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ФИО: Ястребов Олег Александрович
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**Federal State Autonomous Educational Institution of Higher Education
PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA
Patrice Lumumba RUDN University**

Science Faculty/Institute for Physical Research and Technologies

educational division (faculty/institute/academy) as higher education program developer

COURSE SYLLABUS

Computational experiment in the physics of complex systems

(course title)

Recommended by the Didactic Council for the Education Field of:

03.04.02. Physics

field of studies / speciality code and title

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

Fundamental and Applied Physics

higher education program profile/specialisation title

1. COURSE GOAL(s)

The purpose of mastering the discipline “Computational experiment in the physics of complex systems” is to provide basic training for master's students in the field of computational experiment; study of the foundations of setting up a numerical experiment in modern applied physics; studying the principles of organizing and conducting a computational experiment; study of the principles and methods underlying the computational experiment; familiarization of students with the main directions in the computational experiment in physics, as well as the acquisition by students of knowledge and skills in the independent development of numerical models for the study of complex physical phenomena and processes occurring in existing and designed experimental facilities.

2. REQUIREMENTS FOR LEARNING OUTCOMES

Mastering the discipline “Computational experiment in the physics of complex systems” is aimed at developing the following competencies (parts of competencies):

Table 2.1. List of competences that students acquire through the course study

Competence code	Competence descriptor	Competence formation indicators (within this course)
GC-7	Capable to: search for the necessary sources of information and data, perceive, analyze, memorize and transmit information using digital means, as well as using algorithms when working with data obtained from various sources in order to effectively use the information received to solve problems; evaluate information, its reliability, build logical conclusions based on incoming information and data.	GC-7.1. Searches for the necessary sources of information and data, perceives, analyzes, memorizes and transmits information using digital means, as well as using algorithms when working with data received from various sources in order to effectively use the information received to solve problems.
		GC-7.2. Evaluates information, its reliability, builds logical conclusions based on incoming information and data.
GPC-3	Able to apply knowledge in the field of information technology, use modern computer networks, software products and resources of the	GPC-3.1 Uses specialized Internet resources to search for scientific information and analyze trends in the development of sciences.

Competence code	Competence descriptor	Competence formation indicators (within this course)
	information and telecommunications network “Internet” (hereinafter referred to as the “Internet”) to solve problems of professional activity, including those outside the scope of specialized training.	GPC-3.2 Uses modern software for analyzing scientific data and preparing scientific presentations.
GPC-4	Able to determine the scope of implementation of the results of scientific research in the field of his professional activity.	GPC -4.1 Knows the main stages of implementing the results of scientific research in the field of his professional activity. GPC -4.2 Formulates the practical significance of the results of scientific research, taking into account the trends in the development of science and technology

3. COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

The discipline “Computational experiment in the physics of complex systems” refers to the mandatory part of block B1 of the Education Program of Higher Education.

As part of the Education Program of Higher Education, students also master other disciplines and / or practices that contribute to the achievement of the planned results of mastering the discipline “Computational experiment in the physics of complex systems”.

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 disciplines/modules, practices*	Subsequent disciplines/modules, practices*
GC-7	Capable to: search for the necessary sources of information and data, perceive, analyze, memorize and transmit information using digital means, as well as using algorithms when working with data obtained from various sources in order to effectively use the		Undergraduate practice

Competence code	Competence descriptor	Previous disciplines/modules, practices*	Subsequent disciplines/modules, practices*
	information received to solve problems; evaluate information, its reliability, build logical conclusions based on incoming information and data.		
GPC-3	GPC-3. Able to apply knowledge in the field of information technology, use modern computer networks, software products and resources of the information and telecommunications network “Internet” (hereinafter referred to as the “Internet”) to solve problems of professional activity, including those outside the scope of specialized training.	Research work	
GPC-4	Able to determine the scope of implementation of the results of scientific research in the field of his professional activity.	Research work	Undergraduate practice

* To be filled in according to the competence matrix of the higher education programme.

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total workload of the course “Computational experiment in the physics of complex systems” is 288 academic hours, 8 credits.

*Table 4.1. Types of academic activities during the periods of higher education program mastering (full-time training)**

Type of academic activities	Total academic hours	Semesters/training modules			
		1	2	3	4
Contact academic hours	144	-	-	144	-
including:					

Type of academic activities		Total academic hours	Semesters/training modules			
			1	2	3	4
Lectures (LC)		-	-	-	-	-
Lab works (LW)		144	-	-	144	-
Seminars (workshops/tutorials) (S)		-	-	-	-	-
<i>Self-studies</i>		108	-	-	108	-
<i>Evaluation and assessment (exam/passing/failing grade)</i>		36	-	-	36	-
Course workload	academic hours	288	-	-	288	-
	credits	8	-	-	8	-

