

Institute of Mathematics and Mechanics of ANAS
Annual report of the “Optimal Control” Department for 2022
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.).

Submitted project

The project entitled "Development of the Academic Rating System, which supports the process of admission of professors and teachers in universities" with the authorship of Misir Mardanov and Ramin Rzayev, was presented to the current Azerbaijan Science Foundation

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

Stage: Strengthening the necessary conditions for optimality.

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 the extremum in non-smooth problems of variational calculus//Journal of Computational and Applied Mathematics <https://doi.org/10.1016/j.cam.2022>, 2022, vol. 399(113723) (Web of Science Impact Factor 2.872) Q₁.

2. **M.J.Mardanov, T.K.Melikov, S.T.Malik.** Minimum conditions in calculus of variations problems In the presence of various types of degenerations, Динамические системы и компьютерные науки: Теория и приложения (DYSC), Материалы 3-й Международной конференции, с. 126-128, 2021– since the proceedings of this conference were not included in the 2021 report, they are included here.

3. **M.J.Mardanov.** Life of a scientist dedicated to mathematics // Modern Problems of Mathematics and Mechanics (materials of the international scientific conference dedicated to the 110th anniversary of Academician Ibrahim Ibrahimov) pp. 3-12, 29.06.2022-01.07.2022.

4. **M.J.Mardanov, S.T.Malik.** Strong Kelley condition in theory of singular optimal controls. Modern Problems of Mathematics and Mechanics proceedings of the International scientific conference devoted to the 110-th anniversary of academician Ibrahim Ibrahimov. 29 June-01 July, 2022, Baku. pp. 140-142.

5. **M.J.Mardanov, Sh.E.Alieva.** Necessary conditions for the extremum is non-smooth problems of variational calculus // Modern Problems of Mathematics and Mechanics (materials of the international scientific conference dedicated to the 110th anniversary of Academician Ibrahim Ibrahimov) pp. 138-139, 29.06.2022-01.07.2022.

6. **Y.S.Gasimov, H.Jafari, M.J.Mardanov, R.A.Sardarova&Y.A.Sharifov.** Existence and uniqueness of the solutions of the nonlinear impulse differential equations with nonlocal boundary conditions // Quaestiones Mathematicas. 2021 DOI:10.2989/16073606.2021.1945702, Q₁. (Web of Science)

7. **М.Дж.Марданов, Р.М.Асланов.** Штрихи к портрету Давида Гильберта, X Международная научная конференция (К 160-летию со дня рождения Давида Гильберта 27-29 апреля 2022 года).

8. **M.J.Mardanov, P.M.Aslanov.** Бесценное наследие Насиреддина Туси в развитии тригонометрии, Материалы XVII Всероссийской с международным участием научно – практической конференции «Артемовские чтения», г. Пенза, 21 апреля 2021 г., стр. 71-78.

9. **M.J.Mardanov, I.G.Mamedov, I.A.Abdullayeva.** Integral representation of functions in Sobolev's anisotropic space with a dominant mixed derivative. Modern Problems of Mathematics and Mechanics proceedings of the International scientific conference devoted to the 110-th anniversary of academician Ibrahim Ibrahimov. 29 June-01 July, 2022, Baku. pp. 143, 144.

10. **Misir Mardanov.** Необходимые условия оптимальности для нового класса особых управлений. “4-я международная конференция Динамические системы и компьютерные науки: теория и приложения” (DYSC 2022) 19 Сентябрь 2022. Иркутский государственный университет.

Book

Misir Mardanov, "The Azerbaijanis studied of higher institutes to 1920 year". Encyclopedic questionnaire. Volume VII, Baku: Education Publishing House, 2022, 520 pages. (with Adalat Tahirzade).

2) WORK: "Research and development of a numerical method for solving the problem of synthesis of power control and movement of concentrated heat sources."

Executer: Corresponding member of ANAS Kamil Aida-zade

The analysis has been carried out, the formulations of problems for the synthesis of optimal control of capacities and the movement of concentrated heat sources have been proposed and investigated.

