Ministry of Science and Education Republic of Azerbaijan Institute of Mathematics and Mechanics of semi-annual report of the "Optimal Control" Department for 2023
scientific and scientific organization

Employees of the department

The department of "Optimal Control" employs 9 researchers (3 full-time employees, 6 part time) 7 of them are doctors of science, 2 of them are corresponding members of ANAS:

1. Professor Misir Mardanov – head of department (corr. member of ANAS)
2. Professor Kamil Aidazade – Senior Researcher-part time (Corr. Member of ANAS)
3. Professor Telman Melikov – Senior Researcher
4. Professor Hamlet Guliyev – Senior Researcher-part time
5. Professor Yagub Sharifov – Senior Researcher-part time
6. Professor Ramin Rzayev – Senior Researcher-part time
7. Professor Yusif Gasimov – Leading Researcher-part time
8. Ph.D. of Physics and Mathematics Eldar Mammadov – Leading Researcher.
9. Samin Malik, Ph.D. – Scientific Researcher (part-time.).

In the department of "Optimal control", scientific researches were carried out on the topic **"Optimal control problems described by various systems"** 2023 according to the approved plan:

1) Work: "New sufficient conditions for variation calculation and optimal management.

Stage: In the calculus of variations and optimal control, high formulation of necessary conditions and their corresponding sufficient conditions.

Executers: Corresponding member of ANAS, prof. Misir Mardanov, doct. of phys. Math. Sci. prof.Telman Malikov, Scientific Researcher Samin Malik

For a simple optimal control problem, new and more powerful necessary conditions for the optimization of a special controller have been obtained.

The following results were obtained on the topic:

1. M.J.Mardanov, T.K.Melikov, S.T.Malik. Necessary conditions for a minimum in classical calculus of variations in the presence of various types of degenerations, Journal of Computational and Applied Mathematics, Volume 418, 15 January 2023, https://doi.org/10.1016/j.cam.2022.114668

2. M.J.Mardanov, E.N.Mahmudov. "Optimization of hyperbolic-type polyhedral differential inclusions", Proceedings of the International Conference on Modern Problems of Mathematics and Mechanics, Baku 2023, 26-28 April, page. 236-238.

3. Mardanov M.J., Mahmudov E.N. Optimal control of elleptic differential inclusions with mixed boundary conditions, Conference proceedings, Sumqayıt, 2023, № 2, pp. 5-7.

4. Марданов М.Дж., Мансимов К.Б. К оптимальности квазиособых управлений в задаче управления интегро-дифференциальными уравнениями, Conference proceedings, Sumqayıt, 2023, № 2, pp. 143-144.

5. Марданов М.Дж., Мамедов И.Г., Абдуллаева И.А., О корректной разрешимости одной неклассической краевой задачи для обобщенного уравнения Аллера, материалы конференций, Сумгайыт, сс.145-148.

6. M.J.Mardanov, A.M.Isayeva. Euler type system of equations in variational problems with delayed argument. // Modern Problems of Mathematics and Mechanics. Proceedings of theg International Conference dedicated to the 100-th anniversary of the National Leader Heydar Aliyev. Baku, 26-28 Aprel 2023. p. 266-267.

About personalities

7. M.C.Mardanov. "Great scientist, selfless organizer of science and education**",** Republican newspaper, 15 february, 2023 year.

8. M.C.Mardanov. 629th student**,** 525th newspaper, 04 february, 2023 year **(with professor Adalat Tahirzadeh).**

2) Work: "Solving the boundary value problem considering a parabolic differential equation with moving loading points".

Executer: Corresponding member of ANAS Kamil Aida-zade

An initial-boundary problem is posed for loaded parabolic control. In the considered problem, the positions of the loading points change with time and satisfy the system of ordinary differential equations. To solve the problem, it is proposed to use the numerical schemes of the finite difference method.

3) Work: "Optimization for some equations with practical applications, development of analytical and numerical solution methods for direct and inverse problems".

Executer: doct. of phys. Math. Sci. prof. Yusif Qasımov.

