DEVELOPMENT OF THEORETICAL AND METHODOLOGICAL APPROACHES IN THE STUDY OF THEORETICAL MECHANICS BY STUDENTS OF CIVIL ENGINEERING

Ye. V. Ponomareva, O. A. Khokhlova, K. V. Kulemina, A. V. Sinelshchikov

Ponomareva Yelena Vladimirovna, Candidate of Physical and Mathematical Sciences, Associate Professor of the Department "Mechanics and Engineering Graphics", Astrakhan State Technical University, Astrakhan, Russian Federation; e-mail: internet@astu.org;

Khokhlova Olga Aleksandrovna, Candidate of Technical Sciences, Associate Professor of the Department "Mechanics and Engineering Graphics", Astrakhan State Technical University, Astrakhan, Russian Federation; e-mail: zaphy@yandex.ru;

Kulemina Kseniya Vladimirovna, Candidate of Philology, Associate Professor of the Department "Mechanics and Engineering Graphics", Astrakhan State Technical University, Astrakhan, Russian Federation;

Sinelshchikov Aleksey Vladimirovich, Candidate of Technical Sciences, Associate Professor of the Department of Industrial and Civil Engineering, Astrakhan State University of Architecture and Civil Engineering, Astrakhan, Russian Federation; e-mail: laex@bk.ru

Modern realities confront the system of higher professional education with the problem of providing the regions with qualified builders who are able to independently master professional activities and have multidisciplinary systems thinking. The training of future builders is carried out in the process of studying the natural sciences and disciplines of the general professional cycle, including theoretical mechanics, the teaching of which in a modern university is associated with certain difficulties: 1) this discipline is quite difficult for the first-year students to perceive; 2) in the conditions of a sharp reduction in the number of classroom hours, it is necessary to look for ways to optimize the learning process even in a full-time education. This situation leads to the creation of effective interactive distance teaching tools, aimed at organizing students' independent work. Most existing interactive distance teaching tools in theoretical mechanics partially or completely lack for the capacity to: 1) adapt material according to specified criteria to provide the required level of complexity and volume; 2) develop and implement fundamentally new design tasks that are oriented not only toward the formation of basic theoretical knowledge, but also toward the skills acquisition to solve problems closely related to future professional activity. Distinctive features of the interactive distance teaching tools were the use of specialized mathematical packages, as well as the orientation of the presented material toward the future professional activity of students and toward strengthening interdisciplinary connections in mechanical sphere. The authors developed a methodology for performing static and strengthening parameters of mechanical systems (solids, composite structures, trusses) calculations in Maple and MathCAD systems. There worked out the software package used as generators of unique multi-choice, design, prof-oriented problems, ranked according to the degree of complexity. Some ideas of the proposed methodology are found in research works of Russian scientists, but at present the analogue that realizes in full the interactive distance teaching tools capable of solving educational and scientific-practical problems, generating tasks of a given complexity with automatic verification the results obtained, forming a bank for unique multi-choice prof-oriented computational tasks, doesn't exist.

Keywords *computer modeling, import substitution, theoretical mechanics, job generator, distance learning.*

РАЗВИТИЕ ТЕОРЕТИЧЕСКИХ И МЕТОДОЛОГИЧЕСКИХ ПОДХОДОВ ПРИ ИЗУЧЕНИИ ТЕОРЕТИЧЕСКОЙ МЕХАНИКИ СТУДЕНТАМИ СТРОИТЕЛЬНЫХ СПЕЦИАЛЬНОСТЕЙ

Е. В. Пономарева, О. А. Хохлова, К. В. Кулемина, А. В. Синельщиков

Пономарева Елена Владимировна, кандидат физико-математических наук, доцент кафедры «Механика и инженерная графика», Астраханский государственный технический университет, г. Астрахань, Российская Федерация; e-mail: internet@astu.org;

Хохлова Ольга Александровна, кандидат технических наук, доцент кафедры «Механика и инженерная графика», Астраханский государственный технический университет, г. Астрахань, Российская Федерация; e-mail: zaphy@yandex.ru;

Кулемина Ксения Владимировна, кандидат филологических наук, доцент кафедры «Механика и инженерная графика», Астраханский государственный технический университет, г. Астрахань, Российская Федерация;

СинельщиковАлексей Владимирович, кандидат технических наук, доцент кафедры промышленного и гражданского строительства, Астраханский государственный архитектурно-строительный университет, г. Астрахань, Российская Федерация; e-mail: laex@bk.ru

