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Development of Ukrainian mechanics: Context of scientific publications by Kharkiv scientists of the 19th century

Abstract. *This study presents a comprehensive historiographical and content analysis of the development of Ukrainian mechanics in the 19th century, examining scientific publications by Kharkiv scientists through a historical lens. Special attention is paid to the institutional and intellectual contribution of Kharkiv University and Kharkiv Institute of Technology, which together created a unique scientific ecosystem that promotes both theoretical and applied research in the field of mechanics. The study uses an interdisciplinary methodology that combines a historical approach, a content analysis of primary sources, and bibliometric methods to track thematic trends, terminological evolution, and the dynamics of scientific communication. The results of the study indicate that during the 19th and early 20th centuries, Kharkiv emerged as a significant scientific center in the Russian Empire and Eastern Europe. Theoretical mechanics at Kharkiv University flourished thanks to the work of prominent scientists such as O. M. Lyapunov, V. A. Steklov, and I. D. Sokolov, who laid the foundations of modern stability theory, nonlinear dynamics, and mathematical modeling of mechanical systems. At the same time, Kharkiv Institute of Technology developed applied mechanics under the leadership of V. L. Kyrpychov and his colleagues, innovators in research in the field of strength of materials, structural engineering, machine design, and industrial technologies. The analysis highlights the notable synergy between the two institutions, reflected in inter-institutional training, joint research efforts, and the formation of powerful scientific schools. The publication activity of Kharkiv mechanical scientists showed a wave-like trend, reaching a peak between 1880 and 1905, driven by the demands of industrialization and international scientific integration. This period marked a paradigm shift from isolated intellectual efforts to systematic, collaborative scientific production. This article argues that the legacy of Kharkiv mechanical science lies not only in the creation of advanced theoretical constructs, but also in the institutionalization of technical education and research, which significantly contributed to the modernization of Ukrainian and Eastern European engineering sciences. The conclusions drawn from this study offer*

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a deeper understanding of the processes of knowledge production, transfer, and adaptation in the context of scientific globalization of the 19th century. The results of the study show that institutional cooperation between Kharkiv University and the Technological Institute contributed to the creation of a unique scientific ecosystem, which ensured the effective development of mechanics as a scientific discipline. The article reveals the importance of this process for the further formation of Ukrainian technical thought in the 20th century and emphasizes the significance of the legacy of Kharkiv scientists in the global context of the history of science.

Keywords: *history of mechanics; Kharkiv Scientific School; scientific publications; institutional history; theoretical and applied mechanics; scientific communication*

Introduction.

The development of natural sciences in the 19th century was of particular importance for the formation of scientific thought in Ukraine. Among the fundamental areas that determined the technical and engineering progress of the era, mechanics occupied a special place - both applied and theoretical. Kharkiv, as one of the leading scientific centers of Ukraine at that time, played a key role in the formation of the scientific school of mechanics, laying the institutional, methodological, and creative foundations for its further development. In the 19th century, prominent scientists were active in Kharkiv, whose research in the field of mechanics received recognition both within the Russian Empire and beyond. Scientific publications of Kharkiv scientists of this period reflect the processes of the formation of scientific approaches, the formation of terminology, the adaptation of Western European theories, and the creation of their conceptual models of mechanical phenomena. The study of these publications allows us to trace not only the substantive development of the discipline but also the functioning of the scientific environment, the formation of a network of communications between researchers, and the growing role of university education in the dissemination of scientific ideas.

The purpose of this article is to analyze the formation of the foundations of Ukrainian mechanics through the prism of scientific publications of Kharkiv scientists of the 19th century. The formulated objective is consistent with the ideas presented in relevant publications in international scholarly journals, where the historical development of applied mathematics and mechanics is analyzed in Italy (Martini, 1999), Spain (Martínez-Verdú, Massa-Esteve, & Linero-Bas, 2023), France (Darrigol, 2022), Germany, and the Netherlands (Jahnke, Jankvist, & Kjeldsen, 2022).

The study is based on a historical-scientific approach and content analysis of sources, which allows us to identify key topics, research areas, and the degree of their integration into the international scientific context. Special attention is paid to the role of Kharkiv University (KhU) and Kharkiv Institute of Technology (KhIT) as scientific centers that provided institutional support to scientists and facilitated their scientific and publishing activity.

Literature Review.

The study of the development of mechanics in Kharkiv in the 19th century is based on a broad historiographical background, which includes both classical sources of the early 20th century and modern analytical and biographical works.

The first systematic generalizations of the history of Kharkiv University were made in the works of D. I. Bagalei, I. P. Osypov, D. M. Sintsov, in particular in the publications dedicated to the anniversaries of the university (Bagalei, Sumtsov, & Buzeskul, 1906; Sintsov, 1908; Osipov & Bagalei, 1908), in the article by A. N. Krasnov (Krasnov, 1897). They provide a chronicle of the development of departments, the composition of the teaching staff, and a general overview of scientific activity. However, these works are mostly descriptive in nature and do not offer a deep analysis of the content of scientific publications.

