

Institute of Mathematics and Mechanics of ANAS
Report of the “Optimal Control” Department for 2020
scientific and scientific organization

Employees of the department

The department of “Optimal Control” employs 11 researchers (3 full-time employees, 6 part time). 8 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. Professor Ramiz Aslanov – Senior Researcher.
9. Ph.D. of Physics and Mathematics Eldar Məmmədov – Leading Researcher.
10. Samin Malik, Ph.D. – Scientific Researcher(part-time.).
11. Aliyev Nijat. Ph.D. – Scientific Researcher(part-time.).

Grant and programs

During the year, a grant project was implemented under the leadership of the head of the department, Professor Misir Mardanov:

Winner of the project "**Optimization and Application of Oil Exploitation Operations with Gaslift and Depth Pump**" funded by the Science Fund of State Oil Company of Republic of Azerbaijan with amount of **85000 manat** and duration of 12 months. (**jointly with SOCAR-the Oil and Gas Research Project Institute**)

In the project, taking into account the real parameters of the gas lift operation method optimal operating modes were selected by means of modelling via a computer program, periodic gas lift well operating modes were studied, and methods to increase their efficiency coefficient were developed. In addition, parameters have been set to improve the performance of the depth pumping unit.

Аббасов Э.М., Кенгерли Т.С., Абдуллаева Н.Р. Моделирование фильтрации газожидкостной смеси в сопряженной системе пласт-скважина // Инженерно-физический журнал (ИФЖ), 2020, Том 93, № 5.

During the reporting period, the following books of Corresponding member of ANAS, professor Misir Mardanov have been **published**:

1. Azerbaijanis studied university up to 1920-th year. (joint work with prof. Adalat Tahirzadeh) 4th volume was published; For the first time, a 536-page encyclopedic

questionnaire published by Tahsil Publishing House presents a documentary biography of all Azerbaijani statesmen with higher education in the Republic of Azerbaijan (1918-1920);

2. Textbook for Advanced Mathematics. (joint work with prof. Ramiz Aslanov and assoc.prof. Sevda Isayeva)- (536 page.)Was published by "Tehsil" publishing house. The textbook consists of 536 pages. designed for teachers.

In the department of "Optimal control", scientific researches were carried out on the topic "**Optimal control problems described by various systems**" 2020 according to the approved plan:

1) Work: Scientific research was conducted in the field of "Highly necessary conditions for strong and weak extremes in some variations", "Necessary conditions for optimality in control problems described by discrete systems", the results of which are reflected in the following articles:

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

Discrete optimal management issues have been investigated throughout the year.

The problem of discrete control by components was considered, the maximum principle of Pontryagin and the the second order necessary conditions were proved by substituting the conditions of convexity by components on the data of the problem.

The concept of the zeroth, first and second variations of the function is given using the "broadly open set concept in the broadest sense" introduced by Misir Mardanov and Telman Malikov. As a result, the necessary conditions of Euler type and second compilation were obtained for optimality in discrete control.

Discrete control with a delay in the control function was considered. With the help of a new method developed by the authors, Pontryagin's maximum principle was proved for the first time. The novelty of the applied method is that, unlike classical works, the system is not instantaneous, but instantaneous (here is the delay).

1. Misir J.Mardanov, Telman K.Melikov, Samin T.Malik, Kamran Malikov "First-and Second-Order Necessary Conditions with Respect to Component For Discrete Optimal Control Problems" Journal of Computational and Applied Mathematics, volume 364, Article number: UNSP 112342 Published: JAN 15 2020.**WOS**

2. М.Дж.Марданов, Т.К.Меликов «К необходимым условиям оптимальности в дискретных системах управления», Известия Иркутского Государственного Университета серия «Математика», т.31, с.49-61, 2020**WOS**

3. M.J.Mardanov, T.K.Melikov, R.A.Bandaliyev, I.G.Mamedov. Fractional optimal control problem for ordinary differential equation in weighted Lebesgue spaces, Optimization letters, 14, pp.1519-1532, 2020. **WOS**

4. M.J.Mardanov, E.N.Mahmudov “On Duality in optimal control problems with second-order differential inclusions and initial-point constraints”, Proceedings of the Institute of Mathematics and Mechanics, vol. 46, №1, 2020, p. 115-128.2020, **WOS**

5. Misir Mərdanov, Aynur Həsənova, Səbinə Salmanova, “Riyaziyyat bütün elmlərin açarıdır”, Respublika qəzeti, 13 mart, 2020-ci il, səh. 5.