Современные реалии ставят перед системой высшего профессионального образования проблему обеспечения регионов квалифицированными строителями, способными самостоятельно овладевать профессиональными видами деятельности, обладать мультидисциплинарным системным мышлением. Подготовка будущих специалистов осуществляется в процессе изучения естественнонаучных дисциплин и дисциплин общепрофессионального цикла, в том числе теоретической механики, преподавание которой в современном вузе сопряжено с определенными трудностями: 1) дисциплина является достаточно сложной для восприятия студентами начальных курсов; 2) резкое сокращение числа аудиторных часов вызывает необходимость оптимизации учебного процесса даже при очном обучении. Такое положение вещей обуславливает потребность в создании эффективных интерактивных средств дистанционного обучения, направленных на организацию самостоятельной работы студентов. В большинстве случаевпри использовании интерактивных средств по теоретической механике отсутствуют возможности: 1) адаптации материала по заданным критериям для обеспечения требуемого уровня сложности и объема изучения; 2) разработки и внедрения принципиально новых расчетных заданий, ориентированных не только на формирование базовых теоретических знаний, но и на приобретение навыков решения задач, тесно связанных с будущей профессией. Авторами предложено применение специализированных математических пакетов, а также ориентация излагаемого материала на будущую профессиональную деятельность студентов и укрепление связей дисциплин механического профиля. Разработана методология проведения расчетов статических и прочностных параметров механических систем (твердых тел, составных конструкций, ферм) в системах Maple и MathCAD. Сформирован комплекс программ, используемый как генератор уникальных многовариантных расчетных профориентированных заданий, ранжируемых по степени сложности. Отдельные положения предложенной методики встречаются в работах отечественных авторов, однако в настоящее время аналога, реализующего в полном объеме интерактивное средство дистанционного обучения, способное решать образовательные и научно-практические задачи, генерировать задания определенной сложности с автоматической проверкой получаемых результатов, формировать банк уникальных многовариантных профориентированных расчетных заданий, не существует.

Ключевые слова: *компьютерное моделирование, импортозамещение, интерактивные средства обучения, теоретическая механика, генератор профориентированных многовариантных заданий.*

1. Introduction

Currently, the Russian construction industry is in need of a radical modernization. To a large extent, this is due to the critical dependence of some branches of the national economy on foreign suppliers and technologies. To solve such priority tasks as import substitution, energy efficiency and resource saving, development of nuclear, space, medical and information technologies, highly skilled engineers are needed to ensure the competitiveness of Russian products and technologies in domestic and international markets.

Modern reality put before the system of higher professional education the problem of providing regions with qualified engineers who can study independently and master professional activities, understand fundamental engineering sciences, work in a team, who have multidisciplinary system thinking, have high communicative qualities, the ability to creative, critical and independent thinking.

The training of future engineers is the process of studying natural science and disciplines of the general professional cycle, including theoretical mechanics, which is the basis for studying other

related technical disciplines (technical mechanics, applied mechanics, strength of materials, the theory of mechanisms and machines, machine parts, structural mechanics, principles of machine design, etc). Knowledge of the laws and principles of theoretical mechanics is necessary for solving many professional problems (calculation, construction and operation of tall buildings, bridges, tunnels, dams, irrigation and drainage facilities, pipeline transport of oil and gas, etc). The study of theoretical mechanics provides trainees the ability to build and use mathematical and physical models of objects and phenomena of the real world independently, to link the world of abstract math concepts with world of real objects – machines, structures, and devices. In addition, the study of theoretical mechanics helps to expand the scientific horizon, develop the abilities for analytical and logical thinking. Within the framework of this discipline, the practical application of general concepts of mathematics and physics to the study of real systems and their models forms the fundamental knowledge necessary for the independent solution of the problems arising in the course of training students and in their future professional activity.

Thus, theoretical mechanics as a science is a scientific basis for most fields of modern technology, and as an academic discipline, along with mathematics and physics, is of great educational value, and an engineer of any level of proficiency, direction and specialty must know its fundamentals.