In the biographical view, studies devoted to individual figures are of great importance, in particular, V. I. Albitsky (Gutnyk, 2018), V. G. Imshenetsky (Andreev, 1895), V. L. Kyrpychov (Gavrilyuk, 2007, p. 302), O. M. Lyapunov (Larin & Breslavskyi, 2007). These works allow to reconstruct individual scientific trajectories, explore the directions of mechanics that were developing in Kharkiv, and understand the connections between individual scientists and educational institutions.

Particular attention to the formation of natural sciences and technical education at Kharkiv University was paid by O. Ye. Tverytnykova, N. I. Posviatenko, T. V. Melnyk (Tverytnykova, Posviatenko, & Melnyk, 2015), A. G. Zhurylo, D. Yu. Zhurylo (Zhurylo, A. G. & Zhurylo, D. Yu., 2021), A. S. Lytvynko (Lytvynko, 2025), A. K. Sushkevych (Sushkevych, 1956). Their works indicate the growing role of applied mechanics and mechanical engineering in the late 19th and early 20th centuries. In these publications, the emphasis is on the institutional aspect without focusing on the analysis of the content of scientific publications.

Modern research expands historiography through an interdisciplinary approach. For example, N. O. Pasichnyk, R. Ya. Rizhniak, H. V. Deforzh (Pasichnyk, Rizhniak, & Deforzh, 2023) examine publications in specialized scientific publications (such as the “Bulletin of Experimental Physics and Elementary Mathematics”) as a source for the reconstruction of scientific communication. This approach is valuable for content analysis and can be adapted for the study of Kharkiv publications on mechanics.

Special attention in historiography is paid to the role of foreign professors (Greffe, 1999), who significantly influenced the methodological culture of teaching and research in Kharkiv. Their presence contributed to the transfer of Western European ideas into the scientific space of imperial Ukraine, in particular in the field of mechanics.

A significant group consists of sources related to the history of the departments of mechanics of Kharkiv University and the Institute of Technology (Kizilova & Popova, 2011; DTMSM, 2025), as well as memoir sources that provide an idea of the scientific environment of Kharkiv in the 19th century (Posokhov, 2008).

An important component of the historiographical part of the study also consists of articles by foreign authors that examine the particularities of the formation of mechanics in European science – such as the role in world mechanics of the German scholar of Dutch origin Richard von Mises (Siegmund-Schultze, 2018), Felix Klein's development of Galois theory (Heller, 2023), the use of mechanical models from the nineteenth century (Rowe, 2022), the achievements of algebraic research schools in Italy (Martini, 2004), as well as a comprehensive account of the history of European applied mathematics (Barrow-Green & Siegmund-Schultze, 2015).

In conclusion, it is worth noting that the historiography of the topic is quite broad in biographical, institutional, and chronological dimensions. At the same time, a comprehensive analysis of the scientific publications of Kharkiv mechanics of the 19th century, taking into account the context of their appearance, content, terminology, and influence on the further development of Ukrainian mechanics, has not yet been presented. This determines the relevance of the proposed study.

Methodology.

In the process of studying the formation of the foundations of Ukrainian mechanics through the prism of scientific publications of Kharkiv scientists of the 19th century, a complex of methods of historical and scientific analysis was applied, focused both on studying the content of primary sources and on identifying the socio-cultural and institutional context of their creation.

1. The historical and scientific approach became the basis for a general analysis of the formation of mechanics as a scientific discipline in Kharkiv. It allowed us to consider mechanics not only as a set of theoretical knowledge, but as part of the holistic scientific culture of the university environment.

2. Content analysis of historical scientific publications was used to study the thematic spectrum, structure, and terminology of publications by Kharkiv scientists-mechanics (Früh, 2015). The objects of analysis were works published in scientific journals and collections of the university, monographs and manuals of professors, dissertations presented during the 19th century, and individual publications in the professional press devoted to applied and theoretical mechanics.

3. Elements of the bibliometric approach were used to identify the frequency of mentions of individual topics, authors, and scientific schools, as well as to trace the dynamics of publication activity over the century. Although the full quantitative base is limited, the use of elements of this method allowed us to assess general trends.

In addition to the aforementioned methods, techniques for studying scientific processes (citation, collaboration, identification of trends) were applied, as described in the publications of European authors (Renn, 2015; Gibson & Ermus, 2019; Fortunato et al., 2018).

The source base of the study includes primary sources (works published by Kharkiv scientists in the 19th century), reference and biographical literature, memoirs, and archival documents, including anniversary collections, works on the history of university departments and faculties.

Main Research Results.

