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©2024. Kononov Yu.N.¹, Shcherbak V.F.¹, Zuyev A.L.^{1,2}**FOUNDER OF THE DONETSK SCHOOL OF MECHANICS:
ON THE 100TH ANNIVERSARY OF PAVEL KHARLAMOV'S BIRTH**

This paper is devoted to the 100th anniversary of Pavel Vasilievich Kharlamov, known as the founder of the Donetsk School of Analytical Mechanics. We present the main stages of his biography along with information on his research and educational activities. We also provide a brief survey of Kharlamov's principal contributions to rigid body dynamics, the foundations of mechanics, and mathematical problems of mechanics.

MSC: 01A70, 01A72, 70-03, 70Exx, 70Fxx.**Key words:** *Donetsk school of analytical mechanics, rigid body dynamics.***1. Main stages of the biography of P.V. Kharlamov.**

Kharlamov's parents: Efrosinia Pavlovna and Vasily Nikitovich
(1926)

Pavel Kharlamov's life path was difficult, complex, but also interesting. His timeline includes moving to the industrial Donbas and experiencing his youth, World War II and the post-war period, studying at Moscow State University, participating in the foundation of the Institute of Hydrodynamics of the Siberian Branch of the USSR Academy of Sciences and Novosibirsk University, and establishing the Donetsk School of Analytical Mechanics.

Childhood and School Years (1924 – 1941).

Pavel Vasilievich was born on June 25, 1924, in the village of Gakhove, Medvensky District, Kursk Region, to the family of Yefrosiniya Pavlovna and Vasily Nikitovich Kharlamov. In 1925, the Kharlamov family, with their one-year-old child, moved to the industrial Donbas in search of work, where his father secured a job as a carpenter in a construction brigade. Vasily Nikitovich eventually became the chief engineer of a construction trust in Donetsk, known as “the miner's capital”.

One of Pavel's earliest vivid childhood memories was visiting the circus. The fascination of the young boy with the skill of a juggler, who could spin a high stack of plates on one hand, perhaps foreshadowed his future research in the dynamics of rigid body systems. During his school years, Pavel excelled academically, participated in model airplane and radio clubs, and was naturally drawn to sports. In private conversations, Pavel Vasilievich often fondly remembered his wrestling coach.

He also took part in an aeroclub, underwent parachutist training, and tried skydiving. Riding a motorcycle at reckless speeds was among his hobbies, which caused his parents much distress. It was these experiences that sparked his love for engineering and mechanics.



P.V. Kharlamov (1945)

World War II in the Soviet Union and Post-War Years (1941–1947).

During those years, it was common practice to send high school pupils to do agricultural work during summer vacations. In the summer of 1941, after finishing the 9th grade, Pavel was working on a collective farm, learning the profession of a tractor driver, when the war in the Soviet Union began. His father immediately went to the front, and Pavel and his mother spent 22 months under occupation. This difficult period in the life of a 17-year-old left a lasting mark — at that time, having the record “lived in occupied territory” was considered a stain on one’s biography.

Pavel Vasilievich did not like to talk about the next stage of his life, from 1943 to 1946, which was associated with his military service. For someone who had gone through the entire war on the front lines as a soldier in the guards, it was a time of blood, dirt, injuries, and the deaths of comrades. His military ID listed roles such as rifleman, radio operator of a rifle regiment, artilleryman, radio master, and driver of an anti-tank regiment. He sustained two injuries, received the Order of the Red Star for courage and heroism, two medals, and carried a large shell fragment lodged near his spine until the end of his life. His first severe injury occurred in battles on the Molochna River right after his mobilization in October 1943. This saved him, as Marshal A.M. Vasilevsky called this river “the right flank of the Eastern Wall with strong fortifications”, where many Soviet soldiers perished. The second injury occurred in 1944.



MSU student (1947–1952)

After demobilization, Pavel worked as a draftsman while also studying in the 10th grade of a workers’ evening school, from which he graduated with a gold medal in 1947. That same year, his dream came true – he became a student at the Faculty of Mechanics and Mathematics of Moscow State University.