6. Misir J.Mardanov, Samin T.Malik, Discrete maximum principle in system with a delay in control. Proceedings of the Institute of Mathematics and Mechanics, Volume 46, Number 2, December 2020, pp. **WOS**

7. Мисир Дж. Марданов, Самин Т. Малик, Дискретный принцип максимума в системе с запаздыванием в управлении. Федеральное Государственное Бюджетное Образовательное Учреждение Высшего Образования "Иркутский Государственный Университет" Международная Конференция Динамические Системы И Компьютерные Науки: Теория и Приложения (Dysc 2020) **19-22 Октября 2020 Г. Иркутск.**

2) Work: “Investigation and numerical solution of large-scale systems of linear differential equations with nonlinear loads and nonlinear conditions”.

Author: Corresponding member of ANAS Kamil Aida-zade

The existence of solutions for special classes of large-scale systems of ordinary derivative differential equations will be investigated. Schemes will be proposed for the numerical solution of these problems.

1. Айда-заде К.Р. К численному решению линейных дифференциальных уравнений с нелокальными нелинейными условиями // Ж. вычисл. матем. и матем. физ., **2020, №5, с.828-836.** (Web of Science ([Science Citation Index Expanded](#)), *SCOPUS*)

2. Айда-заде К.Р., Абдуллаев В.М. Синтез управления процессом поддержания температуры в одной задаче теплоснабжения // Кибернетика и Системный Анализ. Киев, **2020, №3, с.47-59.** (Web of Science([Science Citation Index Emerging](#)), *SCOPUS*)

3. Aida-zade K.R., Abdullayev V.M. On The Numerical Solution To Optimal Control Problems With Non-Local Conditions // TWMS J. App. Eng. Math. V.10, No.1, 2020, pp. 47-69. (**Web of Science, Scopus**)

4. Aida-zade K.R., Abdullayev V.M. Optimization of the right sides of boundary condition with point and integral values for the ODE system // Lecture Notes in Computer Science (LNCS), Springer, V.12422, 2020, p. 1-15. (**Web of Science, Scopus**)

5. Aida-zade K.R., Hashimov V.A. Feedback Control of the Plate Heating Process with Optimization of the Locations of Sources and Control // Automation and Remote Control, V. 81, No. 4, p. 670-685. (2020). (**Web of Science, Scopus**)

6. Айда-заде К.Р., Гашимов В.А. Синтез локально сосредоточенных управлений стабилизации мембраны с оптимизацией размещения точек контроля и гасителей колебаний // Ж. вычисл. матем. и матем. физ., **2020, №7, с.1126-1142.** (Web of Science ([Science Citation Index Expanded](#)), *SCOPUS*)

3) Work: “Development of methods for solving optimization problems in relation to the field for some operators describing physical processes”.

Authors: Doct. of phys. Math. Sci. professor. Yusif Gasimov

In the reporting year, optimization issues for different operators in relation to the set area are considered and the availability of their solutions is investigated.

1) Y.S.Gasimov, N.H.Cana, O.Nikan, H.Jafari, M.N.Rasoulizadeh. Numerical computation of the time nonlinear fractional generalized equal width model arising in shallow water channel. *Thermal Science*, 2020. (**Web of Science Impact Factor - 1.574**)

2) Y.S.Gasimov, Sh.E.Guseynov, J.E.Napoles-Valdes. On some properties of limit cycles of the Biryukov equation. *Proceedings of the Institute of Mathematics and Mechanics, National Academy of Sciences of Azerbaijan*, Vol. 46, № 2, 2020. (**Web of Science Emerging Source Citation Index**)

4) Work: “The initial control problem observed in the intermediate time moments in the boundary value problem for the hyperbolic equation”.

Executers: Corresponding member of ANAS, prof. Misir Mardanov, Doct. of phys. Math. Sci. prof. Hamlet Guliyev

In this case, the issue of governance observed in two intermediate moments is considered. The problem was brought to the problem of optimal management, the double problem was included, and the necessary condition for optimality in the form of variational inequality was obtained.

Published scientific papers:

1. M.J.Mardanov, H.F.Guliyev, Z.R.Safarova. The problem of starting control with two intermediate moments of observation in the boundary value problem for the hyperbolic equation, *Optimal Control, Applications and Methods*, 2020; 1–10. <https://doi.org/10.1002/oca.2641>.

2. H.F.Guliyev, X.İ.Seyfullayeva. “Nazik lövhənin rəqsləri tənliyi üçün bir idarə olunma məsələsi”. Riyaziyyatın fundamental problemləri və intellektual texnologiyaların təhsildə tətbiqi. Respublika Elmi konfransı. Sumqayıt, 2020. səh. 48-49.

5) Work: “Application of some non-local conditional boundary value problems and optimal management problems described by them”.

Executers: Corresponding member of ANAS, prof. Misir Mardanov, Doct. of phys. Math. Sci. prof. Y.A.Sharifov

Non-local conditional boundary value problems for ordinary differential equations will be studied. It is intended that such problems be reduced to an integral equation equivalent to the original problem by means of certain transformations. With the help of the fixed point principle, sufficient conditions will be found to ensure the existence

and uniqueness of the solution of the integral equation. Necessary conditions for optimality will be removed in the issue of optimal management.

