Federal State Autonomous Educational Institution of Higher Education

PEOPLES' FRIENDSHIP UNIVERSITY OF RUSSIA
RUDN University

Faculty of Physics, Mathematics and Natural Sciences

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

COURSE SYLLABUS

Mathematical models in biology and medicine

course title

Recommended by the Didactic Council for the Education Field of:

01.04.01 Mathematics

field of studies / speciality code and title

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

«Functional methods in differential equations and interdisciplinary research»

higher education programme profile/specialisation title

2025

1. COURSE GOAL(s)

The purpose of mastering the discipline "Mathematical models in biology and Medicine" is to obtain basic knowledge about the laws of nature governing the operation of chemical, biochemical and biological systems, about the methods of constructing mathematical models of these systems and about the methods of analysing the constructed models.

2. REQUIREMENTS FOR LEARNING OUTCOMES

Mastering the discipline "Mathematical models in biology and Medicine" is aimed at developing the following competencies (parts of competencies):

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

Code	Competence	Competence achievement indicators (within this discipline)
GC-5	Able to analyze and take into account the diversity of cultures in the process of intercultural interaction	GC-5.1. Analyzes the most important ideological and value systems, forming which have arisen in the course of historical development; substantiates the relevance of their use in social and professional interaction
		GC-5.2. Builds social and professional interaction, taking into account the characteristics of the main forms of scientific and religious consciousness, business and general culture of representatives of other ethnic groups and confessions, various social groups
		GC-5.3. Ensures the creation of a non-discriminatory environment for interaction when performing professional tasks
PC-10	Able to manage the educational and research activities of students	PC-10.1. Formation of organizational and leadership abilities in scientific and pedagogical activities

3.COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

The discipline "Mathematical models in biology and Medicine" refers to the part formed by the participants in the educational relations of block B1 of the EP HE.

As part of the EP HE, students also master other disciplines and / or practices that contribute to the achievement of the planned results of mastering the discipline "Mathematical models in biology and Medicine".

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

Code	Competence	Previous disciplines/modules, practices	Subsequent disciplines/modules, practices*
GC-5	Able to analyze and take into account the diversity of cultures in the process of intercultural interaction	-	State exam

Code	Competence	Previous disciplines/modules, practices	Subsequent disciplines/modules, practices*
PC-10	Able to manage the educational and research activities of students		State exam

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total labor intensity of the discipline "Mathematical models in biology and Medicine" is 4 credits.

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

Type of study work		TOTAL, a.h.	Semester			
			1	2	3	4
Contact academic hours		*72*		*72*		
including:						
Lectures (LC)		36		36		
Lab work (LW)						
Seminars (workshops/tutorials) (S)		36		36		
Self-studies		*36*		*36*		
Evaluation and assessment (exam/passing/failing grade)		*36*		*36*		
Course workload	a.h.	**144**		**144**		
	credits	**4**		**4**		

5. COURSE CONTENTS

Table 5.1. Course contents and academic activities types

Course Module Title	Brief Description of the Module Content	Type of study work
Section 1. Introduction to mathematical modeling in Biology, Biomedicine and Biochemistry.	Topic 1.1. Mathematics as a method of studying biological systems.	Lecture
Section 2. Phenomenological chemical kinetics, simple reactions.	Topic 2.1. Simple reactions of the 1st order. Topic 2.2. Simple reactions of the 2nd order.	Lecture, seminar
Section 3 Kinetics of complex reactions.	Topic 3.1. Reversible reactions. Topic 3.2. Sequential reactions. Topic 3.3. Parallel reactions.	Lecture, seminar

Section 4 Kinetics of enzymatic reactions.	Topic 4.1. Kinetics of enzymatic reactions. Topic 4.2. Inhibition of the work of enzymes	Lecture, seminar
Section 5 Qualitative analysis of differential equations, linear systems on a plane.	Topic 5.1. Qualitative analysis of the scalar ODE of the 1st order, the Lyapunov method. Topic 5.2. Qualitative analysis and classification of linear systems of 1st order ODES on the plane. Topic 5.2. Qualitative analysis and classification of linear systems of 1st order ODES on the plane.	Lecture, seminar
Section 6 Qualitative analysis of nonlinear biological systems.	Topic 6.1. Nonlinear systems in biology and chemical kinetics Topic 6.2. Quantitative and qualitative methods of investigation of nonlinear systems on the plane. Topic 6.3. Investigation of singular points of nonlinear systems, 1st Lyapunov method. Topic 6.4. Examples of the study of biological systems by qualitative methods. Self-oscillations and limit cycles. The rudeness of the systems. Bistability and threshold. Spatially distributed systems. Topic 6.5. Cooperative processes. Trigger systems in biology.	Lecture, seminar
Section 7 Quantitative study of complex biological systems by numerical methods.	Topic 7.1. Mechanisms of the hemostasis system.	Lecture, seminar

