**
	credits	**3**	**3**

5. COURSE CONTENTS

Table 5.1. Course contents and academic activities types

Course module title	Course module contents (topics)		Academic activities types
Basic information.			LC, S
Methodology of scientific knowledge and creativity.	2.1	Laws of technology development	LC, S
	2.2	General scientific methods.	LC, S
	2.3	System analysis as a method of scientific research.	LC, S
Choosing the direction of scientific research. Statement of the scientific and technical problem and stages of research work.	3.1	Methods of selection and goals of the direction of scientific research.	LC, S
	3.2	Statement of a scientific and technical problem. Stages of research work.	LC, S
	3.3	Relevance and scientific novelty of the research.	LC, S
	3.4	Proposing a working hypothesis.	LC, S
Search, accumulation, and processing of scientific information.	4.1	Documentary sources of information.	LC, S
	4.2	Methods for document analysis.	LC, S
	4.3	Processing scientific information, recording and storing it.	LC, S
Theoretical research.	5.1	Objectives and methods of theoretical research.	LC, S
	5.2	Modeling in scientific and technical creativity.	LC, S
	5.3	Methods for constructing computational models of systems.	LC, S
	5.4	Preliminary control of the mathematical model.	LC, S
	5.5	Analytical methods in scientific research.	LC, S
Experimental research.	6.1	Classification, types and objectives of the experiment.	LC, S
	6.2	Basic issues of experimental research methodology.	LC, S

	6.3	Development of a plan-program for the experiment.	LC, S
	6.4	Similarity theory. Types of similarity. Similarity numbers.	LC, S
	6.5	Measurements, their types and classes.	LC, S
	6.6	Errors and measurement errors, their types, nature of occurrence, basic principles and methods of elimination.	LC, S
Probabilistic and statistical methods for processing experimental data.	7.1	Random variables. Axioms of probability theory.	LC, S
	7.2	General and sample populations.	LC, S
	7.3	Distribution of a random variable, theoretical and empirical distributions, their tabular and graphical presentation.	LC, S
	7.4	Characteristics of theoretical and empirical distribution of a random variable.	LC, S
	7.5	Laws of distribution of random variables.	LC, S
	7.6	Interval estimation using the confidence probability of the accuracy and reliability of a sample of measurements. level of significance.	LC, S
	7.7	Testing statistical hypotheses.	LC, S
Metrological support for experimental studies.			
Methods for presenting the results of experimental studies.	9.1	Graphical methods for experimental representation. results.	LC, S
	9.2	Methods for selecting empirical formulas.	LC, S
	9.3	Approximation, interpolation and extrapolation.	LC, S
Concept of variance analysis.	10.1	One-way analysis of variance.	LC, S
	19.2	Two-factor analysis of variance.	LC, S
	10.3	Full factorial experiment.	LC, S

	10.4	Fractional factorial experiment.	LC, S
	10.5	Planning an experiment to describe the object under study.	LC, S
Optimization problems.	11.1	Production functions.	LC, S
	11.2	Optimization of technological processes using experimental design.	LC, S
	11.3	Geometric solution to the optimization problem.	LC, S
Presentation of scientific research results.	12.1	Presentation of scientific research results.	LC, S
	12.2	Oral presentation of information.	LC, S
	12.3	Presentation and argumentation of the conclusions of scientific work.	LC, S

** 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**	**Specialised educational / laboratory equipment, software, and materials for course study** (if necessary)
Lecture	A lecture hall for lecture-type classes, equipped with a set of specialised furniture; board (screen) and technical means of multimedia presentations.	
Seminar	A classroom for conducting seminars, group and individual consultations, current and mid-term assessment; equipped with a set of specialised furniture and technical means for multimedia presentations.	
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 COURSE STUDY

Main reading:

1. Tikhonov, V.A. Fundamentals of scientific research. Theory and practice: Textbook. al-lowance / V.A. Tikhonov [and others]. – M.: “Helios ARV”, 2006.

2. Masyagin, V. B. Methodology of scientific research in mechanical engineering: lecture notes / V. B. Masyagin. – Omsk: Omsk State Technical University, 2012. – 50 p.
3. Ponomarev, A.B. Methodology of scientific research: textbook. allowance / A.B. Ponomarev, E.A. Pikuleva. – Perm: Perm Publishing House. national research Polytech-nic Univ., 2014. – 186 p.
4. Dreshchinsky, V. A. Methodology of scientific research: textbook for universities / V. A. Dreshchinsky. — 3rd ed., revised. and additional - Moscow: Yurayt Publishing House, 2024. - 349 p. - (Higher education).

Additional reading:

1. Gorelov, N. A. Methodology of scientific research: textbook and workshop for universities / N. A. Gorelov, O. N. Korableva, D. V. Kruglov. — 3rd ed., revised. and additional - Mos-cow: Yurayt Publishing House, 2024. - 390 p. - (Higher education).
2. Mokiy, M. S. Methodology of scientific research: textbook for universities / M. S. Mokiy, A. L. Nikiforov, V. S. Mokiy; edited by M. S. Mokiya. — 3rd ed., revised. and additional - Moscow: Yurayt Publishing House, 2024. - 259 p. - (Higher education).
3. Tsaplin, A.I. Fundamentals of scientific research in mechanical engineering technology: textbook. allowance / A.I. Tsaplin. – Perm: Perm Publishing House. national research Poly-technic Univ., 2014. – 228 p.

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" http://www.trmost.ru

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/

*Training toolkit for self- studies to master the course *:*

1. The set of lectures on the course “Methodology of Scientific Research”.
2. Guidelines for students on the development of the course “Methodology of Scientific Research”.

* The training toolkit for self- studies to master the course is placed on the course 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 UPON COURSE COMPLETION

The assessment toolkit and the grading system* to evaluate the competences formation level (competences in part) upon the course study completion are specified in the Appendix to the course 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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