Kharkiv, as one of the leading scientific and educational centers of Ukraine, played a key role in the formation of domestic science and technology during the 19th and early 20th centuries. This period was characterized by the intensive development of higher education and the formation of scientific schools, in particular in the field of mechanics. The establishment and flourishing of both a classical university and a specialized technological institute in Kharkiv testify to targeted and strategic investments in scientific and technical education. This dual institutional structure allowed for the achievement of both fundamental theoretical achievements (University) and applied engineering solutions (Technological Institute), contributing to the creation of a comprehensive ecosystem for research in the field of mechanics. This approach ensured the multifaceted development of science and industry in the region.

Kharkiv University, founded in 1805, became one of the centers of fundamental scientific research in the Russian Empire, in particular in the fields of Mathematics and Physics. The Department of Physics and Mathematics, which by the 1870s had grown into a powerful faculty with three departments (mathematical, physical and chemical, and natural), played a key role in the development of mechanics. Its transformation into a powerful structure indicates significant institutional maturation. This growth indicates increased academic specialization, resource allocation, and the creation of a reliable intellectual environment conducive to advanced scientific research, which became a prerequisite for the emergence of influential scientific schools in mechanics.

One of the most prominent figures of Kharkiv University, who made a fundamental contribution to mechanics, was Oleksandr Mykhailovych Lyapunov. He worked at Kharkiv University from 1885 to 1902. O. M. Lyapunov developed a rigorous theory of stability of equilibrium and motion of mechanical systems with a finite number of parameters, as well as a general method for solving stability problems in his dissertations “On the stability of ellipsoidal equilibrium forms of a rotating fluid”, “The general problem of stability of motion” and the article “On the body of maximum potential”. His works laid the foundations of a mathematical apparatus adequate for the entire cycle of nonlinear oscillations, which was later used by the school of L. Mandelstam. This emphasizes the long-term, transformative impact of his work on the critical and complex field of mechanics, demonstrating the role of the University in the formation of fundamental theoretical mechanics with a stable global significance. He was also the first to prove the existence of equilibrium figures of homogeneous and weakly inhomogeneous fluids close to a sphere, as well as the existence of equilibrium figures of slowly rotating inhomogeneous fluids under very general assumptions.

Volodymyr Andriiovych Steklov, a student of O. M. Lyapunov, also made a significant contribution to the development of mechanics and related fields. His works were mainly concerned with mathematical physics, in particular, the solution of fundamental problems of potential theory, heat conduction theory, elasticity theory, and hydrodynamics (master's thesis “On the motion of a solid body in a fluid”, doctoral

thesis “General methods for solving basic problems of mathematical physics” and article “On the equilibrium of elastic bodies of rotation”). V. A. Steklov provided a complete justification for the solutions of problems of heat propagation in an inhomogeneous rod and oscillations of an inhomogeneous string or rod. He also derived differential equations of motion of a solid in a fluid under general assumptions and solved a number of problems of the theory of elasticity. V. A. Steklov’s specialization in “mathematical physics” and his doctoral degree in “applied mathematics” are examples of the significant interdisciplinary nature of research in mechanics at Kharkiv University. His work applied mathematical methods to solve complex problems in physical and mechanical phenomena (e.g., thermal conductivity, elasticity, hydrodynamics), demonstrating the bridging of the gap between theoretical mathematics and practical engineering challenges.

In addition to O. M. Lyapunov and V. A. Steklov, other scientists of Kharkiv University also made an important contribution to the field that is the foundation for mechanics. V. I. Imshenetsky developed methods for finding rational solutions of linear differential equations and methods for integrating partial differential equations of the second order, investigated canonical differential equations of a flexible inextensible thread and brachistochrone in the case of potential forces, and generalized the functions of Jacques Bernoulli. V. I. Albitsky, in addition to classical works on practical mechanics, dealt with the problems of solvability of second-degree equations with two variables. A. P. Shymkov combined mathematical physics with experiment, formed a teaching methodology, and created relevant textbooks (“On the compression of gases in connection with the mechanical theory of heat and hypotheses about the internal structure of bodies”, “On the relationship between electricity and heat”). The main directions of scientific activity of I. D. Sokolov were writing the textbook “Dynamics” in 2 parts, researching the problems of the calculus of variations and Lagrange's analytical mechanics. The main works of M. A. Dyachenko belonged to the field of mathematical analysis and its application in other sections of mathematics and mechanics. The scientific works of D. M. Delariu related to mathematical analysis and algebra. And his monograph “General Theory of Algebraic Solving of Equations” was the first book on the foundations of the theory of E. Galois in the empire. V. I. Lapshyn, in addition to productive classes in practical physics, was one of the first to apply mathematical methods in teaching physics (the manual “Experience of Mathematical Teaching of Physics” in 2 parts). V. I. Gruzintsev in the articles “On the Geometry of the Propagation and Absorption of Electromagnetic Energy”, “Mathematical Theory of the Phenomena of Reflection and Refraction of Polarized Light”, “On the Refraction of Light Rays in Media Bounded by Any Surfaces” investigated geometric patterns in the study of physical phenomena. Although these scientists were not direct researchers of “mechanics,” their contribution to fundamental mathematics (differential equations, geometry) provided the necessary analytical tools and theoretical foundations on which advanced research in mechanics could be built, in particular the works of such figures as O. M. Lyapunov and V. A. Steklov. One of the first professors of applied mathematics at Kharkiv University was T. F. Osypovsky, who at the beginning of the

19th century investigated mathematical models of the motion of bodies thrown from the surface of the earth and the patterns of astronomical refraction. The years of activity of mechanical scientists of Kharkiv University, the areas of their scientific research, and the list of key achievements are shown in Table 1.