The following results were obtained on the topic:

1. К.Р.Айда-заде, В.М.Абдуллаев. Управление процессом нагрева стержня с использованием текущей и предыдущей по времени обратной связи Ж. "Автоматика и телемеханика", М., №1, 2022, с. 130-149.(**РИИЦ**)

2. K.R.Aida-zade, V.M.Abdullayev. Controlling the Heating of a Rod Using The Current Time Feedback. Automation and Remote Control, Pleiades Publishing, ltd.,2022, V.83, №1, p.106-122. (**WOS-0, 520**).

3. Aida-zade K.R., Rahimov A.B. Numerical Solution to Inverse Problems of Recovering Special-Type Source of a Parabolic Equation. Mathematical Analysis in Interdisciplinary Research. Springer Optimization and Its Applications, 2022, vol 179. pp. 85-100, Springer, Cham. https://doi.org/10.1007/978-3-030-84721-0_6 (**WOS**)

4. Aida-zade K.R., Rahimov A.B. On recovering space or time-dependent source functions for a parabolic equation with non-local conditions. USA: Applied Mathematics and Computation, Elsevier Inc., 2022. v. 419, – 126849 (17 pages). (**Web of Science, SCIE, IF: 4.091**) <https://doi.org/10.1016/j.amc.2021.126849>

5.K.R.Aida-zade, V.M.Abdullayev. Optimization of the right-hand sides of nonlocal conditions of a controllable system with multipoint and integral objective functional. Optimization A Journal of Mathematical Programming and Operations Research. 13 Jul 2022.<https://doi.org/10.1080/02331934.2022.2098125>

6. K.R.Aida-zade, V.M.Abdullayev. Rod temperature regulation using current and time-delayed feedback. Quaestiones Mathematicae. 45(8), 2022, 22 p. <https://doi.org/10.2989/16073606.2022.2125454>

7.K.R.Aida-zade, V.M.Abdullayev. To the solution of integro-differential equations with nonlocal conditions. Turk J Math. (2022) 46: 177–188, © TÜBİTAK doi:10.3906/mat-2108-89

8. K.R.Aida-zade, V.A.Hashimov. On one problem of feedback control of heating sources of a rod. MATHEMATICS. Том 9, № 2, 2022. 4-9 pp. doi: 10.25206/2311-4908-2021-9-2-4-9 (**РИИЦ**)

3) WORK: “Methods for solving direct and inverse problems for some ordinary and special derivative equations”.

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

On the regularization Cauchy problem for matrix factorizations of the Helmholtz equation in a multidimensional bounded domain was investigated. Also the inverse spectral problem for pt–symmetric Schrodinger operator on the graph with loop was considered.

The solution of the Yu-Toda-Sasa-Fukuyama equation with a (3+1) dimension nonlinear kernel was studied by variational and non-variational approach.

The following results were obtained on the topic:

1. D.A.Juraev, Y.S.Gasimov. On the regularization Cauchy problem for matrix factorizations of the Helmholtz equation in a multidimensional bounded domain. *Azerbaijan Journal of Mathematics*, 12(1), 2022, 142-161. (**Web of Science – Emerging Source Citation Index**).

<https://www.scopus.com/authid/detail.uri?authorId=24171373800>

2. Efendiev, R., Gasimov, Y. (2022). Inverse spectral problem for pt –symmetric Schrodinger operator on the graph with loop. *Global and Stochastic Analysis*, 9(2), *Special Issue: Modern Problems of Equations of Mathematical Physics and its Applications*, 67-77. (**Scopus**).

<https://www.scopus.com/authid/detail.uri?authorId=24171373800>

3. Adeyemo, O.D., Khalique, C.M., Gasimov, Y.S., & Villecco, F. (2022). 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**), <https://www.sciencedirect.com/science/article/pii/S111001682200480X>

4. Carlo Cattani, Yusif Gasimov. (2022). Book Review: Mathematical Modelling by Simov Serovajsky, S. (2021), Chapman & Hall/Crc. *Advanced Mathematical Models & Applications*, 7(2), 249-250. (**Scopus**).

http://jomardpublishing.com/UploadFiles/Files/journals/AMMAV1N1/V7N2/book_review.pdf

4) WORK: “The problem of finding the coefficients of a two-form hyperbolic equation with a non-local boundary condition”.

