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

Nonlinear analysis and optimization

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

1. COURSE GOAL(s)

The main goal of the course is to master the basic skills of independent research work in the field of optimization methods, as well as work in a group of researchers. Side (but no less important) goals are the acquisition of skills in presenting one's own results; performances as speakers, reviewers, opponents on other people's reports; writing and preparing for publication of their own works: theses, notes, articles, dissertations, etc.

2. REQUIREMENTS FOR LEARNING OUTCOMES

Mastering the discipline "Nonlinear analysis and optimization" 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)
PC-5	Able to conduct scientific research and obtain new scientific and applied results independently and as part of a scientific team	PC-5.1 Uses existing and receives new methods for solving mathematical problems
PC-6	Able to organize corporate training processes based on information technology and development of corporate knowledge bases	PC-6.1. Ability to use modern ICT in learning and teaching

3.COURSE IN HIGHER EDUCATION PROGRAMME STRUCTURE

The discipline "Nonlinear analysis and optimization" refers to the obligatory part 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 « Nonlinear analysis and optimization »

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*
PC-5	Able to conduct scientific research and obtain new scientific and applied results independently and as part of a scientific team	Interdisciplinary coursework	State examination
PC-6	Able to organize corporate training	-	State examination

Code	Competence	Previous disciplines/modules, practices	Subsequent disciplines/modules, practices*
	processes based on information technology and development of corporate knowledge bases		

4. COURSE WORKLOAD AND ACADEMIC ACTIVITIES

The total labor intensity of the discipline " Nonlinear analysis and optimization" is 3 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 work, academic hours		*40*			*40*	
Lectures (LC)		20			20	
Lab work (LW)						
Seminars (workshops/tutorials) (S)		20			20	
Self-studies		*41*			*41*	
Evaluation and assessment (exam/passing/failing grade)		*27*			*27*	
Course workload	a.h.	**108**			**108**	
	credits	**3**			**3**	

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. General concepts	Topic 1.1. Classification of extremal problems. Statement of classical problems of calculus of variations and optimal control. Elements of functional analysis	Lecture, seminar
Section 2. Differentiable functionals	Topic 2.1. Differentiable Functionals. Derivative in direction, Lagrange, Gateau and Fréchet. Extremum of differentiable functionals Topic 2.2. Uniqueness of the Fréchet derivative. Fermat's principle and related statements	Lecture, seminar

Section 3. First order conditions in the classical problem of the calculus of variations	Topic 3.1. Statement of the simplest problem of the calculus of variations. Basic Lemmas of the Calculus of Variations Topic 3.2. Extremal smoothness. Derivation of the Euler equation for the classical problem of the calculus of variations. Special cases of the Euler equation	Lecture, seminar
Section 4. The Euler equation in the multidimensional case	TTopic 4.1. Formulation of the problem. Derivation of the Euler equation using the main lemmas of the calculus of variations	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 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.	-
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.	-

7. RESOURCES RECOMMENDED FOR COURSE STUDY

Main literature:

1. Magaril-Ilyaev G.G., Tikhomirov V.M. Convex analysis and its applications. M. Librokom, 2016
2. Sukharev AG Timokhov AV Fedorov VV Numerical optimization methods. 3rd ed. M. Yurait. 2016.

3. Alekseev V.M., Galeev E.M., Tikhomirov V.M. Collection of optimization problems. Theory. Examples. Tasks.2016

Additional literature:

1. Vasiliev F.P. Optimization methods. Moscow: Factorial Press, 2002.
2. Aubin J.-P., Ekland I. Applied nonlinear analysis. M.: Mir, 1988.
3. Polyak B.T. Introduction to optimization. - M.: Nauka, 1983. - 384 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 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/

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 " Nonlinear analysis and optimization" are presented in the Appendix to this Work Program of the discipline

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