At the same time, teaching of theoretical mechanics in a modern university is a challenge. It is connected with the fact that this discipline is quite difficult for the first-year students to perceive and its understanding is possible only if students have good physical and mathematical education. Technical universities professors note the first-year students have a low level of the necessary physical and mathematical knowledge, insufficient motivation and interest in studying mechanics, weak awareness of its role in future career. This points to the lack of continuity between the courses of mathematics, physics, mechanics and further profiling disciplines and the lack of professional orientation in teaching. Moreover, classroom hours to study disciplines related to mechanics, especially theoretical mechanics are cut down dramatically. The negative trends of the last two or three decades have led to a decrease in the number of classroom hours for theoretical mechanics. With the transition to State Educational Standards (SES), the previous two-, three-semester courses of theoretical mechanics, provided for students of construction, transportation, engineering specialties, were reduced to one term in technical universities. The number of

class hours as a whole has decreased by two-three times in recent years. So, at present the typical course of theoretical mechanics is 54 classroom hours (18 lecture hours and 36 practical hours) in one term in Astrakhan State Technical University, it is quite little for good mastery of the discipline. In the conditions of a sharp reduction in the number of classroom hours, leading lecturers are forced to look for ways to optimize the learning process of theoretical mechanics, since, even a full-time student is engaged in independent work for a substantial part of the time. This situation leads to the search and creation of effective interactive distance teaching tools (IDTT), aimed at organizing students' independent work, mastering the knowledge of the subjects and developing the ability to apply this knowledge in their future career. That is why the use of technology and distance learning tools in educational process in technical universities is reflected not only in the works of scholars but also in practical activity of universities.

1.1. The Use of Computer Technologies in the Educational Process

The IDTT are one of the perspective directions used for the formulation and solution of educational, research and engineering problems in the field of mechanics. Such systems are successfully used to create and develop electronic forms of education in the field of higher professional and postgraduate education. The effectiveness of using the IDTT has been confirmed by more than 20 years of implementation.

In the 90s of the last century attempts were made to create multimedia systems aimed at studying technical sciences, in particular, theoretical mechanics (the work of Y. F. Golubev, V. E. Pavlovsky, A. V. Koretsky, N. V. Osadchenko and etc.). Further development was connected with the use of interactive capabilities of personal computers and the Internet (the works of G. I. Melnikov, V. V. Glagolev, V. I. Latyshev, and others). The preferred form of submitting materials was hypertext, www-technologies, online electronic textbooks (the works of A. I. Kobrin, V. G. Kuzmenko, V. E. Pavlovsky, T. O. Nevenchannya, E. V. Ponomareva [2–5, 8, 9]). Recently, more and more work began to appear based on combining traditional approaches to creating information-learning systems and the capabilities of specialized mathematical packages – Maple and MathCAD (the works of M. N. Kirsanov [6], A. V. Matrosov [7], E. G. Makarov, V. D. Bertyaev, V. P. Dyakonov), which not only increased the scientific and practical level, but also opened new ways for increasing the interactivity of such systems.

Despite there are many existing IDTT in theoretical mechanics, most of them have partially or completely lacked the capacity to: 1) adapt according to specified criteria theoretical and informational material, exercises and tasks to provide the required level of complexity and volume; 2) increase the interactivity of IDTT and their presentation in the form of virtual stands (2D and 3D-laboratories) to study the mechanical systems; 3) use homogeneous tools in creating IDTT, ensuring uniformity of the appearanceand style of the system; 4) develop and implement fundamentally new design tasks that are oriented not only toward the formation of basic theoretical knowledge in theoretical mechanics, but also toward the skills acquisition to solve problems closely related to future professional activity, toward strengthen interdisciplinary connections of mechanical profile, development the capacity for creative thinking, allowing them to build and use mathematical and physical models of objects and phenomena of the real world [1].

1.2. Material Orientation toward the Students' Professional Activity

The authors are currently developing the IDTT in the form of an electronic textbook on theoretical mechanics [2], developed in 2003 in the Department of Theoretical and Applied Mechanics of Astrakhan State Technical University. The section 'Oscillations' was added to the electronic textbook, the lecture material was expanded, and quantity of the test tasks was significantly enlarged.

Distinctive features of this IDTT were the orientation of the presented material toward the future professional activity of students, as well as the use of specialized mathematical packages in the study of mechanics. Let us consider these features in detail.

In order to motivate students to study the subject, to encourage in them the desire to acquire new knowledge, to search for a solution to the set tasks, to develop the capacity for independent thinking and creativity, the authors tried to accompany the presentation of the lecture course in the electronic textbook with enough examples of practical application from the field of the future professional activity, drawn up in an understandable for students form (fig. 1).