Executer: doct. of phys. Math. Sci. prof. Hamlet Guliyev.

In the work the problem of finding the coefficients of the second order hyperbolic equation was considered. First, the problem of the existence of an optimal controller was studied, then the necessary optimality condition in the form of a variational inequality was obtained. In addition, the existence of an optimal pair in the problem of the fastest effect for the two-order nonlinear hyperbolic equation was proved, and a necessary condition for optimality in the form of a variational inequality was deduced. The problem of finding the boundary function for the two-order hyperbolic equation was brought to the optimal control problem and the obtained problem was studied with the help of optimal control theory methods.

In this work, the problem of optimal control with coefficients for the oscillation equation of a thin plate with a truncated solution was considered, the theorem of the existence of an optimal controller was proved, and a necessary condition for optimality in the form of an integral inequality was deduced.

Hamlet Guliyev was Sevda Isayeva's, Sharif Nasibov's, Mubariz Khalilov's doctoral opponent, and Samira Rustamova's doctor of Philosophy opponent.

Hamlet Guliyev is a member of the organizing committee of 1 republic and 1 international conference.

The following results were obtained on the topic:

1. Кулиев Г.Ф. Сейфуллаева Х.И. Задача граничной управляемости для уравнения колебаний тонкой пластины. “Riyaziyyatın tətbiqi məsələləri və yeni informasiya texnologiyaları” IV Respublika elmi konfransı. Sumqayıt, 09-10 dekabr 2021. s.62-63

2. H.F.Quliyev, İ.M.Askerov. On a determination of the boundary function in the initial-boundary value problem for the second order hyperbolic equation. Вісник Київського національного університету імені Тараса Шевченка. Серія: Фізико-математичні науки, 2022, № 1, с. 56-60. ZbMATH.

3. H.F.Quliyev, İ.M.Askerov. On a determination of the coefficients of the second order hyperbolic equation with discontinuous solution. Advanced Mathematical Models and Applications. Vol. 7, № 1, 2022, pp. 30-37. (Scopus).

H.F.Quliyev, İ.M. Askerov. The problem of finding the prime factor of a two-order hyperbolic equation with a truncated solution. Materials of the Republican scientific conference "Actual problems of Mathematics and Mechanics" dedicated to the 99th anniversary of the birth of national leader Heydar Aliyev. May, 2022, səh. 3.

4. H.F.Guliyev, H.T.Tagiyev, N.Z.Mammadlı. An optimal control problem for a second order hyperbolic equation with a nonlocal boundary condition and with discontinuity of solution. The 8th International Conference on Control and Optimization with Industrial Applications, 24-26 August 2022, Baku, Azerbaijan. pp. 189-191.

5. H.F.Guliyev, H.İ.Seyfullayeva. Optimal control problem with coefficients for the equation of vibrations of a thin plate with discontinuous solution. Proceedings of the Institute of Mathematics and Mechanics. Vol. 48, Issue 2. Dekabr, 2022 (**Scopus və Web of Science**).

5) WORK: “Exploration of some integrated boundary conditional boundary and optimal control issues”.

Executers: Corresponding member of ANAS, prof. Misir Mardanov and doct. of phys. Math. Sci. prof. Yaqub Şərifov

This work considers boundary value problems for nonlinear integro-differential fractional equations with nonlocal boundary conditions, A suitable Green function was constructed for the first time in order to reduce this problem into a corresponding integral equation. So that by using the Banach contraction mapping principle (BCMP) and Krasnoselskii's fixed point theorem (KFPT) on the integral equation, we can show that the solution of the nonlocal problem exists and it is unique.

The following results were obtained on the topic:

1. M.J.Mardanov, Y.A.Sharifov, H.N.Aliyev. Existence and Uniqueness of Solutions for Nonlinear Fractional Integro-Differential Equations with Nonlocal Boundary Condition, EUROPEAN JOURNAL OF PURE AND APPLIED MATHEMATICS Vol. 15, No. 2, 2022, 726-735, ISSN 1307-5543 – ejam.com, Published by New York Business Global. **Web of Science**.