5. COURSE CONTENTS

Table 5.1. Course contents and academic activities types

Course module number	Course module title	Course module contents (topics)	Academic activities types*
Section 1.	Topic 1. Methods for solving nonlinear algebraic equations	Chord method (method of secants). Newton's method (method of tangents). Combined method of chords and tangents. Iteration method (method of successive approximations). Dichotomy method (method of dividing a segment in half).	LW
	Topic 2. Solving interpolation and extrapolation problems	Lagrange interpolation polynomial. Solution of the interpolation problem at equally spaced and unequal interpolation nodes.	LW
Section 2.	Topic 3. Analytical methods for solving ordinary differential equations	The method of successive approximations (Picard's method). A method of integrating differential equations using power series.	LW
	Topic 4. Numerical methods for solving ordinary differential equations	Euler's method. Runge-Kutta method. Adams method.	LW
	Topic 5. Finite Difference Method. Solving the Heat Conduction Problem	Finite differences. Explicit and implicit difference schemes. Formulation of the heat conduction problem and its solution using the finite	LW

Course module number	Course module title	Course module contents (topics)	Academic activities types*
		difference method.	
Section 3.	Topic 6. Solution of elliptic partial differential equations	Classification of partial differential equations. Canonical form of an elliptic differential equation. Laplace's equation.	LW
	Topic 7. Methods for solving parabolic and hyperbolic partial differential equations	Canonical form of parabolic and hyperbolic differential equations. Wave equation.	LW
	Topic 8. Solution of partial differential equations for a domain with a curved boundary	Solution of the Laplace equation for a domain with a curved boundary.	LW

* - 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	Specialised educational / laboratory equipment, software, and materials for course study (if necessary)
Lab work	A classroom for laboratory work, individual consultations, current control and intermediate certification, equipped with a set of specialized furniture and equipment.	Lab. 171, 355.
Self-studies	A classroom for individual work of students (can be used for seminars and consultations), equipped with a set of specialized furniture and computers with access to the EIOS.	Computers for conducting computational experiments

* - the audience for individual work of students is indicated **MANDATORY!**

7. RESOURCES RECOMMENDED FOR COURSE STUDY

Main literature:

1. Volkov E. A. Numerical methods: a textbook for universities / E. A. Volkov. – 8th ed., reprinted – St. Petersburg: Lan, 2025. – 252 p.

2. Amosov A. A. Computational methods: textbook for universities / A. A. Amosov, Yu. A. Dubinsky, N. V. Kopchenova. – 6th ed., revised. – St. Petersburg: Lan, 2025. – 672 p.
3. Ermakov S. M. Monte Carlo Method in Computational Mathematics. Introductory Course: A Textbook for Universities / S. M. Ermakov. – 2nd ed., corrected and supplemented. – St. Petersburg: Lan, 2024. – 192 p.
4. Rusina L. G. Computational Mathematics. Numerical Methods of Integration and Solution of Differential Equations and Systems: A Textbook for Universities / L. G. Rusina. – 2nd ed., reprinted – St. Petersburg: Lan, 2022. – 168 p.
5. Kvasov B. I. Numerical methods of analysis and linear algebra. Using Matlab and Scilab: a tutorial / B. I. Kvasov. – St. Petersburg: Lan, 2016. – 328 p.

Additional literature:

1. Samarsky A. A., Vabishchevich P. N. Additive schemes for problems of mathematical physics. – Moscow: Nauka, 2001. – 312 p.
2. Samarsky A. A., Vabishchevich P. N. Mathematical modeling and numerical experiment. – Institute of Mathematical Modeling MM RAS, 2000. - (Internet publication). – <http://www.imamod.ru/~vab/matmod/MatMod.htm>.
3. Samarsky A. A., Vabishchevich P. N. Computational heat transfer. – Moscow: URSS, 2003. – 784 p.
4. Ibragimov I. M. Fundamentals of computer modeling of nanosystems: a textbook for universities / I. M. Ibragimov, A. N. Kovshov, Yu. F. Nazarov. – 2nd ed., reprinted – St. Petersburg: Lan, 2026. – 380 p.
5. Demidovich B. P. Fundamentals of Computational Mathematics: a textbook for universities / B. P. Demidovich, I. A. Maron. – 9th ed., reprinted. – St. Petersburg: Lan, 2026. – 672 p.

Resources of the information and telecommunications network «Internet»:

1. RUDN ELS and third-party ELS, to which university students have access on the basis of concluded agreements:
 - RUDN Electronic Library System - RUDN ELS <http://lib.rudn.ru/MegaPro/Web>
 - ELS “University Library Online” <http://www.biblioclub.ru>
 - ELS URAIT <http://www.biblio-online.ru>
 - ELS “Student Advisor” www.studentlibrary.ru
 - EBS “Lan” <http://e.lanbook.com/>
 - ELS “Troitsky Most”
2. Databases and search engines:
 - 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/>
 - abstract database SCOPUS <http://www.elsevierscience.ru/products/scopus/>

Educational and methodological materials for individual work of students in the development of the discipline/module:*

1. Laboratory workshop on the discipline “Computational experiment in the physics of complex systems”.

* - all educational and methodological materials for individual work of students are placed in accordance with the current procedure on the page of the discipline in TUIS (LMS)!

DEVELOPERS:

Associate Professor, IPRT (IFIT)

Position, BEU

Signature

Nikolaev N.E.

Family Name

HEAD OF BEU:

Acting Director of IPRT (IFIT)

Name of BEU

Signature

Kravchenko N.Yu.

Family Name

**HEAD OF EDUCATIONAL PROGRAM
OF HIGHER EDUCATION:**

Director of IPRT (IFIT)

Position, BEU

Signature

Loza O.T.

Family Name