Numerical and analytical solutions of equations describing various physical and mechanical processes were investigated.

The following results were obtained on the topic:

1. **Adeyemo O.D., Khalique C.M., Gasimov Y.S.&Villecco F**. (2023). Variational and non-variational approaches with Lie algebra of a generalized (3+1)-dimensional nonlinear potential Yu-Toda-Sasa-Fukuyama equation in Engineering and Physics. Alexandria Engineering Journal. **(Web of Science Impakt Faktor – 6.626 – Q1).**

2. **Jafari H., Ganji R.M., Ganji D.D., Hammouch Z., Gasimov Y.S.** (2023). A novel numerical method for solving fuzzy variable-order differential equations with Mittag-Leffler kernel. Fractals, https://doi.org/10.1142/S0218348X23400637. **(Web of Science Impakt Faktor – 4.555 – Q1).**

3. **Golmankhaneh A.Kh., Welch K., Tunc C., Gasimov Y.S.** (2023). Classical mechanics on fractal curves. Eur. Phys. J. Spec. Top., https://doi.org/10.1140/epjs/s11734-023-00775-y. **(Web of Science Impakt Faktor – 2.891 – Q2).**

4. **Agamalieva, L., Gasimov Y.S., and Valdes J.E.N**. (2023). On a generalization of the Wirtinger inequality and some its applications. Stud. Univ. Babes-Bolyai Math. 68(2), 237-247. https://doi.org/10.24193/subbmath.2023.2.01 **(Web of Science ESCI).**

5. **Gasimov Y.S., Guliyev H.F.** The speed-in-action problem for the nonlinear hyperbolic equation with a nonlocal condition. The 7th International Conference on Computational Mathematics and Engineering Sciences / 20-21 May. 2023, Elazığ-Türkiye. (Plenary report)

4) Work: "The optimal fastest effect problem for a two-order hyperbolic equation with a non-local boundary condition".
Executer: doct. of phys. Math. Sci. prof. Hamlet Guliyev.

Here, the problem of finding the right-hand side of a two-order hyperbolic equation is brought to the problem of optimal control through a functional constructed with the help of an additional condition. In the obtained problem, the existence of an optimal controller is proved, and a necessary condition for optimality is derived in the form of an integral inequality.

The following results were obtained on the topic:

1. **Кулиев Г.Ф., Сейфуллаева Х.И.** Задача граничной управляемости для уравнения колебаний тонкой пластины. // Теоретические и прикладные проблемы математики. III Международная научная конференция. 25-26 апреля 2023. Сумгайыт. с. 131-132.

2. **Кулиев Г.Ф., Исмаилова Г.Г.** Исследование одной обратной граничной задачи для уравнения колебаний струны методом оптимального управления. // Теоретические и прикладные проблемы математики. III Международная научная конференция. 25-26 апреля 2023. Сумгайыт с. 133-135.

5) Work: “A study of non-local boundary value problems and optimal control problems described with them”.
Executers: Corresponding member of ANAS, prof. Misir Mardanov and doct. of phys. Math. Sci. prof.Yaqub Sherifov

In this work, the problem of optimal control with a "clean" integral boundary condition is considered. Green's function is constructed. Sufficient conditions for the uniqueness of the solution of the boundary problem have been found with the help of Banach's principle of compressed analysis. Pontryagin's maximum principle was proved with the help of the method of functional increments. The first and second variations of the functional are calculated. With the help of variations of the control functions, different second formulation necessary conditions for optimality are obtained.

The following results were obtained on the topic:

1. M.J. Mardanov, Y.A. Sharifov. An optimal control problem for the systems with integral boundary conditions**,** Bulletin of the Karaganda university, Mathematics series, 2023, (109) 1 (**WEB of Science).** DOI10.31489/2023 M1/11-123 UDC 517.97

2. M.J. Mardanov, Y.A. Sharifov. Fixed-point iteration method for solution first order differential equations with integral boundary conditions. // Modern Problems of Mathematics and Mechanics. Proceedings of the International Conference dedicated to the 100-th anniversary of the National Leader Heydar Aliyev. Baku, 26-28 Aprel 2023. p. 268-270.