Thus, in the 'Statics' section, there given examples of determining the pressure of a bridge crane on rails, the tasks for calculating the forces in the rods of bridge trusses and overlapping of real buildings, wind pressure effect [10], determining the slings' load-carrying capacity according to a given type of loading; the problems for determining the maximum weight of the counterweight and the payload lifted by a balance crane.
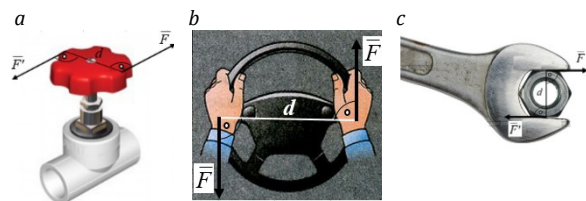

Fig. 1. (a, b, c) examples of applying a force couple to a rigid body

Let us consider some examples.

Example 1. A construction crane with weight P rests on rails A and B (fig. 2). Wide gauge is l. The crane center of gravity C is located at equal distances from the supports A and B. The counterweight center of gravity, G, is separated from the vertical line passing through point C at a distance l_1. Determine 1) the maximum weight value G of the counterweight for an unloaded crane; 2) the maximum weight Q of the payload lifted by a balance crane. Example 2. Determine the pressure force of the bridge double-girder crane *AB* on the rails, depending on the position of the trolley C with the attached winch (fig. 3). The position of the trolley is determined by the distance of its center from the left rail in fractions of the total bridge length. The weight of the bridge is *P*, the weight of the trolley with lifted load is P_1.
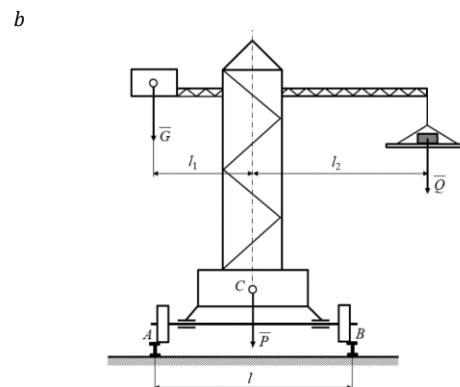

Fig. 2. Illustration for example 3: (a) photograph of the crane, (b) calculation scheme
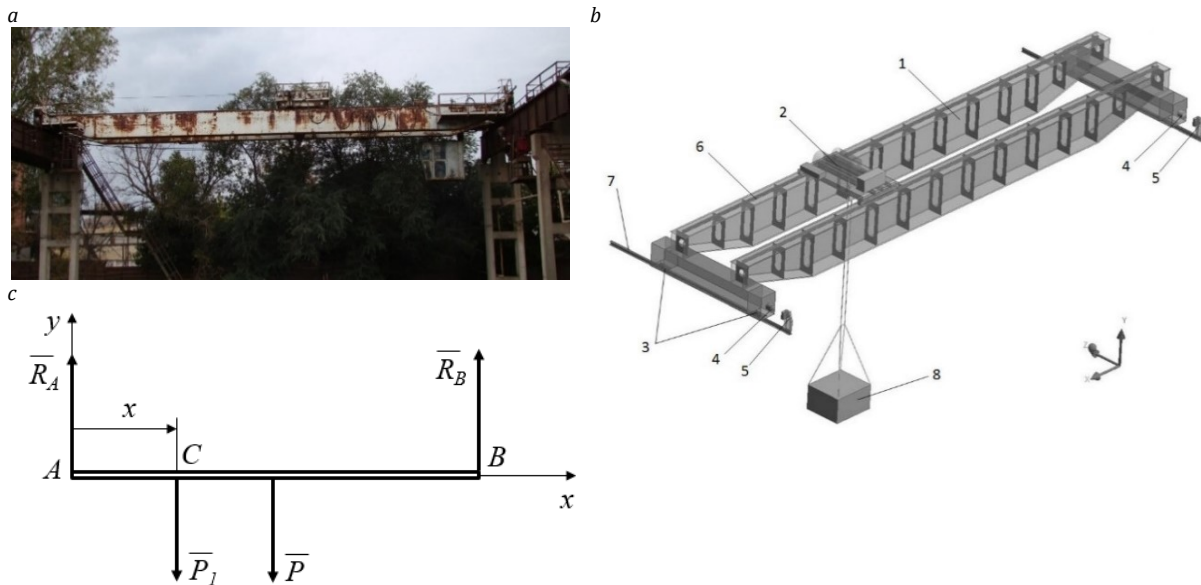
Fig. 3. Bridge double-girder crane: (a) photograph; (b) structural model of bridge crane:
1 – metal construction; 2 – freight trolley; 3 – running wheels of the crane; 4 – buffer; 5 – buffer stop; 6 – sub-rail tracks;
7 – crane rail tracks; 8 –- useful cargo on a flexible pendant; (c) a design scheme for example

In each problem the main emphasis is placed on understanding the physical meaning of the applied law, after which the mathematical formulation of the solution is made. Some problems are solved in several ways, an analysis of the mechanics' laws used during the solution is made, as well as the analysis of the obtained results verifying the correctness of the solution, and the conclusions are drawn.

