МЕДИЦИНА, ПЕДАГОГИКА И ТЕХНОЛОГИЯ: ТЕОРИЯ И ПРАКТИКА
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THE SYSTEM OF WAVE EQUATIONS INVOLVED BY THE RIMAN-LIOUVILLE FRACTIONAL-ORDER OPERATOR INTO THE CANONICAL FORM.

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Abstract. In this article, the conversion of the system of fractional-order wave oscillation equations with initial conditions into the canonical form is studied, and the achieved results are presented.

Key words : Riemann-Liouville fractional derivative, initial condition, integral equation,

Today, it is necessary to stimulate scientific research and innovative activities, to create effective mechanisms for the implementation of scientific and innovative achievements in practice, to establish specialized research and experimental laboratories, high technology centers and technological parks at universities and research institutes. important tasks have been defined. In particular, a lot of significant work is being done in the field of mathematics. As a clear example of this, the decision of the President of the Republic of Uzbekistan dated 05.07.2020 on measures to improve the quality of education in the field of mathematics and research development No. We can cite the Decree of the President of the Republic of Uzbekistan No. PF-5847 on approval of the concept of development of the transport system until 2030.

In recent years, the field of fractional calculus has attracted the interest of researchers in several fields such as mathematics, physics, chemistry, engineering, and economics and social sciences. Today, fractional calculus is a new branch of mathematical research that deals with the investigation and application of wholeorder derivatives and integrals. Advanced systematic research was done and studied by Liuville, Riemann, Leibniz, Caputo and other scientists in the 19th century.

The fractional derivative of the exponential function obtained by Liouville in 1832 and the fractional derivative of the power function obtained by Riemann in 1847 were studied [1]. In other words, there are several definitions for the derivative of a fraction, and all of them are mathematically correct.

The initial, initial boundary value problem for fractional order differential equations has been studied by many researchers.

Let's look at the system of differential equations with a fractional part:

$$\left(I \cdot D_t^{\alpha} + A\frac{\partial}{\partial x} + B\frac{\partial}{\partial y}\right) U(x,y,t) = f(x,y,t), \qquad (1)$$

Here$U = (\rho, u, v)^*$, $*$- the transposition sign, $D_t^{\alpha}$and $0 < \alpha < 1$the Riemann-Liouville fractional derivative of order ,

$$A = \begin{pmatrix} 0 & \rho_0 c_o^2 & 0 \\ \frac{1}{\rho_o} & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}, \quad B = \begin{pmatrix} 0 & 0 & \rho_0 c_o^2 \\ 0 & 0 & 0 \\ \frac{1}{\rho_o} & 0 & 0 \end{pmatrix}, \quad f = \begin{pmatrix} f_1 \\ f_2 \\ f_3 \end{pmatrix}(x,y,t).$$

Definition 1 so $n-1 < \alpha < n$the Riemann-Liouville fractional integral and derivative of order a are defined as follows:

$$I_t^{n-\alpha}u(x,t) = \frac{1}{\Gamma(n-\alpha)}\int_0^t (t-\tau)^{n-\alpha-1}\, u(x,\tau)d\tau,$$

and

$$D_t^{\alpha}u(x,t) = \left(\frac{d}{d\,t}\right)^n \left(I_t^{n-\alpha}u(x,t)\right)(x,t), \;\; \alpha \in C, \;\; Re(\alpha) > 0, \;\; n < [Re(\alpha)] + 1.$$

Now , with respect to the variables $t$and x, we bring the system (1) into the canonical form. Let's make an equation for this

$$|A - \lambda I| = 0, \qquad (2)$$

where is $I - 3 \times 3$the dimensional unit matrix. λThe last equation with respect to has the following solutions:

$$\lambda_1 = c_0 \quad \lambda_2 = -c_0 \quad \lambda_3 = 0.$$

Now we choose a non-degenerate matrix T(x_3,t) so that the equality is as follows

$$T^{-1}AT = \Lambda \tag{3}$$

Here $\Lambda$is a diagonal matrix whose diagonal A contains the eigenvalues of the matrix.

$$\Lambda = diag\,(c_0, -c_0, 0)$$

Formula (3) assumes equality:

$$AT = \mathrm{T}\Lambda.$$

So, T is a column with number I of the matrix. Mathematical calculations show that can choose as matrices (not unique) $T$and $T^{-1}$and satisfying the above conditions.