Study at Moscow State University (1947–1952). During his studies at Moscow State University (MSU), Pavel Kharlamov acquired fundamental knowledge in mathematics and mechanics, met leading scientists, and chose a scientific direction. At the university, Pavel Kharlamov met Elena Zabelina, a fellow student from the Mechmath Faculty, who later became his wife, closest friend, and lifelong scientific collaborator.

Notably, the book by Doctor of Physical and Mathematical Sciences, Professor Elena Ivanovna Kharlamova, published in 2001 [14], artistically and comprehensively describes Pavel's life and scientific path, supplementing the brief reference information about him found in encyclopedic sources.

Pavel Vasilievich began his scientific activity during his student years under the guidance of Corresponding Member of the USSR Academy of Sciences, Nikolai Gurievich Chetaev. At the university, lectures on theoretical mechanics were delivered by L.N. Sretenskii, N.G. Chetaev, and A.P. Minakov; on elasticity theory by M.M. Filonenko-Borodich; on vibration theory by B.V. Bulgakov; on applied mechanics by Y.N. Roitenberg; and on hydromechanics by L.I. Sedov. Among the mathematical courses, Pavel Vasilievich especially highlighted differential equations, taught by V.V. Stepanov. N.G. Chetaev also supervised his diploma work. During his studies, Pavel was nominated for the Stalin Scholarship but was denied due to a "stain" on his record. Because of this "stain", after graduating with honors from the university, he was not retained at the university, not recommended for postgraduate studies, nor included in the group being prepared for S.P. Korolev's design bureau, and was only offered a job at an agricultural research institute.



The Kharlamov family: Pavel and Elena (1951)

Donetsk Industrial Institute (1952–1959). After graduating from Moscow State University in 1952 with honors in theoretical mechanics, P.V. Kharlamov began his career at Donetsk Industrial Institute in the Department of Theoretical Mechanics, where he served until 1959. He started as an assistant, was promoted to senior lecturer, and eventually became the head of the department. In 1955, he successfully defended his candidate's dissertation titled "Motion of a Rigid

Body in a Fluid", supervised by N.G. Chetaev. Historical references to his school of learning are available on the Mathematics Genealogy Project [9].

Participation in the Foundation of the Siberian Scientific Center (1959–1965). From 1959 to 1965, P.V. Kharlamov was a senior researcher at the Institute of Hydrodynamics of the Siberian Branch of the USSR Academy of Sciences in Novosibirsk. According to Elena Ivanovna's memories, "Pavel Vasilievich had room to grow! Together with Y.N. Rabotnov, he delved into strength tasks, worked on plates and shells, explored filtration issues, and with P.Y. Kochina, he dealt with the irrigation of the Kulunda Steppe. At the university's mathematics faculty, he lectured on almost all branches of mechanics: theoretical mechanics, elasticity and plasticity theory within the framework of continuum mechanics, vibration theory, and hydrodynamics. He developed a special course on the dynamics of a rigid body, led a scientific seminar, and, based on this special course, published 'Lectures on the Dynamics of a Rigid Body' in 1965. Pavel Vasilievich's working energy was astounding and inspiring".

One time, Pavel Vasilievich took a dip in an ice hole in the Ob Sea, much to the amazement of the fishermen at the ice holes and particularly to the staff of the Akademgorodok. Elena Ivanovna recalls, “Pavel Vasilievich was generally indifferent to both cold and heat. He walked without a coat until almost the first frosts in autumn, and in spring, he quickly took off his jacket and ‘slipped’ into a short-sleeved shirt”.



Wind over La Manche (1965)

On May 9, 1964, Pavel Vasilievich defended his doctoral dissertation titled “On the Solution of the Equations of the Dynamics of a Rigid Body” at the Academic Council for Physical, Mathematical, and Technical Sciences of the Siberian Branch of the USSR Academy of Sciences. The referees were P.Y. Kochina, V.V. Rumyantsev, and A.I. Lur’e.

