RUDN university

FACULTY OF SCIENCE

MATHEMATICAL MODELS IN INTERDISCIPLINARY RESEARCH

MASTER'S DEGREE PROGRAMME

PROGRAM ADVANTAGES

- The field of professional activity of a graduate student in “Applied Mathematics and Computer Science” is research, mathematical modeling, information technology in the areas of software development and testing, creation, support and administration of information and communication systems, as well as teaching in the fields of general, professional and additional education.
- The acquired knowledge and practical skills allow graduates to work in scientific and research centers. Graduates are successful in the aviation and space industries, as well as in education, thanks to teaching skills.
- Considerable time is devoted to student’s research projects, work in teams of researchers, and preparation of the graduate work.
- The entire educational process and scientific research are carried out in multimedia classrooms, scientific and educational laboratories of the S.M. Nikol’skii Mathematical Institute, and in computer classes equipped with modern hardware and software for development of numerical simulation.
- Russian and foreign world-class scientists are regularly invited to deliver lectures and masterclasses on actual issues of pure and applied mathematics and mathematical modeling.
- During the program, students take part in research activities of interdisciplinary scientific centers operating within the Mathematical Institute: the interdisciplinary scientific center “Mathematical Modeling in Biomedicine” under the guidance of a visiting professor V.A. Volpert (France), Scientific Center for Nonlinear Problems of Mathematical Physics under the guidance of visiting professor A.E. Shishkov (Ukraine).
- Due to the internationality of the study groups, students build their own network of professional international contacts in the university and beyond.
- In accordance with the cooperation agreement with Al-Farabi Kazakh National University, students have the opportunity to study part of the disciplines at the partner University.

STUDYING PROCCESS

120 credits

Lectures, practical exercises and independent work, several types of practice.

MATHEMATICAL MODELS IN ECONOMICS AND ECOLOGY

- Lyapunov stability and orbital stability.
- Lyapunov methods of stability research.
- Structural stability.
- The model of conflict behavior of individuals of the same species.
- Stability research. Dynamics of “predator-prey” populations.
- Volterra–Lotka equations.
- The Holling–Tanner model and its structural stability.
- Bee economy.
- The benefits of combining.
- “Division of labor” in insect colonies and structural instability.
- Goodwin economic models.
- Rayleigh-type equations.
- Limit cycles for Rayleigh-type equations of economic models.
- Hopf bifurcation of Rayleigh equations.

NONLOCAL BOUNDARY-VALUE PROBLEMS

- Function spaces used in the course, interpolation inequalities, facts from the theory of boundary-value problems for elliptic equations with a parameter, boundary-value problems for elliptic equations in nonsmooth domains; rise of nonlocal boundary-value problems and their classification.
- The problem where the support of nonlocal terms is located inside the domain.
- The problem where the support of nonlocal terms approaches to the boundary outside the conjugation points.
- The problem where the support of nonlocal terms approaches to the conjugation points.

NEURAL NETWORKS

- Biological prototypes, artificial neurons, single-layer and multi-layer artificial neural networks.
- Training artificial neural networks. Learning algorithms.
- Perceptron architecture.
- The range of tasks for which the perceptron is used.
- Training.
- Backpropagation procedure.
- An overview of the main stochastic methods used to train neural networks: metal annealing method, Boltzmann training, Cauchy training, artificial heat capacity method.
- Study of various methods of training neural networks.
- Systematization of the studied.

ADDITIONAL CHAPTERS OF MATHEMATICAL MODELING

- Construction of mathematical models based on the nature fundamental laws.
- Universality of mathematical models.
- Models of hard to formalize objects.
- Keynes business cycle model and Weidlich–Haag sociodynamics.
- Infections spread models.
- Quasi-one-dimensional model of hemodynamics on graphs.
- The Samarsky–Mikhailov model “authoritiy-society” the legal system.
- The Lefebvre–Prigogine “brusselator” model.
- Geometric methods for ODE systems on the plane.
- Hopf’s theorem on cycle-birth bifurcation for a one-parameter ODE system.
- Cycle-birth bifurcation for local semi-flows.
- Methods of waves propagation and separation of variables in mixed problems for linear hyperbolic systems on graphs.