1) M.J.Mardanov, Y.A.Sharifov, R.A.Sardarova, H.N.Aliyev “Existence and Uniqueness of Solutions Differential Equations with three-point and Integral Boundary Conditions”, Azerbaijan Journal of Mathematics, vol. 10, №1, p.110-126, 2020. **WOS**

2) M.J.Mardanov, Y.A.Sharifov, K.E.Ismayilova. Existence and uniqueness of solutions for the system of integro-differential equations with three-point and nonlinear integral boundary conditions, Bulletin of the Karaganda University, MATHEMATICS series. № 3(99)/2020. pp. 26-37. DOI 10.31489/2020M3/26-37 MSC 34B37, 37C25, 37C75.**WOS**

3) M.J.Mardanov, Y.A.Sharifov. Existence and uniqueness results for the first-order non-linear differential equations with multi-point boundary conditions. The 7th International Conference on Control and Optimization with Industrial Applications Baku, Azerbaijan, 26-28 August, vol.II, pp.263-265, 2020**WOS**

6) Scientific research on "Optimization of higher education management" was conducted:

Work: “Development of neural-fuzzy methods for intellectual analysis and forecasting of historical data characterizing educational indicators, multi-criteria selection within the framework of complex assessment and ranking of universities”.

Authors: Corresponding member of ANAS, professor. M. J. Mardanov, doctor of technical science, professor R. R. Rzayev

A new method of fuzzification of weakly structured historical data has been developed, which increases the level of adequacy of fuzzy time series models and, accordingly, the quality of their forecasting.

Published scientific papers:

1. Марданов М. Дж., Рзаев Р.Р., Ализаде П.Е. Об одном подходе к фаззификации данных на примере временного ряда индекса Доу-Джонса. Математические машины и системы, Институт Проблем Математических Машин и Систем, Киев, 2020, №2, стр. 3 – 13.

2. Mardanov M.C., Rzaev R.R. Alizade P.E. About one approach to modeling and forecasting the fuzzy time series, Proceeding of the 7th International Conference on Control and Optimization with Industrial Applications, Baku, 26-28 August, vol.I, pp.269-271, 2020.**WOS**

The research was conducted entitled “**History of Science-History of Mathematics:**

Work: “History of mathematics and mathematical education current problems”.

Author: Prof. R. M. Aslanov

The articles explain the program of history of mathematics in pedagogical universities and the material on its teaching, the solution of problems and examples of the theory of complex variables by computer technology, methodical instructions on the teaching of mathematics and physics in secondary schools and the role of spreadsheets in this field.

Works published and submitted for publication by R.M.Aslanov during the reporting period:

Published works:

1. Textbook in Higher Mathematics, “Tehsil” Publisher , 2020, 536 s. (co-authors Mardanov M.C., İsayeva S.E.)

2. Сборник задач по теории функций комплексного переменного: текстовое учебное электронное издание на компакт-диске / Р.М.Асланов, Е.А.Горин, В.В.Сушков; Федер. гос. бюджет. образоват. учреждение высш. образования «Сыктыв. гос. ун-т им. Питирима Сорокина». – Электрон. текстовые дан. (1,7 Мб). – Сыктывкар: Изд-во СГУ им. Питирима Сорокина, 2020. – 1 опт. компакт-диск (CD-ROM). – ISBN 978-5-906810-47-21.

Articles

1. Нравственные и духовные ценности в трудах Насреддина Туси.//**Перспективы и приоритеты педагогического образования в эпоху трансформаций, выбора и вызовов.** VI Виртуальный Международный форум по педагогическому образованию: сборник научных трудов. Ч. I. – Казань: Издательство Казанского университета, 2020. – 346 с. (стр.200-210) (соавторы Марданов М.Дж., Исаева С.Э.).

2. Moral and Spiritual Values in Works of Nasreddin Tusi.//ARPHA Proceedings 3: 159-169 doi: 10.3897/ap.2.e0159. Published: 25 Nov 2020 (соавторы Марданов М.Дж., Исаева С.Э.)

3. Содержательно-методические линии комплексного анализа и их реализация в сборнике задач по теории функций комплексного переменного: линия аналитических функций // Вестник Набережночелнинского государственного педагогического университета: сборник научных трудов. Вып.2(27). - Набережные Челны, 2020. - С. 6-9.(соавтор Сушков В.В.)

4. О курсе истории математики в педагогическом вузе // Вестник Набережночелнинского государственного педагогического университета: сборник научных трудов. Вып.2(27). - Набережные Челны, 2020. - С. 24-27. (соавтор Игнатушина И.В.)