The application of such professionally-oriented tasks is the main means of implementing the applied orientation of teaching theoretical mechanics in technical and civil engineering universities.

1.3. Statement and Solution of the Task: the Development of a Generator of Multi-choice Tasks of Different Complexity Levels

The authors developed a methodology for performing static calculations in MathCAD and Maple systems, and a set of mws-programs written in mathematically oriented Maple programming language was formed. The complex of programs is intended for computer modeling and automatic calculation of mechanical systems' static parameters (solids, composite structures, trusses) with visualized results (by displaying two- and three-dimensional design schemes with marking all sizes, applied loads, and also, if necessary, with graphical dependencies of the calculated parameters from the structure size). This approach to studying the behavior of building structures under the action of external loading is not new [10].

The developed programs allow not only to solve the tasks, but also are used as generators of unique multi-choice, prof-oriented, design problems, ranked according to the degree of complexity. Each program is related to the solution of a specific standard problem and is structurally included in the IDTT topic on theoretical mechanics [11, 12]. Work with the program precedes the study of theoretical material on the relevant topic, an analysis of the general problem, including a plan for its solution with the necessary theoretical explanations and examples, as well as a mode of operation the program itself. Examples of schemes of multi-choice different complexity level tasks are given in the table. In the problems of the first four types, a rigid body can be fixed by the following combinations of connections: 1) a rigid embedding; 2) hinged-movable and hinged-fixed supports; 3) the rod and the hinge-fixed support; 4) a combination of three rod supports; 5) a combination of three hinge-moving supports; 6) combination of rods and pivot-movable supports. In addition to the straight-line arrangement of the rigid body axis (see table 1, the minimum complexity level of the task), it is possible to construct design schemes consisting of a number of bars located at an angle to each other (the number of rods is specified by the program user) (see table 2), as well as schemes of composite constructions, "Rod – truss – flat plate" (see table 5–8).

The tasks in table 1 are a special case of the tasks in 2, if the number of rods is taken equal to one, and the angle of inclination to the horizon is zero degrees.

In all assignments to the composite construction, in addition to determining the reactions in the supports, the trainee is also asked to calculate the position of the center of gravity.

In tasks (see table 5-8), the correctness of the solution is checked using the principle of possible displacements (section 'Analytical Mechanics').

Some ideas of the proposed methodology are found in research works [2, 5–8, 12], but at present the analogue that realizes in full the information and training system capable of solving educational and scientific-practical problems, generates tasks of a given complexity with automatic verification the results obtained, forms bank for unique multi-level, multi-choice computational tasks, ranked according to the degree of complexity, doesn't exist.

The authors are working on expanding the number of multi-choice tasks, it is planned to realize calculations of not only static [13], but also kinematic [14], dynamic and strength characteristics of mechanical systems.