Pavel Vasilievich had a dream, and in 1964, at the age of 40, he wrote a letter to the Chairman of the Council of Ministers of the USSR, N.S. Khrushchev. In the letter, he noted that he had undergone parachute training in an aeroclub in high school, participated in the Great Patriotic War, was awarded the Order of the Red Star and two medals, graduated from the Faculty of Mechanics and Mathematics of Moscow State University, and defended the dissertation for the degree of Doctor of Physical and Mathematical Sciences. At that time, Vostok spacecraft were already carrying scientists among the cosmonauts. However, Pavel’s request was denied.

In May 1965, Pavel Vasilievich made his first overseas scientific trip. He was sent to Hungary in a delegation from the USSR Academy of Sciences for a scientific session dedicated to the 200th anniversary of the birth of Joseph Louis Lagrange.

Foundation of the Donetsk School of Analytical Mechanics (1965–2001).

In 1965, Pavel Vasilievich accepted the invitation of his friend, the founding director of the Donetsk Computing Center of the Academy of Sciences of the Ukrainian SSR, corresponding member of the Academy of Sciences of the Ukrainian SSR, Ivan Ilyich Danilyuk, to take part in the development of mathematical science in Donbas. He returned to Donetsk, where he founded and headed the Applied Mechanics Department of the Institute of Applied Mathematics and Mechanics of the Academy of Sciences of the Ukrainian SSR. In the same year, P.V. Kharlamov was elected a corresponding member of the Academy of Sciences of the Ukrainian SSR.

In the 1960s, the main efforts of the school of mechanics in Donetsk were focused on the qualitative theory of the dynamics of a rigid body. At the same time, work was carried out on the stability and oscillations of mechanical systems, celestial mechanics, and control theory. P.V. Kharlamov was the founder and Editor-in-Chief of the scientific journal “Mehkanika Tverdogo Tela”, which was published since 1969 and translated

into English by Allerton Press as “Mechanics of Rigid Bodies”. By the early 1980s, the Donetsk school of mechanics had developed into a large research and educational center with a high level of scientific and pedagogical potential. A comprehensive survey of main results, obtained in the field of rigid body dynamics in the Donetsk school, can be found in the book [10].



Award for the Honored Science Figure of Ukraine
(1984)

In addition to research activities, Pavel Vasilievich paid great attention to teaching. Under his leadership, lecture courses and special courses on theoretical mechanics, elasticity theory, vibration theory, and control theory were developed and conducted. His textbooks and lecture notes were in great demand among students and specialists. Under the leadership of Pavel Vasilievich, his department actively developed international scientific relations. Joint research with leading scientists from different

countries was carried out, and many staff members had internships abroad. The results of research were presented at international conferences and published in leading scientific journals.

Pavel Vasilievich was an active member of the scientific community. He was a member of the editorial boards of several scientific journals, a member of the scientific councils of various institutions, and a participant in many scientific conferences and congresses. He was also a member of the National Committee of Theoretical and Applied Mechanics of Ukraine and the National Committee of Mechanics of the International Union of Theoretical and Applied Mechanics.

2. Selected Scientific Results and Publications.

Pavel Vasilievich's scientific interests were diverse. He worked in the field of rigid body dynamics, qualitative theory of ordinary differential equations and dynamical systems, theory of oscillations, and continuum mechanics [13].

In 1963, Kharlamov [1] extended Steklov's analogy on the motion of a rigid body in a fluid to include the case of a perforated body. He obtained several analytical solutions to the problem of the motion of a multiply connected body in an unbounded ideal fluid, generalizing the solutions of Steklov, Lyapunov, and Bobylev [5]. To simplify the study of the Euler–Poisson equations in rigid body dynamics, he introduced special axes of coordinates associated with the gyration ellipsoid [3]. He proposed a representation for the three autonomous equations with respect to angular velocity components. This representation was subsequently used by the Donetsk school for constructing analytical solutions in rigid body dynamics.

Pavel Kharlamov obtained a particular solution for the heavy gyrostat problem by extending the Sofya Kovalevskaya configuration [6]. This solution is characterized by

the assumption that the gyrostatic moment is parallel to the body's axis of dynamic symmetry, given certain constraints on the initial conditions. It is distinguished by an invariant relation that is quadratic with respect to the components of angular velocity. In the paper [4], he proposed polynomial solutions for the case where the gyrostatic moment is directed along the first coordinate axis, carrying the body's center of mass.