$$T = \begin{pmatrix} \rho_0 c_0 & \rho_0 c_0 & 0 \\ 1 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix},$$

and

$$T^{-1} = \frac{1}{-2\rho_0 c_0} \begin{pmatrix} -1 & -\rho_0 c_0 & 0 \\ -1 & \rho_0 c_0 & 0 \\ 0 & 0 & -2\rho_0 c_0 \end{pmatrix}.$$

Uwe express the vector function with the following equation

$$U = TV.$$

this expression in equation (1)- σ hi:

$$ITD_t^{\alpha} V(x,y,t) + AT\frac{\partial}{\partial x}V(x,y,t) + BT\frac{\partial}{\partial y}V(x,y,t) = f(x,y,t).$$

We multiply it byT^{-1}

$$T^{-1}ITD_t^{\alpha}V(x,y,t) + T^{-1}AT\frac{\partial}{\partial x}V(x,y,t) +$$

$$+T^{-1}BT\frac{\partial}{\partial y}V(x,y,t) = T^{-1}f(x,y,t).$$

Then we get the following result:

$$ED_t^{\alpha}V(x,y,t) + \Lambda\frac{\partial}{\partial x}V(x,y,t) + B_1\frac{\partial}{\partial y}V(x,y,t) = F(x,y,t), \qquad (4)$$

here

$$T^{-1}IT = E = \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix}, \qquad \Lambda = \begin{pmatrix} c_0 & 0 & 0 \\ 0 & -c_0 & 0 \\ 0 & 0 & 0 \end{pmatrix},$$

$$B_1 = \begin{pmatrix} 0 & 0 & \frac{1}{2}c_0 \\ 0 & 0 & \frac{1}{2}c_0 \\ c_0 & c_0 & 1 \end{pmatrix}, \quad F(x,y,t) = \begin{pmatrix} \frac{1}{2\rho_0\, c_0}f_1(x,y,t) + \frac{1}{2}f_2(x,y,t) \\ \frac{1}{2\rho_0\, c_0}f_1(x,y,t) - \frac{1}{2}f_2(x,y,t) \\ f(x,y,t) \end{pmatrix}.$$

Results achieved

The Riemann-Liuviil fractional operator was involved

$$\left(I \cdot D_t^{\alpha} + A\frac{\partial}{\partial x} + B\frac{\partial}{\partial y}\right) U(x,y,t) = f(x,y,t)$$

as a result of normalizing the system of differential equations, we got the following result:

$$ED_t^{\alpha}V(x,y,t) + \Lambda\frac{\partial}{\partial x}V(x,y,t) + B_1\frac{\partial}{\partial y}V(x,y,t) = F(x,y,t)$$

Summary

Thus, in this article, the canonicalization of the system of fractional differential equations was studied.

Studying the system of fractional differential equations provides the following opportunities:

1) Research of tectonic movements in underground layers in geology;
2) Solving thermodynamic problems;

3) Building models in thermoelasticity issues.

Used literature

1. Muxtaram Boboqulova Xamroyevna. (2024). GEYZENBERG NOANIQLIK PRINTSIPINING UMUMIY TUZILISHI . TADQIQOTLAR.UZ, 34(3), 3–12.

2. Muxtaram Boboqulova Xamroyevna. (2024). THERMODYNAMICS OF LIVING SYSTEMS. Multidisciplinary Journal of Science and Technology, 4(3), 303–308.

3. Muxtaram Boboqulova Xamroyevna. (2024). QUYOSH ENERGIYASIDAN FOYDALANISH . TADQIQOTLAR.UZ, 34(2), 213–220.

4. Xamroyevna, M. B. (2024). Klassik fizika rivojlanishida kvant fizikasining orni. Ta'limning zamonaviy transformatsiyasi, 6(1), 9-19.

5. Xamroyevna, M. B. (2024). ELEKTRON MIKROSKOPIYA USULLARINI TIBBIYOTDA AHAMIYATI. *PEDAGOG*, *7*(4), 273-280.

6. Boboqulova, M. X. (2024). FIZIKANING ISTIQBOLLI TADQIQOTLARI. *PEDAGOG*, *7*(5), 277-283.

7. Xamroyevna, M. B. (2024). RADIATSION NURLARNING INSON ORGANIZMIGA TASIRI. *PEDAGOG*, *7*(6), 114-125.

8. Jalilov, R., Latipov, S., Aslonov, Q., Choriyev, A., & Maxbuba, C. (2021, January). To the question of the development of servers of real-time management systems of electrical engineering complexes on the basis of modern automation systems. In CEUR Workshop Proceedings (Vol. 2843).