Table

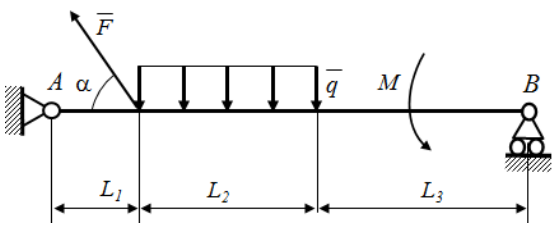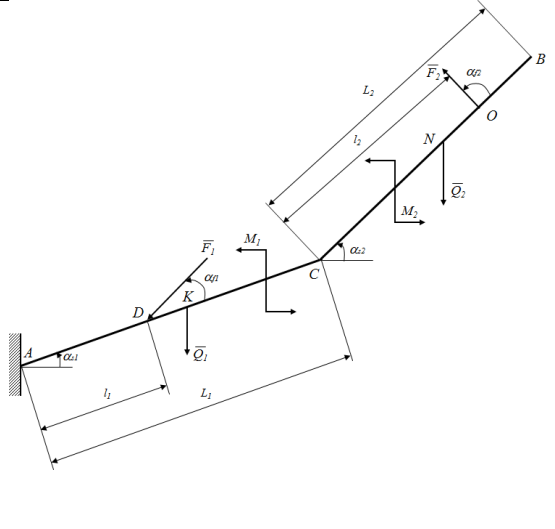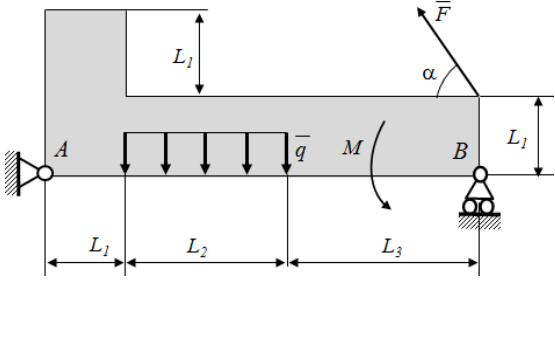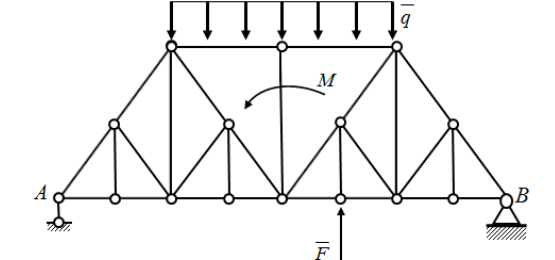**Examples of the Methodology Implementation: Multi-choice Different Complexity Levels Tasks**

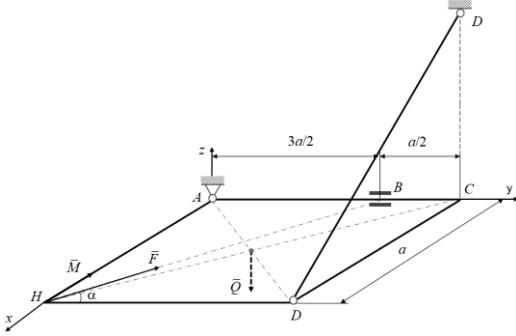| Name	Design Scheme	Notes
A plane system of forces acted toward a rigid body		The rigid body AB, whose dimensions L_1, L_2, L_3 are shown in the diagram, is fixed at points A and B. A prescribed force F is placed at the angle α to the horizon, a couple force with a moment M, a distributed load of intensity q. Determine the reactions in the supports for a rigid body
A plane system of forces acted toward a rigid body consisting of several inclined rods, rigidly connected to each other		The rigid frame ACB is fixed at point A by means of a rigid fit. The frame acted by the given forces F_1 and F$_2$, as well as force couple with moments M$_1$ and M$_2$. The lengths of sections L_1, L_2, l_1, l_2, respectively, are the line weights of sections q$_1$ and q$_2$. The angles of rods inclination to the horizon, respectively, will be denoted α_{s1}, α_{s2}, the angles of the force vectors inclination to the rods α_{f1}, α_{f2} (the positive direction of the angles is counted against the clockwise direction). Determine the reactions in support A
A plane system of forces acted toward a rigid body made in the form of a flat plate		A homogeneous plate, whose dimensions L_1, L_2, L_3 are shown in the diagram, is fixed at points A and B. The plate is acted by a given force F, located at an angle α to the horizon, a force couple with a moment M, a distributed load intensity q. Determine the reaction in the plate supports
A plane system of forces acted toward a plane truss		Determine the reactions in the truss supports at given geometric characteristics (the dimensions of all the rods and the inclination angles to the horizon), as well as the loads – the known force F, the force couple with the moment M, the distributed load intensity q

Table continuation

Name	Design Scheme	Notes
Plane composite construction consisting of rectilinear rods		The composite construction *ACB*, consisting of two rods *AC* and *CB*, is fixed at points *A* and *B* by means of pivot-fixed supports, at the point C – by a cylindrical hinge. The composite construction is loaded with the force *F*, a force couple with a moment *M*, a distributed load intensity q. Determine the reactions in the supports
Plane composite construction consisting of rectilinear rod and truss		Determine the reactions in the supports of the composite construction and the pressure in the hinge C with the given geometric characteristics (the dimensions of all the rods and the angles of inclination to the horizon) and the known loads – the force F, the force couple with the moment M, the distributed load intensity q
Plane composite construction consisting of rectilinear rod and flat plate		Determine the reactions in the supports of the composite construction and the pressure in the hinge C with the given geometric characteristics (the sizes of all elements and the angles of inclination to the horizon) and the known loads – the force F, the force couple with the moment M, the distributed load intensity q
Plane composite construction consisting of flat truss and flat plate		Determine the reactions in the supports of the composite construction and the pressure in the hinge C with the given geometric characteristics (the sizes of all elements and the angles of inclination to the horizon) and the known loads – the force F, the force couple with the moment M, the distributed load intensity q
Center of gravity: shape of rods, plate, volume, flat section		For a given flat figure (the composite section of a column or beam), determine the position of the center of gravity. Section consists of a rectangle 1 with the given size, a corner 2 with the size 80 × 80 × 7 and channel №20