In 1964, P.V. Kharlamov published the differential equations that govern the stationary hodograph in the problem of motion of a rigid body with a fixed point [2]. These equations allow for a full geometric description of solutions to a series of integrable rigid body dynamics problems in the form of rolling without slipping of a moving cone on another stationary cone. P.V. Kharlamov called such a description "complete solutions" of a rigid body dynamics problem and highly valued such geometric results [7].

P.V. Kharlamov is recognized as the founder of the study of the dynamics of mechanical systems of a fairly general form, which consist of an arbitrary number of rigid bodies. His significant contribution is highlighted in his article [11], where he derived the equations of motion for chains of rigid bodies (or gyrostats) that are connected in series by spherical or cylindrical hinges.

P.V. Kharlamov introduced the concept of an invariant relation in the sense of the set determined by a sequence of algebraic equations obtained through successive differentiation of a given generating function [7, 12]. The systematic application of this method of invariant relations facilitated the analytical construction of a series of solutions in rigid body dynamics and enabled the solving of a broad spectrum of problems related to stability, control, and identification in the subsequent publications by the Donetsk school.

The paper [8], which provides a critical analysis of mathematical models in non-holonomic mechanics, is extensively cited by the international research community. In this paper, Kharlamov applied Lindelöf's and Kozlov's approaches to model the motion of a billiard ball and concluded that the resulting description of motion in these models is not acceptable from a mechanical viewpoint.

Pavel Kharlamov took the problems of the methodology of science, the foundations of mechanics, and the interconnection between mathematics and mechanics seriously. His work, "Mathematics and Mechanics: The State and Trends in the Development of Their Relations", included in the collection [13], serves as a compelling example of a thorough analysis of methodological approaches in mathematics and mechanics from the perspectives of philosophy and the history of science. We present quotes from the aforementioned work to illustrate P.V. Kharlamov's philosophical conclusions:

- "The goal of mechanics is the study of motion."
- "Mathematics does not have objective criteria for the acceptability of its theories, therefore, there is a wide range of opinions in mathematics regarding its relation to natural sciences."
- "From the arsenal of mathematics, mechanics uses the necessary tool, bringing contradictions from the foundation of mathematics into mechanical constructions."

- “Constructing a solution and bringing it to a numerical result, specifying a mathematical method based on a critical analysis of the result – all these features are fundamental differences in the approaches of a mechanic and a mathematician.”
- “... examples illustrate the role and significance of a subjectively formed mathematical model (which reflects the worldview of the authors) when describing an objective phenomenon. They also illustrate possible variants of the relationship between mechanics and mathematics in natural sciences, the results of which can always be evaluated according to the criteria of correctness, admissibility, and simplicity.”

3. Conclusion.

Throughout his life, Pavel Vasilievich remained true to his principles and ideals. He was a man of high moral character, a talented scientist, a dedicated teacher, and a wise mentor. His legacy continues to live on in the works of his students and followers, in the research he initiated, and in the institutions he helped to create and develop.

In summary, Pavel Vasilievich Kharlamov's life and work serve as a testament to his enduring contributions to the field of analytical mechanics, his unwavering dedication to scientific discovery, and his profound impact on the academic and scientific community. His legacy is commemorated not only in the advancements he made but also in the inspiration and guidance he provided to generations of scientists and scholars.

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Засновник Донецької школи механіки: до 100-річчя від дня народження Павла Васильовича Харламова.

Статтю присвячено 100-річчю від дня народження Павла Васильовича Харламова – засновника Донецької школи аналітичної механіки. У статті описано етапи біографії П.В. Харламова та наведено інформацію про його науково-педагогічну діяльність. Також надано стислий огляд основних наукових результатів П.В. Харламова, що стосуються динаміки твердого тіла, математичних проблем механіки та методології науки.

Ключові слова: *Донецька школа аналітичної механіки, динаміка твердого тіла.*

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