6. CLASSROOM EQUIPMENT AND TECHNOLOGY SUPPORT REQUIREMENTS

Table 6.1. Classroom equipment and technology support requirements

Classroom type	**Classroom equipment**	**Specialized educational/laboratory equipment, software and materials for mastering the discipline**
Lecture	An auditorium for lecture-type classes, equipped with a set of specialized furniture; board (screen) and technical means of	-

Classroom type	Classroom equipment	Specialized educational/laboratory equipment, software and materials for mastering the discipline
	multimedia presentations.	
Seminar	An auditorium for conducting seminar-type classes, group and individual consultations, current control and intermediate certification, equipped with a set of specialized furniture and technical means for multimedia presentations, and PC for students	PC for students with pre-installed Python, with libraries numpy, matplotlib, scipy; the marker of chalk desk
For independent work of students	An auditorium for conducting seminar-type classes, group and individual consultations, current control and intermediate certification, equipped with a set of specialized furniture and technical means for multimedia presentations, and PC for students	PC for students with pre-installed Python, with libraries numpy, matplotlib, scipy; the marker of chalk desk

7. RESOURCES RECOMMENDED FOR COURSE STUDY

Main literature:

1. O.E. Solovyov. Mathematical modeling of living systems. Ural University Press, 2013.
2. Alexander Panfilov (Alexander Panfilov). Qualitative analysis of differential equations, 2010. https://arxiv.org/abs/1803.05291
3. Murray James D. Mathematical Biology. Vol. 1 : Introduction / D. Murray ; translated from English by L.S. Vanag and A.N. Dyakonova; edited by G.Yu. Riznichenko. - Moscow ; Izhevsk : SIC "Regular and chaotic Dynamics" : Institute of Computer Research, 2009. - 776 p. - (Biophysics. Mathematical Biology). - ISBN 978-5-93972-743-3 : 1022.00.
4. Murray, James D. Mathematical Biology. Vol. 2 : Spatial models and their applications in biomedicine / D.D. Murray ; edited by G.Y. Riznichenko; translated from English by A.N. Dyakonova, A.V. Duba, P.V. Shelyakina. - Moscow ; Izhevsk : SIC "Regular and chaotic dynamics" : Izhevsk Institute of Computer Research, 2011. - 1104 p. : ill. - (Biophysics. Mathematical Biology). - ISBN 978-5-93972-882-9 : 1110.00.

Additional literature:

1. 1) Бордовский, Г. А. Физические основы математического моделирования : учебник и практикум для вузов / Г. А. Бордовский, А. С. Кондратьев, А. Чоудери. — 2-е изд., испр. и доп. — Москва : Издательство Юрайт, 2022. — 319 с. — (Высшее образование). — ISBN 978-5-534-05365-4. — URL : https://urait.ru/bcode/491147
2. Riznichenko, G. Y. Mathematical modeling of biological processes. Models in biophysics and ecology : a textbook for universities / G. Yu. Riznichenko. — 2nd ed., reprint. and add. — Moscow : Yurayt Publishing House, 2022. - 181 p. — (Higher education). — ISBN 978-5-534-07037-8. — URL : https://urait.ru/bcode/490489
3. Riznichenko G.Y. Lectures on mathematical models in biology. Publishing house "RHD", 2011
4. A.B. Rubin. Biophysics: textbook. M.: KNORUS, 2006.

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 EBS http://lib.rudn.ru/MegaPro/Web
- ELS "University Library Online" http://www.biblioclub.ru
- EBS Yurayt http://www.biblio-online.ru
- ELS "Student Consultant" www.studentlibrary.ru
- EBS "Lan" http://e.lanbook.com/
- EBS "Trinity Bridge"

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/
- Google Academy (Google Scholar) https://scholar.google.ru / – search engine for full texts of scientific publications of all formats and disciplines.
- PubMed https://pubmed.ncbi.nlm.nih.gov / – a database of medical and biological publications created by the US National Center for Biotechnological Information.

8. ASSESSMENT TOOLKIT AND GRADING SYSTEM* FOR EVALUATION OF STUDENTS' COMPETENCES LEVEL UPON COURSE COMPLETION

Evaluation materials and a point-rating system* for evaluating the level of formation of competencies (parts of competencies) based on the results of mastering the discipline "Mathematical models in biology and Medicine" are presented in the Appendix to this Work Program of the discipline

Developer:

A.S. Mozokhina

signature name and surname

HEAD
OF HIGHER EDUCATION PROGRAMME:

V.I. Burenkov

signature name and surname

HEAD
OF EDUCATIONAL DEPARTMENT

A.B. Muravnik

signature name and surname