Table continuation

Name	Design Scheme	Notes
Spatial-statics		A uniform rectangular plate, attached to the wall by means of a spherical hinge *A* and a cylindrical hinge *B*, is held in a horizontal position by means of a cable *DE*. In addition to the force of gravity $\bar{Q}$, the plate acted by force $\bar{F}$ and a force couple with the moment *M*. Determine the reaction of the hinges and the tension of the cable

Conclusion

Using the IDTT to solveeducational and scientific-practical problems in the field of mechanics (in this case – theoretical mechanics, the section 'Statics') increases the interest of students in discipline due to better clarity of the material presented. The subject area of 'theoretical mechanics' is a suitable basis for the use of such information technology tools as computer modeling, visualization, etc., which significantly enriches and intensifies the educational and research process. The joint application of IDTT and specialized mathematical packages (for example, Maple or MathCAD) brings such research works to a new qualitative level, making them suitable to modern requirements and information technology capabilities. Forming a single database of computational algorithms and applied universal programs in the environment of the Maple mathematical package or the MathCAD system allows to make calculations automatic, graphically display the results, build two- or three-dimensional animated models, and 'feel' the solution of the problems in 'dynamics'. Varying the initial data, it is possible to solve new tasks and generate different in complexity versions of assignments for students.

The use of abstract models rather than abstract models to study statics (truss bridges, cranes, overlaps, etc.) can provide a better understanding of the material presented and its role in future professional activity.

References

1. Ovchinnikov I. G. Trends in the optimal design of metal structures, taking into account operating conditions / I. G. Ovchinnikov, V. S. Mavzovin // Engineering and Construction Bulletin of the Caspian Sea. – 2020. – № 1 (31). – Pp. 43–50.

2. Sinelshchikov A. V. Development of a set of universal mws-programs (Maple) for computer modeling and automation of calculations in the field of mechanics / A. V. Sinelshchikov, E. V. Ponomareva//Vestnik of Astrakhan State Technical University. Series: Ma-nagement, Computer Sciences and Informatics. – 2014. – № 1. – C. 69–80.

3. Nevenchannaya T. Using Visualized Tools for Distance Learning / T. Nevenchannaya, E. Ponomareva, O. Khokhlova, et al. // Vestnik of Moscow State University of Printing Arts. – 2010. – № 11. – Pp. 124–133.

4. Ponomareva E. The Application of a Complex of Electronic Problem-Oriented Learning Systems in Theoretical Mechanics / E. Ponomareva, O. Khokhlova, A. Khokhlov // Vestnik of Astrakhan State Technical University. – 2017. – № 1. – Pp. 69–76.

5. Ponomareva E. The Concept of the Internet Textbook on Theoretical Mechanics. Innovations in E-learning / E. Ponomareva, T. Nevenchannaya, V. Pavlovsky // Instruction Technology, Assessment and Engineering Education. – Springer Netherlands, 2007. – Pp. 373–377.

6. Ivanov V. A. Analytical method of determining the extreme positions of special mechanisms using software systems / V. A. Ivanov, et al. //Izvestiya MGTU MAMI. – 2014. – Vol. 8, № 4–3. – Pp. 24–31.

7. Mironov A.I. Mathematical and software for the study of transverse vibrations of ship propeller shafts /A. I. Mironov, E. V. Ponomareva // Bulletin of the Astrakhan StateTechnical University. Series: Management, Computer Engineering and Informatics. –2014. –№ 3. – Pp. 102–112.

8. KirsanovM. Reshebnik. Theoretical Mechanics / M. Kirsanov. – Moscow : Fizmatlit, 2008. – 384 p.

9. Matrosov A. Maple 6. Solving Problems in Higher Mathematics and Mechanics / A. Matrosov. – Saint-Petersburg : BHV-Petersburg, 2001. – 526 p.