Table 1. Key figures and their contribution to the development of mechanics at Kharkiv University (19th – early 20th centuries) (Author' Source).

Scientist's initials and surname	Years of activity at the KhU	Main areas of research	Key scientific achievements
O.M. Lyapunov	1885–1902	Theory of stability of motion, nonlinear oscillations, equilibrium figures of liquids	Development of a strict theory of stability, a general method for solving stability problems, proving the existence of equilibrium figures of liquids, the foundations of the theory of nonlinear oscillations.
V.A. Steklov	1891–1906	Mathematical Physics, potential theory, heat conduction, theory of elasticity, hydrodynamics	Substantiation of solutions to problems of heat conduction and oscillations, derivation of equations of motion of a solid in a liquid, solution of problems of the theory of elasticity, organization of science.
V.I. Imshenetsky	1872–1882	Linear differential equations	Method for finding rational solutions
A.P. Shymkov	1871–1904	Theoretical Physics	Development and publication of the first textbook on theoretical physics at Kharkiv University
D.M. Delariu	1861–1862 1866–1884	Analytical Mechanics (Statics, Kinematics, Dynamics of a point and Dynamics of systems of material points)	Solving first-order differential equations with two variables
I.D. Sokolov	1840–1866	Calculus of variations and analytical mechanics	Investigation of sufficient conditions for solving variational problems, generalization of variation of motion and the principle of least action
M.A. Dyachenko	1832–1835 1837–1839	Application of mathematical analysis in mechanics	Solving problems using definite integrals in mechanics
M.M. Arkhangelsky	1813–1837	Mathematical theory of fluids	Solving models of fluid motion
T.F. Osypovsky	1805–1820	Course of Mathematics, study of dynamic systems	Solving problems to determine the state of equilibrium under the action of forces on flexible bodies

It should be noted that the teaching of mechanics at Kharkiv University was closely connected with the activities of leading scientists who formed scientific schools. The fact that "scientific schools were formed" indicates a more structured, continuous, and collaborative research effort that went beyond individual scientific pursuits. This indicated a reliable model of mentorship, where leading scientists, such as O. M. Lyapunov, not only conducted groundbreaking research but also actively trained and influenced the next generation of scientists (e.g., V. A. Steklov), ensuring the preservation and growth of specific research areas and intellectual traditions in mechanics.

Kharkiv Practical Technological Institute (since 1898 – Kharkiv Technological Institute, KhTI) was founded in 1885. It played a crucial role in the training of engineering personnel and the development of technical sciences in Ukraine. Since its foundation, theoretical and analytical mechanics have been taught as fundamental disciplines. The very foundation of KhTI as a practical technological institute in 1885 testifies to changes in educational and scientific priorities towards applied sciences and industrial needs, which directly complemented the more theoretical orientation of Kharkiv University. Such institutional design inherently promoted research in applied mechanics, materials science, and various engineering disciplines, directly responding to the growing needs of industrialization of Ukrainian territories at the end of the 19th century. The creation of the scientific school of mechanics at KhTI began in 1885–1893 and was associated with the scientific interests of the first director of the institute, Volodymyr Lvovych Kyrpychov, Professor of Mechanics, who was an outstanding scientist and a founder of higher technical education in Ukraine. His scientific school is one of the most famous in the field of technical sciences at KhTI. He developed the theory of similarity, widely used the reciprocity theorem in the resistance of materials (a famous speech at the general meeting of Kharkiv Department of Imperial Russian Technical Cooperation "New investigations on strength of metal, steel and copper''), and significantly simplified the method of calculating various statically indeterminate structures. V. L. Kyrpychov worked productively in the field of structural mechanics, resistance of materials (monograph "Resistance of Materials"), and the theory of mechanisms. His active participation in the establishment of the scientific school of mechanics at KhTI and the invitation of other prominent mechanics demonstrate conscious efforts to create a critical mass of expertise and promote a common research environment. Scientific and practical contributions of V. L. Kyrpychov (similarity theory, resistance of materials, structural mechanics, theory of mechanisms) clearly emphasize the applied, engineering-oriented nature of research in mechanics at KhTI, which directly corresponds to the mission of the institute and provides a strong contrast to the more theoretical emphasis of Kharkiv University.