6) WORK: Scientific research on "Comprehensive approach to the calculation of university rankings" was conducted:
Stage: “Development of adequate models
Executers: Corresponding member of ANAS, prof. Misir Mardanov, doctor of technical science, professor Ramin Rzayev

A comprehensive assessment of the competitiveness of universities, as a weakly structured issue, requires a multifaceted approach. Therefore, methods and models of mathematical statistics, elements of fuzzy logic, fuzzy sets and theories of neural networks, as well as hybrid (neural-fuzzy) systems and modern information technologies were used to solve it.

The following results were obtained on the topic:

1. Mardanov M.C., Aliyev E.R., Rzayev R.R., Abdullayev X.X. Calculating the integral index based on the expert analysis of indicators reflecting the academic performance of university teachers // Azerbaijan school.| Azerbaijan Journal of Educational Studies. 2023, №1.

2. Mardanov M.C., Aliyev E.R., Rzayev R.R., Abdullayev X.X. Formation of the academic index of a university teacher based on weighted evaluation criteria //

International Conference on Intelligent and Fuzzy Systems (INFUS 2023), August 22-24, 2023, İstanbul Technical University and Galatasaray University, Istanbul, Turkish

SCIENTIFIC AND SOCIAL ACTIVITIES

Head of department professor Misir Mardanov is a chairman of the Dissertation Council ED 1.04 and of the Scientific Council of IMM. He is depute editor-in-chief of "ANAS News" journal, a member of the editorial board of "Azerbaijan Journal of Mathematics" and "Chebyshevskii sbornik", editor-in-chief of "Proc. of IMM ANAS", a member of the international editorial board of "TWMS Journal of Applied Mathematics" and chairman of Scientific Publishing of ANAS.

Phd in Physics and Mathematics, correspondign member of ANAS, professor Kamil Aydazadə,chairmanof the labaratory "Numerical methods of decision on the deterministic systems" of ANAS, editor in board in the journal pubslihed in Turkey "Ege University journal of the Faculty of Science", editor in board in "NASA Proceedings of the İnstitute of Mathematics and mechanics" international journal, the journal published in Russia, "Прикладная математика и фундаментальная информатика", TWNS "Pure and Applied Mathematics" international journal, Proceedings of İnstitute of Applied Mathematics, ANAS news (physics-and technology, mathematics), ANAS news ("Problems of Informatics and Control"), editor in board in Azerbaijan State Exam Center journal of "Abituriyent.

Professor Telman Melikov is a member of the AAC Expert Council in Mathematics and Mechanics.Editor in board in **Proceedings of the Institute of Mathematics and Mechanics**.

Doctor of Physical and Mathematical Sciences of Department of Mechanics and Mathematics, BSU, Department of Mathematical Control, professor Hamlet Guliyev is a member of the editorial board of the journal "Modern Mathematical Models and Applications".

Professor Yagub Sharifov is a member of the editorial board of the journal "Proceedings of the Institute of Applied Mathematics", a member of the Scientific Committee of the ICRAPAM-2019 conference.

Professor Ramin Rzayev is a senior researcher at the Institute of Control Systems of ANAS, a member of the editorial board of the Scientific Journal of Automation and Metabolism, a member of the program committee of the International Scientific Conference "Information Systems and Technologies: Achievements and Prospects." Member of "ICSCCW - International Conference on Theory and Application of Soft Computing, Computing with Words and Perceptions" and "ICAFS - International Conference on Theory and Applications of Fuzzy Systems and Soft Computing" program committee of the international conference .

Department's Senior Researcher Yusif Gasimov**is a founder and director of Jomard Publishing that issues 8 scientific journals,** is editor in-chief of international journal "Advanced Mathematical Models and Applications", journal of "Modern Technology and Engineering" - International journalist member of the editorial board

of Applied Mathematics and Information Science - international editorial board, Proceedings of the Institute of Mathematics and Mechanics.

Head of department: **Corr. member of ANAS prof. Misir Mardanov**