10. Prosvirina I.S. Influence of wind speed on the nature of pressure distribution outside multi-storey buildings / I. S. Prosvirina, E. M. Derbasova// Engineering and Construction Bulletin of the Caspian Sea.– 2020. – № 4 (34). – Pp. 57–60.

11. Tarasov D.A. Numerical modeling of the work of bending elements in the elastic-plastic region under the action of a transverse impact / D. A. Tarasov // Engineering and Construction Bulletin of the Caspian Sea. – 2022. – № 2 (40). –Pp. 21–25.

12. Ponomareva E. Concept, structure and program realization of the Internet textbook on classical mechanics /E. Ponomareva, T.Nevenchannaya, V. Pavlovsky // IFTOMM – 2007 : Proceedings of Twelfth World Congress in Mechanism and Machine Science. – Besancon, France, June 17-21 2007. – Vol. 2. – Pp. 38–43.

13. Ponomareva E. Distance information – reference – training software complex for scientific research and educational / E. Ponomareva, T. Nevenchannaya, V. Pavlovsky // Preprint of Institute of applied mathematics named after M.V. Keldysh RAS. – 2008. – 32 p.

14. Nevenchannaya T. Electronic Internet Textbook on Theoretical Mechanics / T. Nevenchannaya, V. Pavlovsky, E. Ponomareva. – 3 Dec 2004. – Certificate of official registration № 2004612620.

15. Ponomareva E. The Program for Calculating the Basic Kinematic Parameters of the Motion of a Material Point / E. Ponomareva, O. Khokhlova, A. Khokhlov. – 27 July 2010. – Certificate of official registration № 2010614882.

ГРАДОСТРОИТЕЛЬНОЕ ПРЕОБРАЗОВАНИЕ ТЕРРИТОРИИ АРКТИЧЕСКОЙ ЗОНЫ РОССИЙСКОЙ ФЕДЕРАЦИИ: НОВЫЕ ПОДХОДЫ И РЕШЕНИЯ

О. А. Сотникова, Т. С. Халеева, Е. А. Саласин

Сотникова Ольга Анатольевна, доктор технических наук, профессор, заведующий кафедрой проектирования зданий и сооружений им. Н. В. Троицкого, Воронежский государственный технический университет, г. Воронеж, Российская Федерация, тел.: +7 (473) 2-774-339; e-mail: hundred@vgasu.vrn.ru;

Халеева Татьяна Сергеевна, старший преподавателькафедры проектирования зданий и сооружений им. Н. В. Троицкого, Воронежский государственный технический университет, г. Воронеж, Российская Федерация, тел.: +7(473) 2-774-339; e-mail: xaleewatatyana@yandex.ru;

Саласин Евгений Андреевич, студент, Воронежский государственный технический университет, г. Воронеж, Российская Федерация

В статье рассматривается отечественный опыт градостроительного освоения территорий Арктической зоны Российской Федерации, на основании которого предлагаются современные подходы и концепции, затрагивающие различные отрасли человеческой деятельности. Приводится оценка существующей ситуации в системе расселения и действующих градообразующих отраслей экономики региона с предпосылками формирования патерналистской модели освоения. Материалы статьи посвящены ретроспективному анализу проектов компактных градообразований для Арктики на примере разработок советских и российских архитекторов. Рассмотрены примеры реализации современных концепций автономных военных баз. В рамках обзора градостроительных тенденций кафедрой проектирования зданий и сооружений им. Н. В. Троицкого Воронежского государственного технического университетапредложены наработки градостроительных концепций создания патерналистских моделеймикропоселений с общественными пространствами, включающими в том числе образовательные и медицинские центры для Арктической зоны.

Ключевые слова: градостроительство, Арктическая зона Российской Федерации, моногорода, патернализм, энергоэффективность, быстровозводимые конструкции.

URBAN CONVERSION OF THE AZRF TERRITORY: NEW APPROACHESAND SOLUTIONS

O. A. Sotnikova, T. S. Khaleyeva, Ye. A. Salasin

Sotnikova Olga Anatolyevna, Doctor of Technical Sciences, Professor, Head of the Department of Design of Buildings and Structures named after N. V. Troitsky, Voronezh State Technical University, Voronezh, Russian Federation, phone: +7 (473) 2-774-339; e-mail: hundred@vgasu.vrn.ru;

Khaleyeva Tatyana Sergeyevna, Senior Lecturer, Voronezh State Technical University, Voronezh, Russian Federation, phone: +7 (473) 2-774-339; e-mail: xaleewatatyana@yandex.ru;