A number of other scientists at KhTI also made a significant contribution to the development of applied aspects of mechanics. Kharlampii Sergiovych Golovin was one of the professors invited by V. L. Kyrpychov, an outstanding mechanic who was teaching the results of research into the problems of solid mechanics in the books "On Internal Tensions in the Walls of Metal Cylinders" and "One of the Problems of Solid

Statics". The teaching staff of the institute included such famous professors as D. S. Zernov (researched the problems of strength of materials), V. I. Albitsky (created drawings of machine parts and design), O. V. Grechaninov (dealt with the hydrodynamic theory of friction), A. I. Predtechensky (dealt with the mechanics of foundry production), P. M. Mukhachov (dealt with steam locomotive construction), A. P. Lidov (investigated chemical technologies), K. O. Zvorykin (founder of the theory of metal cutting), O. K. Pogorelko (studied the deformations of solid bodies under the influence of electrical pressures). The diverse and specialized contributions of these scientists (foundry production, metal cutting, steam locomotive construction, radio-controlled mechanisms) illustrate the wide and interdisciplinary scope of applied research in mechanics at KhTI. This indicates that mechanics was considered not as an isolated branch, but as a fundamental discipline underlying various industrial and technological achievements.

Since 1885, theoretical mechanics has been studied at KhTI as a separate discipline of the curriculum for training engineers. Famous scientists were invited to teach it, in particular O. M. Lyapunov and V. A. Steklov (in addition to the above-mentioned scientists, other professors of Kharkiv University were invited to teach various courses – M. D. Pylchykov (author of works on optics, terrestrial magnetism, electrical and radio engineering, electrochemistry), M. M. Beketov (author of physicochemical research), D. O. Grave (researched systems of differential equations of the three-body problem), K. A. Andreev (researcher of problems of projective geometry and mathematical analysis), M. A. Dyachenko (researcher of the functionality of hydraulic wheels)). The fact that theoretical mechanics has been taught as a separate discipline since the foundation of KhTI (1885), and that prominent figures such as O. M. Lyapunov and V. A. Steklov were invited to teach, reveals the importance of scientific relations and the depth of intellectual cooperation between the two institutions. This indicates that KhTI, despite its applied orientation, recognized the fundamental importance of theoretical mechanics and actively used the experience available at the University. The years of creative activity of mechanical scientists of the Kharkiv Institute of Technology, the main areas of scientific research and a list of their key achievements are shown in Table 2.

Thus, Kharkiv University, as a classical institution of higher education, focused on fundamental theoretical research in mechanics and mathematical physics, as evidenced by the works of O. M. Lyapunov (theory of stability, nonlinear oscillations) and V. A. Steklov (potential theory, hydrodynamics). In contrast, Kharkiv Institute of Technology, as a technical university, focused on applied mechanics, the strength of materials, structural mechanics, and engineering applications, as reflected in the works of V. L. Kyrpychov and other mechanical scientists. This clear division of labor in research in mechanics – fundamental theory at the university and applied engineering at the technological institute – is a complex and effective model of scientific development within the boundaries of one city. Such specialization allowed each institution to achieve success in its respective field, while collectively contributing to the broader development of mechanics. This indicates a mature and strategically

developed scientific ecosystem in Kharkiv, which optimized the allocation of resources and intellectual focus. Despite their differences, both institutions were centers of formation of scientific schools and played a key role in training highly qualified personnel. There was a noticeable interconnection between the two institutions, in particular through the exchange of personnel and knowledge. An example is the invitation of O. M. Lyapunov and V. A. Steklov, leading scientists of Kharkiv University, to teach theoretical mechanics at KhTI. This indicates that the institutions, despite their different missions, understood the need for a strong theoretical foundation even in a practical engineering context, contributing to a holistic approach to education and research in mechanics in Kharkiv. This spirit of cooperation probably accelerated the overall scientific progress in the city.

Table 2. Key figures and their contribution to the development of mechanics at Kharkiv Institute of Technology (19th – early 20th centuries) (Author' Source).

Scientist's name and initials	Years of activity at KhTI	Main areas of research	Key scientific achievements
V. L. Kyrpychov	1885–1898	Similarity theory, resistance of materials, structural mechanics, theory of mechanisms	Development of the similarity theory, use of the reciprocity theorem, simplification of the calculation of statically indeterminate structures.
H. S. Golovin	1885–1893	Mechanics of solids	Solving the problem of bending curved rods using methods of the theory of elasticity
D. S. Zernov	1891–1902	Mechanics of strength of materials	Development of the theory of resistance of materials
A. I. Predtechensky	1889–1900	Mechanics of foundry production	Initiator of systematic research in foundry production
K. O. Zvorykin	1889–1898	Mechanics of metal cutting	He laid the foundations of the science of metal cutting
P. M. Mukhachov	1887–1917	Steam power generation, forging technology	Development of problems of steam power generation and forging technology.
M. D. Pylchykov	1898–1908	Wireless telegraphy, radio communication, radio-controlled mechanisms	Development of ideas of radio-controlled mechanisms.
O. K. Pogorelko	1885–1898	Mechanics of solids and fluids	Solving problems of fluid motion

The substantive (content) analysis (Früh, 2015) of the main publications of Kharkiv mechanical scientists of the 19th and early 20th centuries, which allowed to identify the leading directions of scientific research that developed in Kharkiv during this period. The main scientific directions of research were as follows.