NONLINEAR PROBLEMS OF MATHEMATICAL PHYSICS

- Bochner measurability, Bochner integral.
- Integrable functions spaces.
- Strong and weak continuity.
- Strong and weak differentiability.
- Generalized derivatives.
- Generalized differentiable functions spaces.
- Semigroups of operators.
- Groups of operators.
- Abstract evolution equations.
- Special properties of unitary groups of operators.
- The Korteweg–de Vries equation.
- The linearized Korteweg–de Vries equation.
- The Cauchy problem for the Korteweg–de Vries equation.
- Mixed problems for the Korteweg–de Vries equation.

ANALYTICAL-NUMERICAL METHODS FOR HYDRODYNAMICS PROBLEMS

- The course is devoted to modern analytical-numerical methods for the hydro- and gas dynamics problems.
- We consider the balance equation and the state equation, characteristics and Riemann invariants, relations at a strong discontinuity, a stationary direct shock wave, the Hugoniot adiabat, and various types of shock waves.
- Particular attention is devoted to application of simple wave solutions to the analysis of unsteady flows of an ideal gas. For this, we consider the problem of a piston moving out of a pipe filled with gas.
- In the practical part of the course, the skills of constructing and implementing effective algorithms for partial differential equations are formed.
- The skills of using technology of a full cycle of mathematical modeling are formed on the example of solving the classical problem of the arbitrary gap decay.

STUDENTS FEEDBACK

NIKITA IVANOV, RUSSIA

I am grateful to the Program «Applied Mathematics and Informatics» of the faculty of Physics, Mathematics and Natural Sciences of RUDN University for the opportunity to get a master's degree in 2019. The educational program had a wide range of mathematical disciplines and applications that allowed me to get an idea of specific mathematical problems and science in general. I especially remember the scientific seminars at the Mathematical Institute that helped me to expand my scientific horizons and increase my interest in the subject. I would like to express special gratitude to professors and tutors for their professionalism and responsiveness. I have only positive emotions about studying for a master's degree.

NATALIA IZVARINA, RUSSIA

My master's degree at RUDN University gave me an opportunity to plunge deeper into scientific life after finishing my bachelor's degree. During the two years of studying, there were opportunities to speak at international conferences (with financial support from the University). I was also given the opportunity to gain invaluable experience in conferences organization. Moreover, the S.M. Nikol'skii Mathematical Institute actively promotes students' trips to probation at foreign universities for joint research activities with foreign specialists. I would like to express great gratitude to the faculty members for their dedication, responsiveness and attention to each student.

STUDENTS FEEDBACK

KONSTANTIN ZHUIKOV, RUSSIA

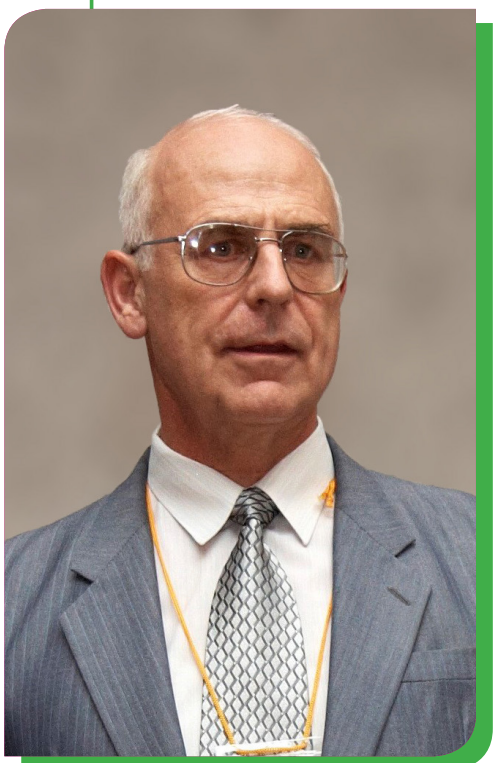
From an early age, mathematics occupied a special place in my range of interests. Behind the conciseness of the formulas, the hidden beauty firmly defined my future, and the first steps to make it a reality began with the development of the master's program in the direction of "Applied Mathematics and Informatics". I got a deep mathematical knowledge, as well as programming skills in diverse popular languages. A significant part of the educational program was devoted to mathematical modeling of various biological and economic processes. The deep professionalism of the faculty members has turned training into an entertaining process of learning and applying the knowledge gained to actual problems of modern natural science. RUDN University provides a wide range of opportunities for growth and self-realization in the scientific field: the high scientific level and strong international cooperation allowed me to participate in the foreign probation, as well as in the organization of several major scientific events, which left an indelible impression and gave extremely fruitful results.