2. Y.A.Sharifov. Fixed-point iteration method for solution first order differential equations, Modern Problems of Mathematics and Mechanics, Proceedings of the International scientific conference devoted to the 110-th anniversary of academician Ibrahim Ibrahimov, p.197, Baku, June 29-July 1, 2022.

3. **M.J.Mardanov, Y.A.Sharifov.** Quasilinearisation iteration method for solution first order differential equations with nonlocal boundary conditions. Proceedings of the 8-th International Conference on Control and Optimization with Industrial Application, Vol. 1, pp. 330-332, 24-26 august, 2022, Baku. **Web of science.**

4. **Y.A.Sharifov, S.A.Zamanova, R.A.Sardarova.** Existence and uniqueness of solutions for nonlinear fractional integro-differential equations with nonseparated boundary conditions. Proceedings of the 8-th International Conference on Control and Optimization with Industrial Application, Vol. 2, pp. 447-449, 24-26 august, 2022, Baku. **Web of science.**

5. **M.J.Mardanov, Y.A.Sharifov.** Fixed-point iteration method for solution first order differential equations with integral boundary conditions. Proceedings Sixth International Conference on Analysis and Applied Mathematics, Oct. 31-Nov.6, Antalya, Turkey.

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., Rzayev R.R., Jamalov Z.R.** Assessment of the University Competitiveness in the Paradigm of the Humanistic System Behavior // Lecture Notes in Networks and Systems, Vol. 362, pp. 591-598, 2022
URL: <https://link.springer.com/bookseries/15179> (**Scopus və Web of Science**)

2. **M.J.Mardanov, R.R.Rzayev.** Determination of university rankings using expert-fuzzy methods of multi-criteria evaluation // The 8th International Conference on Control and Optimization with Industrial Applications (COIA – 2022) 24-26 August 2022, Baku, Azerbaijan (**SCOPUS, Web of Science**)

3. **Misir Mardanov, Ramin Rzayev, Xanmurad Abdullayev.** The importance of Lotfi Zadeh's heritage and fuzzy logic in the study of the behavior of humanistic systems // Azerbaijan school. Azerbaijan Journal of Educational Studies. 2021, №3/696, pp. 11-28.

7) WORK: “Investigation of the two-parameter spectral problem with a compact self-adjoint operator”.

Executers: Ph.D. of Physics and Mathematics Eldar Mammadov

The eigenvalues and eigenelements of the two-parameter spectral problem with a compact self-adjoint operator were investigated, and a constructive method for finding their sequence was determined. Since the variation method was applied to solve this problem, it was necessary to investigate the construction of the numerical domain of the problem.

E.Sh.Mammadov. Completeness of a system of eigenelements of twoparameter problems. // the 5th International E-Conference on Mathematical Advances and Applications, held on May 11-14, 2022, Istanbul, Turkey

SCIENTIFIC AND SOCIAL ACTIVITIES

Head of department professor Misir Mardanov is a chairman of the Dissertation Council D.01.111 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 Aydzadə, chairman of the laboratory “Numerical methods of decision on the deterministic systems” of ANAS, editor in board in the journal publshed in Turkey “Ege University journal of the Faculty of Science”, editor in board in “NASA Proceedings of the Institute 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 Institute 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.

Final Information

Department staff throughout the year

- 1) 1 book have been published,
- 2) 37 scientific works have been published,
- 3) 21 of them are scientific articles,
- 4) 17 conference materials (6 published abroad, 11 in Azerbaijan),
- 5) 18 scientific papers have been published in journals listed by WOS, SCOPUS and PИИЦ,
- 6) 3 scientific works were published in journal included in WOS and SCOPUS, 10 of them in journals included in WOS (3 of them with Impact Factor); and 2 of them in journals included in PИИЦ, 3 of them only in journal included in Scopus base,
- 7) The number of references to scientific works of employees of the department is 302.

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