1. Theoretical mechanics – this direction covered the fundamental problems of motion, equilibrium of bodies, flexible systems, calculus of variations and stability.

The key topics of this direction were the calculus of variations, equations of motion of a rigid body, stability of mechanical systems, and analytical mechanics. This direction was represented by O. M. Lyapunov, I. D. Sokolov, V. A. Steklov, V. G. Imshenetsky, T. F. Osypovsky. The publications of this direction were characterized by a high level of mathematization of research, the influence of the works of the luminaries of mathematics Lagrange and Euler, and the development of the ideas of classical dynamics.

2. Mechanics of deformed bodies and resistance of materials - this direction was associated with applied mechanics, in particular with the determination of the strength of materials, stresses, and the influence of external forces. The key topics of this group of publications were the study of the regularities of stresses in the walls of cylinders, the calculation of beams and joints, and the study of the properties of metals. Representatives of this direction were the publications of H. S. Golovin, V. L. Kyrpychov, D. S. Zernov. The scientific works of scientists of this direction of research were oriented towards industrial engineering and were important for the development of construction, mechanical engineering, and military equipment.

3. Hydraulics and fluid mechanics – the subject of research in this direction was the phenomena of fluid motion, pressure, hydraulic wheels, lubrication. The key research topics were the principles of operation of hydraulic machines, the definition and consideration of friction in a liquid medium, and the modeling of the motion of bodies in liquids. This direction of research is represented by the publications of M. A. Dyachenko, O. V. Grechaninov, V. A. Steklov, V. I. Albitsky. This direction of publications was closely related to engineering practice, the construction of mills, pumps, and water intakes.

4. Mechanical engineering and gear transmissions – this applied direction demonstrates the development of mechanical engineering culture in Kharkiv, associated with the design of mechanical connections, gear wheels, and steam locomotives. The key research topics in this direction were the methodology of using graphical calculation methods, the features of designing screws, bolts, gears, designing and building steam engines, and locomotives. This direction was represented by scientific and practical research by V. I. Albitsky, A. I. Predtechensky, P. M. Mukhachov. This group of publications was focused on the practical training of engineers and the development of the industrial potential of Kharkiv and the region.

5. Mathematical foundations of mechanics and physics – the works of this direction were interdisciplinary in nature, related to mathematical physics, electromagnetism, and thermodynamics. The key research topics of scientists were the theory of refraction and polarization of light, the properties of gases and heat, the mathematical substantiation of physical laws. The main publications of this direction were the results of research by A. P. Shymkov, O. P. Gruzintsev, V. I. Lapshin. Research in this area was aimed at the formation of a physical and mathematical school at the junction of mechanics, thermodynamics and optics.

Thus, in Kharkiv in the 19th and early 20th centuries, a wide range of research in the field of mechanics was formed, from fundamental dynamics to applied mechanical

engineering. The scientific tradition was interdisciplinary, with active use of mathematical apparatus to describe physical and technical processes. Practical publications by V. I. Albitsky, V. L. Kyrpychov, A. I. Predtechensky became the basis of technical education in engineering universities. Theoretical research by O. M. Lyapunov, V. A. Steklov, and I. D. Sokolov placed Kharkiv School in the pan-European context of mathematical mechanics. To determine the trends in the publication activity of scientists-mechanics of Kharkiv University and Kharkiv Institute of Technology during 1805–1905, a time series with indicators of scientists' publications for 5-year periods of the specified time period was constructed. This made it possible to identify periods of changes in publication activity, which can be characterized as follows.

1. Initial period (1800–1830): isolated publications – in the first third of the 19th century, the publication activity of Kharkiv mechanical scientists was low and was limited mainly to the works of T. F. Osypovsky and M. M. Arkhangelsky. This is explained by the formation of the university, the absence of stable scientific schools, and a limited publishing base.

2. Growth period (1850–1870): the emergence of a stable academic environment – in the second half of the 19th century, a gradual increase in the number of publications is noticeable. New authors appear (I. D. Sokolov, A. P. Shymkov), and university education begins to actively produce research on applied and theoretical mechanics. The first departments appear, the number of students increases.

3. Peak of activity (1876–1900): institutionalization of science – this period became the peak of scientific productivity. It was at this time that O. M. Lyapunov, V. G. Imshenetsky, V. A. Steklov, V. I. Albitsky, V. L. Kyrpychov actively published. Publications were concentrated around the Kharkiv Mathematical Society, university departments, and technical schools. This surge was explained by stable institutional support for science (university, technical society, polytechnic institute), international integration (the influence of German and French engineering schools), and the demand for engineering personnel in the conditions of industrialization.