AMINA ADHAMOVA, RUSSIA

In 2018, I graduated with honors with a master's degree. The program includes both subjects related to theoretical mathematics and applied mathematics with such current topics as mathematical medicine, economics, and others. One of the features of the program is the wide variety of extracurricular seminars and lectures that allow one to better study a particular field of mathematics or computer science. I would also like to mention the possibility of a probation abroad provided by the S.M. Nikol'skii Mathematical Institute. And I would like to express my gratitude to the faculty members for their attention to students and creation of the environment in which you want to do science! I also advise undergraduate students to enroll in this program. You will get an unforgettable experience of studying at an intercultural University and valuable knowledge that you can use at work.

HEAD OF THE PROGRAMME

ALEXANDER LEONIDOVICH SKUBACHEVSKII



Doctor of physical and mathematical sciences, professor, Director of the S.M. Nikol'skii Mathematical Institute. He holds the post of the Chairman of Expert council of the Higher Attestation Commission for mathematics and mechanics of the Ministry of Education and Science of the Russian Federation; is a member of Presidium of the Scientific and Methodological Council for mathematics of the Ministry of Education and Science of the Russian Federation; is a Deputy Chairman of the Dissertation Council D212.203.27 at the Peoples' Friendship University of Russia; is a member of the Doctoral Dissertation Council D002.022.02 of the V.A. Steklov Mathematical Institute of the RAS; is member of the Moscow Mathematical Society and the American Mathematical Society. A.L. Skubachevskii is Deputy of the Chief Editor of the journal «Contemporary Mathematics. Fundamental Directions», which is published in RUDN and translated into English by Springer publishing house (since 2003). A.L. Skubachevskii was awarded by the prize named after I.G. Petrovsky of the RAS in 2016.

- He was awarded by medal «850 Years of Moscow», by Certificate of the Ministry of Education and Science of the Russian Federation for achievements in education and training of highly qualified personnel, by Breastplate «For merits in the development of the Republic of Kazakhstan». A.L. Skubachevskii is a Honorable Professor of the L.N. Gumilyov Eurasian National University, is Honored Scientist of the Russian Federation (2019). In 2014, A.L. Skubachevskii became the winner of the Competition for state support of leading scientific schools (SSh-4479.2014.1).

HEAD OF THE PROGRAMME

- Areas of scientific interests: oscillation of solutions of functional differential equations, boundary-value problems for functional differential equations, theory of control for systems with aftereffect, boundary-value problems for elliptic and parabolic functional differential equations, nonlocal elliptic boundary-value problems, Feller semigroups, the Kato square root problem for an operator, mixed problems for the Vlasov–Poisson equations.
- He is the author of more than 100 scientific articles in peer-reviewed Russian and foreign scientific journals (VAK, SCOPUS, Web of Science), he regularly gives lectures at international conferences.
- A.L. Skubachevskii is a member of the Program Committee of the Crimean International Mathematical Conference, which takes place in Crimea annually, since 1990 he is a chairman of the Program Committee of the International Conference on Differential and Functional Differential Equations (DFDE) which takes place every 1994 with the support of the Peoples' Friendship University of Russia, V.A. Steklov Mathematical Institute of the RAS, M.V. Lomonosov Moscow State University since.
- He repeatedly received grants from Russian and foreign scientific funds (the RFBR, the Ministry of Education of the Russian Federation, Soros' fund, INTAS, the Kawaii Foundation London Mathematical Society, the German Scientific Society DFG).