9. To’raqulovich, M. O. (2024). OLIY TA’LIM MUASSASALARIDA AXBOROT KOMMUNIKASIYA TEXNOLOGIYALARI DARSLARINI TASHKIL ETISHDA ZAMONAVIY USULLARDAN FOYDALANISH. *PEDAGOG*, *7*(6), 63-74.

10. Muradov, O. (2024, January). IN TEACHING INFORMATICS AND INFORMATION TECHNOLOGIES REQUIREMENTS. In *Международная конференция академических наук* (Vol. 3, No. 1, pp. 97-102).

11. To’raqulovich, M. O. (2024). OLIY TA’LIM MUASSASALARIDA TA’LIMNING INNOVASION TEXNOLOGIYALARDAN FOYDALANISH. *PEDAGOG*, *7*(5), 627-635.

12. To’raqulovich, M. O. (2024). IMPROVING THE TEACHING PROCESS OF IT AND INFORMATION TECHNOLOGIES BASED ON AN INNOVATIVE APPROACH. *Multidisciplinary Journal of Science and Technology*, *4*(3), 851-859.

13. Murodov, O. (2024). DEVELOPMENT AND INSTALLATION OF AN AUTOMATIC TEMPERATURE CONTROL SYSTEM IN ROOMS. *Solution of social problems in management and economy*, *3*(2), 91-94.

14. Tursunov, B. J., & Allanazarov, G. O. (2019). Perspektivnye tehnologii proizvodstva po uluchsheniyu kachestva benzina. *Theory and practice of contemporary science*, *3*(45), 305-308.

15. Турсунов, Б. Ж., & Алланазаров, Г. О. (2019). Перспективные технологии производства по улучшению качества бензина. *Теория и практика современной науки*, (3 (45)), 305-308.

16. Tursunov, B. Z. (2023). Analysis of Concepts About the Effect of an Explosion in Solid Wednesday. *American Journal of Public Diplomacy and International Studies (2993-2157)*, *1*(10), 296-304.

17. Tursunov, B. Z. (2023). Methods of Control of Explosion Energy Distribution in Rocks. *Intersections of Faith and Culture: American Journal of Religious and Cultural Studies (2993-2599)*, *1*(10), 108-117.

18. Tursunov, B. Z. (2023). WASTE-FREE TECHNOLOGY FOR ENRICHMENT OF PURIFIC COPPER-ZINC ORE. *American Journal of Public Diplomacy and International Studies (2993-2157)*, *1*(9), 288-293.

19. Tursunov, B. Z. (2023). ANALYSIS OF MODERN METHODS FOR OIL SLUDGE PROCESSING. *American Journal of Public Diplomacy and International Studies (2993-2157)*, *1*(9), 280-287.

20. Jumaev, K., & Tursunov, B. (2022, December). Environmentally friendly technology for obtaining fuel briquettes from oil waste. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1112, No. 1, p. 012005). IOP Publishing.

21. Ахмедова, О. Б., Турсунов, Б. Ж., & угли Худойбердиев, Н. Н. (2022). Анализ физико-химических свойств нефтешламов Бухарского НПЗ и рациональные способы их утилизации. *Science and Education*, *3*(6), 495-507.

22. Турсунов, Б. Д. (2016). Анализ и выявление путей совершенствования процессов горного дела. *Молодой ученый*, (23), 105-106.

23. Djuraevich, A. J. (2021). Zamonaviy ta'lim muhitida raqamli pedagogikaning o'rni va ahamiyati. *Евразийский журнал академических исследований*, *1*(9), 103-107.

24. Ashurov, J. D. R. (2023). OLIY O 'QUV YURTLARI TALABALARIGA YADRO TIBBIYOTINI O 'QITISHDA INNOVATSION TA'LIM TEXNOLOGIYALAR VA METODLARINI QO 'LLASHNING AHAMIYATI. *Results of National Scientific Research International Journal*, *2*(6), 137-144.

25. Ashurov, J. D. (2024). TA'LIM JARAYONIDA SUN'IY INTELEKTNI QO'LLASHNING AHAMIYATI. *PEDAGOG*, *7*(5), 698-704.

26. Djurayevich, A. J. (2021). Education and pedagogy. *Journal of Pedagogical Inventions and Practices*, *3*, 179-180.

27. Ashurov, J. (2023). THE IMPORTANCE OF USING INNOVATIVE EDUCATIONAL TECHNOLOGIES IN TEACHING THE SCIENCE OF INFORMATION TECHNOLOGY AND MATHEMATICAL MODELING OF PROCESSES. *Development and innovations in science*, *2*(12), 80-86.