4. Stabilization at the turn of the century, when activity remains high, but the growth rate slows down. The number of applied research (mechanical engineering, steam boilers, gear transmissions) is increasing, which reflects a shift in emphasis from theoretical to technical and applied science.

Thus, during the 19th and early 20th centuries, publication activity had a wave-like character, with a distinct peak in 1880–1905 (see Fig. 1). The transition from individual creativity to systemic science took place in the last third of the 19th century. Theoretical mechanics developed in parallel with engineering education, which was oriented towards the needs of the railway, machine-building and military sectors. Kharkiv during this period became the leading scientific center of mechanics in Ukraine and within the Russian Empire.

Discussion.

The formation of mechanics in Kharkiv in the nineteenth century took place in close dialogue with the European scientific tradition, yet it also had its own specific features. Kharkiv University, oriented toward fundamental research, embodied an approach close to the German model, with its emphasis on the mathematization of mechanics and the development of analytical methods. At the same time, the Kharkiv Technological Institute, focused on applied tasks, resembled the French grandes écoles system, where the emphasis was placed on engineering education and practical calculations. The Spanish context demonstrated a slower assimilation of new mechanical theories, shaped by a long-standing reliance on translations and the local adaptation of Western works, whereas in Kharkiv a more dynamic integration of Western European ideas was evident.

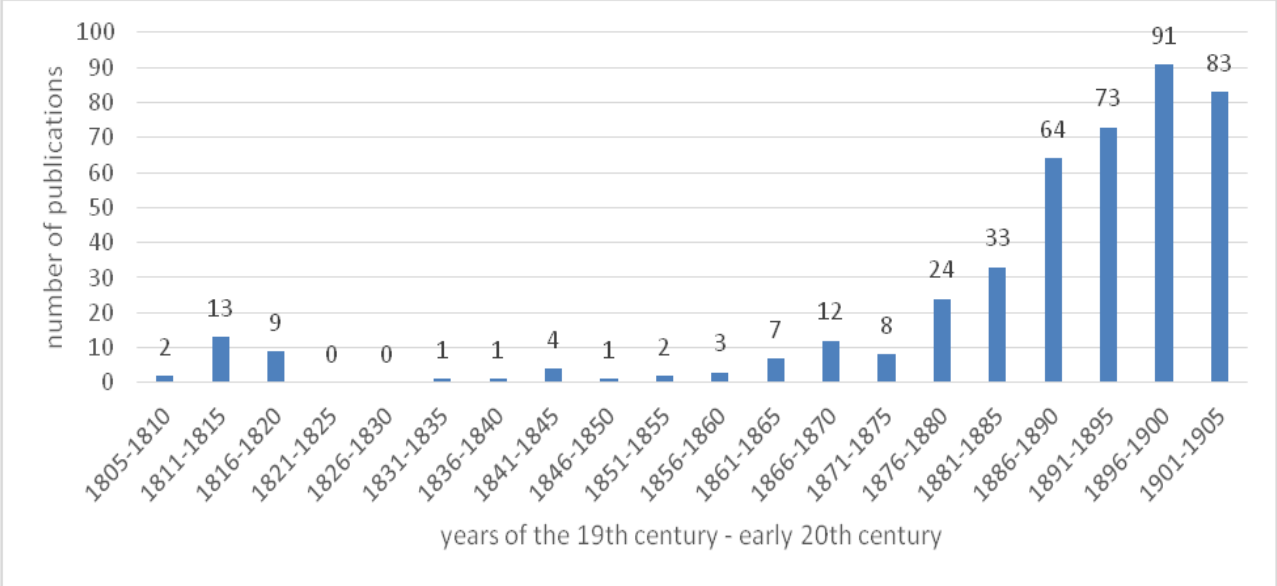

Figure 1. Dynamics of publication activity of mechanical scientists of Kharkiv (1805–1905) (Author' Source).

Significantly, German universities – most notably Göttingen – formed scientific schools around figures such as Klein or Helmholtz, whereas in Kharkiv the corresponding centers were Lyapunov and Steklov, whose research secured entry into the broader European scientific arena (Barrow-Green & Siegmund-Schultze, 2015; Jahnke, Jankvist, U. T., & Kjeldsen, 2022; Heller, 2023). In France, an important factor was the institutional synthesis of the École Polytechnique and the universities, which combined theoretical training with engineering applications—analogous to the dual structure of Kharkiv University and the Technological Institute (Darrigol, 2003). In Spain, despite the smaller number of specialized centers, the development of mechanics was supported through educational reforms and the gradual introduction of applied disciplines in technical schools, which resonates with Kharkiv's efforts in engineering training (Navarro-Loidi & Llombart, 2008).

Unlike many European centers, where the specialization between fundamental and applied mechanics emerged gradually, in Kharkiv this division was clearly

formalized thanks to the existence of two separate institutions. Such a structure ensured broad interdisciplinarity and complementarity, reflected in joint publications and in the invitation of university scholars to teach at the Technological Institute. Compared to France or Germany, the Kharkiv model reveals a more explicit example of coordination between theory and practice at the local level.

