



Some Models for Teaching of Geometry and Mechanics

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May 21, 2022

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Since 2021, the Museum of the History of Physics and Mathematics has begun its activities at St. Petersburg State University in Peterhof (the site is <https://spbu.ru/universitet/muzei-i-kollekcii-spbgu>). The main exhibits are the models of scientific research and mechanisms of the nineteenth century. One of the exhibits is an inventory book of the Cabinet of Practical Mechanics from Saint-Petersburg Imperial University (now it is the Saint-Petersburg State University). The first entries in which date back to 1865. Since the middle of the 19th century, this cabinet has been an auxiliary office of the Faculty of Physics and Mathematics of the Imperial St. Petersburg University, intended, in particular, for storing teaching aids in the form of books, instruments, static and kinematic models in mathematics and mechanics (see [1–5]). The cabinet was regularly updated with new models. In this cabinet there were two main groups for the models. The first group contained the models of mechanisms (mainly kinematic models and static models). The sections from the inventory book mentioned above are Kinematic and Static models and Devices (Pribory). Today the models (mainly from this section) are preserved and they are the main exhibits for the Museum of the History of Physics and Mathematics of SPbGU. In this group there is a distinctive feature – there are some of the original mechanisms of Russian famous mathematician P.L. Chebyshev (see also the site www.tcbeb.ru, [3]). Another parts of this group are the kinematic mechanisms of Professor F. Reuleaux [2] and models produced by Russian and other manufactures. We note that in almost all the oldest universities in the world there are museums (or special departments), the exhibits of which are former visual material - models of the nineteenth century or the beginning of the twentieth century. The collection of mechanisms of Professor F. Reuleaux at Cornell University, USA, is presented as a department of its digital collection (<https://digital.library.cornell.edu/collections/kmoddl>) of the library

of kinematic models of mechanisms (KMODDL). The Reuleaux models are the famous models of the historical heritage of the famous technical Russian university – Moscow State Technical University named after N.E. Bauman [6, 7]. There are some Reuleaux models at Politecnico di Torino[8].

The second group was the mathematical models (mainly geometric models and some for mechanics also). The inventory book has the section “Mathematical models”. Here are descriptions of the series of mathematical models that were purchased in 1881–1911. Among them are a series of models by L. Brill from Darmstadt, which are also present in the catalog of the Martin Schilling manufactory [9,10]. In the photograph of 1899 (see Fig. 1) from the photo album of B. Menshutkin, cabinets with plaster mathematical models of the mechanical cabinet of St. Petersburg University are visible.



Figure 1. Mechanical cabinet, at the end of 19th century (photo from the museum of the History of SPbGU).

Many of these models are from the catalog for mathematical models of workshop by Martin Schilling in Germany (Catalog mathematischer modelle for den hooheren mathematischen Unterricht. Leipzig: Verlag von Martin Schilling, 1911 [9]). The famous book "Visual Geometry" (Anschauliche Geometrie) by D. Hilbert and S. Cohn-Vossen,

published in German in 1932 in Berlin, contains photographs of many models of them as illustrations. There is currently a publishing house "Forgotten Books" (www.forgottenbooks.com) that publishes rare and classic books, including publishing this catalog in 2018 [10]. The modern Italian researchers designed a set of interdisciplinary teaching courses, between mathematics (via geometry) and drawing (via Architectural Drawing and Survey Laboratory courses), based on the use of physical models from the catalog by Martin Schilling [11,12]. in conjunction with digital tools, in order to make the cognitive geometric process more effective.

At Saint-Petersburg State University (the theoretical mechanics direction) among the modern courses for two-year students there is an individual coursework (a term paper). This year, one of the students (Aleksandr Cherenkov) chose a term paper on creating a computer model in mechanics from the website www.etudes.ru. The model had to be created by a computer means in the form ready for printing on a 3D printer. He use the program Blender (free software for 3D graphics). His report with the topic Model in mechanics "rotation of the generatrix of the hyperboloid" (under the supervision by docent G. Kuteeva and engineer K. Tverev) was listened to with attention and received approval. The next step in this work is to make a computer model for an illustration from the book "Visual Geometry" (Anschauliche Geometrie) by D. Hilbert and S. Cohn-Vossen, a model for "rolling of a hyperboloid on a hyperboloid". The virtual model "rolling of a hyperboloid on a hyperboloid" was done in form on figure 2.