28. Ashurov, J. D. (2022). Nuclear medicine in higher education institutions of the republic of uzbekistan: Current status and prospects.

29. Umarov, S. K., Nuritdinov, I., Ashurov, Z. D., & Khallokov, F. K. (2017). Single crystals of TlIn 1–x Co x Se 2 (0≤ x≤ 0.5) solid solutions as effective materials for semiconductor tensometry. *Technical Physics Letters*, *43*, 730-732.

30. Умаров, С. Х., Нуритдинов, И., Ашуров, Ж. Ж., & Халлоков, Ф. К. (2019). Удельные сопротивления и тензорезистивные характеристики кристаллов твердых растворов системы TlInSe _2–CuInSe _2. *Журнал технической физики*, *89*(2), 214-217.

31. Umarov, S. K., Nuritdinov, I., Ashurov, Z. Z., & Khallokov, F. K. (2019). Resistivity and Tensoresistive Characteristics of TlInSe 2–CuInSe 2 Solid Solutions. *Technical Physics*, *64*, 183-186.

32. Ашуров, Ж. Д., Нуритдинов, И., & Умаров, С. Х. (2011). Влияние температуры и примесей элементов I и IV групп на тензорезистивные свойства монокристаллов TlInSe2. *Перспективные материалы*, (1), 11-.

33. Ashurov, J. (2023). TA’LIMDA AXBOROT TEXNOLOGIYALARI FANI O ‘QITISHDA INNOVATSION TA’LIM TEXNOLOGIYALARINING AHAMIYATI. *Theoretical aspects in the formation of pedagogical sciences*, *3*(4), 105-109.

34. Djo‘rayevich, A. J. (2024). THE IMPORTANCE OF USING THE PEDAGOGICAL METHOD OF THE" INSERT" STRATEGY IN INFORMATION TECHNOLOGY PRACTICAL EXERCISES. *Multidisciplinary Journal of Science and Technology*, *4*(3), 425-432.

35. Ashurov, J. D. (2024). AXBOROT TEXNOLOGIYALARI VA JARAYONLARNI MATEMATIK MODELLASHTIRISH FANINI O ‘QITISHDA INNOVATSION YONDASHUVGA ASOSLANGAN METODLARNING AHAMIYATI. *Zamonaviy fan va ta'lim yangiliklari xalqaro ilmiy jurnal*, *2*(1), 72-78.

36. Ashurov, J. (2023). OLIY TA’LIM MUASSASALARIDA “RADIOFARMATSEVTIK PREPARATLARNING GAMMA TERAPIYADA QO ‘LLANILISHI” MAVZUSINI “FIKR, SABAB, MISOL,

UMUMLASHTIRISH (FSMU)" METODI YORDAMIDA YORITISH. *Центральноазиатский журнал образования и инноваций*, *2*(6 Part 4), 175-181.

37. Djorayevich, A. J. (2022). EXPLANATION OF THE TOPIC" USE OF RADIOPHARMACEUTICALS IN GAMMA THERAPY" IN HIGHER EDUCATION INSTITUTIONS USING THE" THOUGHT, REASON, EXAMPLE, GENERALIZATION (THREG)" METHOD.

38. Ашуров, Ж. Д. (2023). ИННОВАЦИОННЫЕ ТЕХНОЛОГИИ И МЕТОДЫ ОБУЧЕНИЯ В ПРЕПОДАВАНИИ ЯДЕРНОЙ МЕДИЦИНЫ СТУДЕНТАМ ВЫСШИХ УЧЕБНЫХ ЗАВЕДЕНИЙ. *Modern Scientific Research International Scientific Journal*, *1*(4), 29-37.

39. Djo'rayevich, A. J., & Xojiyevich, B. E. (2022). OLIY TA'LIM MUASSASALARIDA "YADRO TIBBIYOTIDA RADIATSION XAVFSIZLIK" MAVZUSINI O 'QITISHDA MUAMMOLI VAZIYAT METODINI QO 'LLASH. *Farg'ona davlat universiteti*, (5), 69-69.

40. Behruz Ulugbek og, Q. (2024). ADOBE PHOTOSHOP CC DASTURIDA ISHLASH. *PEDAGOG*, *7*(4), 390-396.

41. Behruz Ulugbek og, Q. (2024). FUNDAMENTALS OF ALGORITHM AND PROGRAMMING IN MATHCAD SOFTWARE. *Multidisciplinary Journal of Science and Technology*, *4*(3), 410-418.