Thus, it can be argued that in the nineteenth century Kharkiv created its own "miniature Europe", combining the German tradition of fundamental science, the French orientation toward engineering, and the Spanish attention to the gradual adaptation of knowledge. This synthesis made Kharkiv one of the leading centers of mechanics in Eastern Europe and ensured the continuity of a scientific school that had a lasting influence in the twentieth century.

Conclusions.

As a result of the study, it was established that Kharkiv in the 19th and early 20th centuries became the leading scientific center for the development of mechanics in Ukraine and within the Russian Empire. The formation of two institutional centers – Kharkiv University and Kharkiv Institute of Technology – ensured the integration of fundamental and applied research areas, which contributed to the development of both theoretical mechanics and engineering education.

1. Fundamental research at Kharkiv University, embodied in the works of O. M. Lyapunov, V. A. Steklov and others, laid the foundations of the theory of stability, mathematical analysis of mechanical systems, which ensured the emergence of the Kharkiv school at the pan-European level.

2. Applied research carried out at the Kharkiv Institute of Technology under the leadership of V. L. Kyrpychov and his followers became the basis for the development of technical sciences and the training of engineering personnel for the needs of industrialization.

3. Scientific publications of Kharkiv scientists indicate a high level of interdisciplinarity, as they combined mathematical apparatus with applied engineering tasks (hydrodynamics, resistance of materials, mechanical engineering, theory of mechanisms).

4. Analysis of publications has shown the transition from isolated scientific initiatives to the formation of a stable scientific tradition and schools based on mentoring, academic heredity and interinstitutional cooperation.

5. The dynamics of publication activity in the 19th century confirmed the wave-like nature of the development of science with a peak of productivity in the last third of the century. This surge was due to institutional support, the influence of Western European science, and the urgent needs of the region's technical development.

Thus, a unique scientific ecosystem was formed in Kharkiv, combining fundamental and applied research, contributing to the development of mechanics as a science and creating the basis for further achievements of Ukrainian technical thought in the 20th century.

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Розвиток української механіки: Контекст наукових публікацій харківських вчених XIX століття

Анотація. *Це дослідження пропонує комплексний історіографічний та контент-аналіз розвитку української механіки у XIX столітті крізь призму наукових публікацій харківських вчених. Особлива увага приділяється інституційному та інтелектуальному внеску Харківського університету та Харківського технологічного інституту, які разом утворили унікальну наукову екосистему, що сприяє як теоретичним, так і прикладним дослідженням у галузі механіки. У дослідженні використовується міждисциплінарна методологія, що поєднує історичний підхід, контент-аналіз першоджерел та бібліометричні методи для відстеження тематичних тенденцій, термінологічної еволюції та динаміки наукової комунікації. Результати дослідження показують, що протягом XIX та початку XX століть Харків став важливим науковим центром Російської імперії та Східної Європи. У Харківському університеті теоретична механіка процвітала завдяки роботам видатних вчених, таких як О. М. Ляпунов, В. А. Стєклов та І. Д. Соколов, які заклали основи сучасної теорії стійкості, нелінійної динаміки та математичного моделювання механічних систем. Одночасно Харківський технологічний інститут розвивав прикладну механіку під керівництвом В. Л. Кирпичова та його колеги, новатори досліджень у галузі міцності*

матеріалів, конструкційної інженерії, проектування машин та промислових технологій. Аналіз підкреслює помітну синергію між двома установами, що відображається в міжінституційному навчанні, спільних дослідницьких зусиллях та формуванні потужних наукових шкіл. Публікаційна активність харківських вчених-механіків демонструвала хвилеподібну тенденцію, досягши піку між 1880 і 1905 роками, зумовлену вимогами індустріалізації та міжнародної наукової інтеграції. Цей період ознаменував зміну парадигми від ізольованих інтелектуальних зусиль до системного, спільного наукового виробництва. У цій статті стверджується, що спадщина харківської механічної науки полягає не лише у створенні передових теоретичних конструкцій, але й в інституціоналізації технічної освіти та досліджень, що значною мірою сприяло модернізації українських та східноєвропейських інженерних наук. Висновки, отримані в результаті цього дослідження, пропонують глибше розуміння процесів виробництва, передачі та адаптації знань у контексті наукової глобалізації 19-го століття. Результати дослідження засвідчують, що інституційна співпраця між Харківським університетом і Технологічним інститутом сприяла створенню унікальної наукової екосистеми, яка забезпечила ефективний розвиток механіки як наукової дисципліни. Стаття розкриває важливість цього процесу для подальшого формування української технічної думки у XX столітті та підкреслює значущість спадщини харківських учених у глобальному контексті історії науки.

Ключові слова: *історія механіки; харківська наукова школа; наукові публікації; інституційна історія; теоретична та прикладна механіка; наукова комунікація*

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