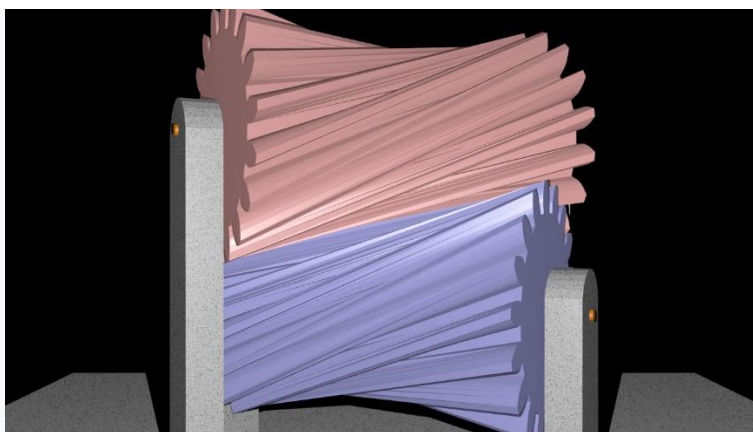


Figure 2. Virtual model "rolling of a hyperboloid on a hyperboloid".

References.

- [1] Tovstik P.E., Yushkov M.P., Kuteeva G.A., Sinilshchikova G.A., Trifonenko B.V. The collection of mechanisms by P.L. Chebyshev at the department of theoretical and applied mechanics of St. Petersburg University // Journal of Physics: Conference Series. Ser. "International Scientific Conference on Mechanics "The Ninth Polyakhov's Reading", ISCM 2021" 2021. P. 012050.
- [2] Kuteeva G.A., Sinilshchikova G.A., Trifonenko B.V. Reuleaux models at St.Petersburg State University // AIP Conference Proceedings. 8th Polyakhov's Reading: Proceedings of the International Scientific Conference on Mechanics. 2018. P. 110001.
- [3] Kuteeva G., Ershov B., Voloshinova T. Models of mechanisms by P.L.Chebyshev in St.Petersburg University (2015) International Conference on Mechanics — Seventh Polyakhov's Reading. 2015. P. 7106745.
- [4] Anastasenko G. F., et al. Collection of knowledge. Museums and Collections of St. Petersburg State University. Saint-Petersburg, 2018. P. 287.
- [5] Kuteeva G. A., Sinilshchikova G. A., Trifonenko B. V., Mathematical models from the catalogue by Martin Schilling // Matematika v vysshem obrazovanii. 2017. N 15. P. 89-94. (in Russian)
- [6] Bazanchuk G.A., Kurakov S.V., Visual aids for teaching practical mechanics at the end of the XIX century as a source of study historical heritage of MRUZ-IMTU-MVTU (Naglyadnyye posobiya dlya prepodavaniya prakticheskoy mekhaniki v kontse XIX veka kak istochnik izucheniya istoricheskogo naslediya MRUZ-IMTU-MVTU) // V sbornike: Sovremennoye tekhnologicheskoye obrazovaniye. Sbornik nauchnykh statey. V 2-kh chastyakh. Pod redaktsiyey A.A. Aleksandrova i V.K. Baltyana. Moskva, 2021. P. 285-293. (in Russian)
- [7] Golovin, A., & Tarabarin, V. Russian Models from the Mechanisms Collection of Bauman University. History of Mechanism and Machine Science Vol. 5, Berlin: Springer. 2008. https://doi.org/10.1007/978-1-4020-8776-9_3

[8] Franco W., Trivella A., Quaglia G. Mechanism and Machine Science Educational Workshop Based on Schröder-Reuleaux Ancient Models of Politecnico di Torino // **Advances in Historical Studies**, Vol.9 No.5, December 8, 2020

[9] Schilling M. Catalog Mathematischer Modelle für den Höheren Mathematischen Unterricht. Leipzig: Verlag von Martin Schilling, 1911. 145 p (in German)

[10] Schilling M. Catalog Mathematischer Modelle für den Höheren Mathematischen Unterricht (Classic Reprint) (German Edition) – January 12, 2018, 145 p (in German)

[11] M. Pavignano, C. Cumino, U. Zich, Catalog Mathematischer Modelle. Connessioni tra testo, rappresentazione grafica e descrizione analitica. Catalog Mathematischer Modelle. Connections between Text, Graphic Representation and Analytical Description // 42th International Conference of Representation Disciplines Teachers. Congress of Unione Italiana per il Disegno. 2020 (in Italian, in English)

[12] C. Cumino, M. Pavignano, M. L. Spreafico, U. Zich, Geometry to Build Models, Models to Visualize Geometry // Digital Experiences in Mathematics Education (2021) 7:149–166
<https://doi.org/10.1007/s40751-020-00080-6>