42. Babaev, S., Olimov, N., Imomova, S., & Kuvvatov, B. (2024, March). Construction of natural L spline in W2, σ (2, 1) space. In *AIP Conference Proceedings* (Vol. 3004, No. 1). AIP Publishing.

43. Behruz Ulugbek og, Q. (2023). TECHNOLOGY AND MEDICINE: A DYNAMIC PARTNERSHIP. *International Multidisciplinary Journal for Research & Development*, *10*(11).

44. Behruz Ulug'bek o'g, Q. (2023). USE OF ARTIFICIAL NERVOUS SYSTEMS IN MODELING. *Multidisciplinary Journal of Science and Technology*, *3*(5), 269-273.

45. Quvvatov, B. (2024). ALGEBRAIK ANIQLIGI YUQORI BOLGAN KVADRATUR FORMULALAR. KLASSIK GAUSS KVADRATURALARI. *Инновационные исследования в науке*, *3*(2), 94-103.

46. Quvvatov, B. (2024). ALGEBRAIK ANIQLIGI YUQORI BOLGAN KVADRATUR FORMULALAR. SIMPSON FORMULASI. *Models and methods in modern science*, *3*(2), 223-228.

47. Quvvatov, B. (2024). ALGEBRAIK ANIQLIGI YUQORI BOLGAN KVADRATUR FORMULALAR. ROMBERG INTEGRALLASH FORMULASI. *Центральноазиатский журнал образования и инноваций*, *3*(2 Part 2), 107-112.

48. Quvvatov, B. (2024, February). TORTBURCHAK ELEMENT USTIDA GAUSS–LEJANDR FORMULASI. In *Международная конференция академических наук* (Vol. 3, No. 2, pp. 101-108).

49. Behruz Ulug‘bek o‘g, Q. li.(2023). Mobil ilovalar yaratish va ularni bajarish jarayoni. *International journal of scientific researchers*, *2*(2).

50. Quvvatov, B. (2024, February). ALGEBRAIK ANIQLIGI YUQORI BOLGAN KVADRATUR FORMULALAR. REKURSIV TRAPETSIYALAR QOIDASI. In *Международная конференция академических наук* (Vol. 3, No. 2, pp. 41-51).

51. Quvvatov, B. (2024). ALGEBRAIK ANIQLIGI YUQORI BOLGAN KVADRATUR FORMULALAR. ORTOGONAL KOPHADLAR. *Инновационные исследования в науке*, *3*(2), 47-59.

52. Quvvatov, B. (2024). ALGEBRAIK ANIQLIGI YUQORI BOLGAN KVADRATUR FORMULALAR. GAUSS KVADRATUR FORMULALARI. *Models and methods in modern science*, *3*(2), 114-125.

53. Quvvatov, B. (2024). GLOBAL IN VIRTUAL LEARNING MOBILE APP CREATION INFORMATION SYSTEMS AND TECHNOLOGIES. *Science and innovation in the education system*, *3*(1), 95-104.

54. Quvvatov, B. (2024). WEB FRONT-END AND BACK-END TECHNOLOGIES IN PROGRAMMING. *Theoretical aspects in the formation of pedagogical sciences*, *3*(1), 208-215.

55. Quvvatov, B. (2024). FINDING SOLUTIONS OF SPECIAL MODELS BY INTEGRATING INTEGRAL EQUATIONS AND MODELS. *Current approaches and new research in modern sciences*, *3*(1), 122-130.

56. Quvvatov, B. (2024). CONSTRUCTION OF SPECIAL MODELS THROUGH DIFFERENTIAL EQUATIONS AND PRACTICAL SOLUTIONS. *Solution of social problems in management and economy*, *3*(1), 108-115.

57. Karimov, F. (2022). ANIQ INTEGRALNI TAQRIBIY HISOBLASH. *ЦЕНТР НАУЧНЫХ ПУБЛИКАЦИЙ (buxdu. uz)*, *14*(14).

58. Quvvatov, B. (2024). SQL DATABASES AND BIG DATA ANALYTICS: NAVIGATING THE DATA MANAGEMENT LANDSCAPE. *Development of pedagogical technologies in modern sciences*, *3*(1), 117-124.

59. Quvvatov, B. (2023). ALGEBRAIK ANIQLIGI YUQORI BOLGAN KVADRATUR FORMULALAR. UMUMLASHGAN TRAPETSIYALAR QOIDASI. *Академические исследования в современной науке*, *3*(7), 137-142.