5. Межпредметные связи математики и физики в основной школе как средство развития функциональной грамотности с применением электронных таблиц. // Математика – основа компетенций цифровой эры: Материалы XXXIX Международного научного семинара преподавателей математики и информатики университетов и педагогических вузов (01-02 октября 2020 года). – Москва: ГАОУ ВО МГПУ, 2020 – 396 с. Стр.31-34. (соавтор Игнатова О.Г.)

6. Содержательно-методические линии комплексного анализа как основа для разработки электронных обучающих средств.// Математика – основа

компетенций цифровой эры: Материалы XXXIX Международного научного семинара преподавателей математики и информатики университетов и педагогических вузов (01-02 октября 2020 года). – Москва: ГАОУ ВО МГПУ, 2020 – 396 с. Стр.34-38. (соавтор Сушков В.В.).

7. Современные образовательные web-технологии в реализации личностного потенциала обучающихся. Федеральное государственное автономное образовательное учреждение высшего образования «Национальный исследовательский Нижегородский государственный университет им. Н.И. Лобачевского» Арзамасский филиал ННГУ. Сборник статей участников международной научно-практической конференции 20-21 мая 2020 г., г. Арзамас. 580 стр.

Work: "Approximate calculation of some structural stability radii for high-order Hamiltonian systems"

Author: junior researcher, Doctor of Philosophy in Mathematical Sciences, Nijat Aliyev.

The study presents fast algorithms for calculating some stability radii for high-order Hamiltonian systems. It has been proven that these algorithms converge super-linearly. The results are reflected in the following article:

Published works:

1. Aliyev N., Mehrmann V., Mengi E. “Approximation of stability radii for large-scale dissipative Hamiltonian systems”, *Advances in Computational Mathematics*, 2020, 46:6, <https://doi.org/10.1007/s10444-020-09763-5>.

Following scientific seminars of department were held

1. 16.01.2020 – Professor Telman Malikov, Senior Scientific Researcher of the "Optimal Control" Department, "Necessary conditions for an extremum in nonsmooth problems of the calculus of variations".

2. 06.02.2020 – At the seminar professor of Baku State University, doct. of phys. Math. Sci. Misreddin Allahverdi oglu Sadigov, “Abnormal mathematical programming problem”.

3. 20.02.2020 – At the seminar professor of Baku State University, doct. of phys. Math. Sci. Misreddin Allahverdi oglu Sadigov, “Abnormal mathematical programming problem” (continuation).

4. 05.03.2020 – Dr. Nijat Aliyev, Scientific Researcher of the “Optimal Control” Department, “Large Scale Computation of H_∞ Norms by a Greedy Subspace Method”.

SCIENTIFIC AND SOCIAL ACTIVITIES

Head of the department, professor Misir Mardanov is Chairman of the Dissertation Council D.01.111 and of the Scientific Council of IMM. He is deputy editor-in-chief of

“AMEA Xəbərləri” 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.

The second volume of the “The Azerbaijanis studied of higher institutes to 1920 year” written by director of the Institute of Mathematics and Mechanics of ANAS, corresponding member of ANAS, professor Misir Mardanov and professor Adalat Tahirzade devoted to 100 years of People Republic of Azerbaijan was published.

Head of the department professor Misir Mardanov is Chairman of the Dissertation Council D.01.111 and of the Scientific Council of IMM. He is depute editor-in-chief of “AMEA Xəbərləri” 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 Proceedings of the Institute of Applied Mathematics.

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.

Professor Ramiz Aslanov is a member of the editorial board of the following journals:

1. «Вестник Сыктывкарского университета. Серия 1. Математика. Механика. Информатика». (г. Сыктывкар, РФ)
2. Научно-методический журнал «CONTINUUM. Математика. Информатика. Образование». Елецкий государственный университет им. И.А. Бунина.(г. Елец, РФ)
3. «Вестник Елецкого государственного университета» им. И.А. Бунина. – Серия «Педагогика».(История и теория математического образования) (г. Елец, РФ).

Coordinator of the memorandum between Institute of Mathematics and Mechanics and Universities of Russia since 2016.

(Vologda State University (Vologda), North Arctic Federal University named after M.V.Lomonosov (Arkhangelsk), Syktyvkar State University named after P.Sorokin (Syktyvkar), Moscow State Pedagogical University (Moscow), Naberezhnye Chelny State Pedagogical University (Naberezhnye Chelny), Ulyanovsk State Pedagogical University. I.N. Ulyanova (Ulyanovsk)).

Final Information

During the year, 34 scientific works of the department employees were published. One of them is a textbook for university students (Higher Mathematics), and the other is a popular scientific encyclopedic questionnaire (Azerbaijanis who studied in universities until 1920). Furthermore, 25 scientific articles, 2 of 7 conference materials, 16 of 25 articles were published in the journals that are found in database of **WOS** .

Head of department:

Corr. member of ANAS prof. Misir Mardanov