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Creation of Problemic Lessons of Learning the Subject of "Theoretical Mechanics" with the Help of Modern Information Technology

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Abstract: This work examines the problematic lessons of teaching the subject "Theoretical Mechanics" and its solution with the help of modern information technology.

Keywords: Support forces reactions, equilibrium equations, package, MatchCad 15, COMPASS, equilibrium equation system.

Literature review. Today, problem-based learning is understood as such an organization of training sessions, which involves the creation of problem situations under the guidance of a teacher and active independent activity of students to resolve them, as a result of which there is a creative mastery of professional knowledge, skills, abilities and the development of thinking abilities. Many works have been published in this direction. It includes the works of A. V. Kononov, M. O. Ploskinnaya, T. V. Levchenkov, O. A. Kishkinov, and others.

Main part. Problem learning methods were used in the Socratic school. For teaching students, this method was proposed by the American scientist and educator John Dewey in 1894. The concept acquired a clear formulation thanks to the works of the Soviet scientist S. Rubinstein, who proposed a way to develop the consciousness of children through the formulation of cognitive problems.

It is known that the course of "theoretical mechanics" is one of the compulsory subjects, which for students of technical universities. The course begins with a study of the statics section. This section deals with the problem of equilibrium of systems of forces acting on a structure. Pedagogical experience shows that students are often mistaken and it will be difficult for them to compose the equations of the equilibrium of the systems of forces acting in the structure. Currently, there are many computer packages designed to solve engineering problems in different directions. These packages are not only for training but also for calculating them for a specific situation.

Solving problems of statics, is one of the direction of construction, engineering calculation of load-bearing structures on static equilibrium and others. At the same time, when designing structures or structures, the KOMPAS package is used with great success.

Our goal is to apply the capabilities of this package not only for engineering drawing, but also to involve statics in solving problems. It is clear that any structure has always remained in equilibrium according to the traditional method. Draws up the equilibrium equations according to the following general formula:

$$\begin{cases} \sum np_x(\vec{F_i}) = 0 \\ \sum np_y(\vec{F_i}) = 0 \\ \sum M_a(\vec{F_i}) = 0 \end{cases} \quad (1)$$

The first two equations are the projection of all forces on the coordinate axis, and the third is the moment of forces relative to some point. We are faced with the task of automating this process as much as possible. This requires:

- ➢ The technical drawing of the structure must comply with the stringent requirements of GOST with the help of KOMPAS;

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- Determine the length of the shoulder using "Tools" => "Geometry" => "Auxiliary lines" => "Perpendicular lines";
- According to the condition of calculating the moment, it will calculate the torque relative to the point.

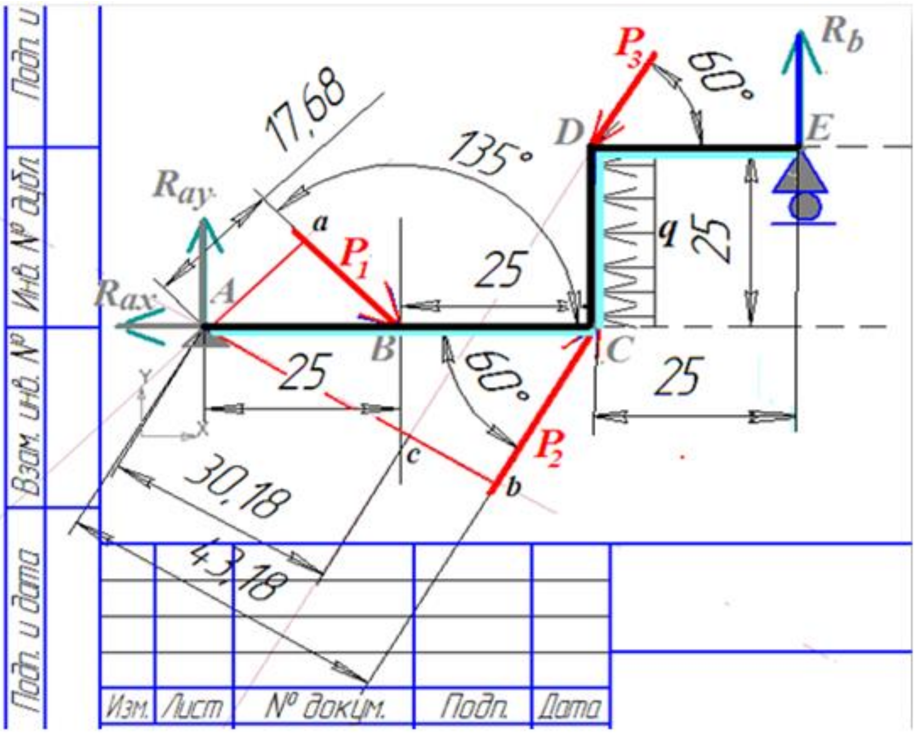

Figure 1. Working drawing of the structure.
Rax, Ray, Rb force reactions on supports. P1, P2, P3, q external forces.

Suppose we were given the task of determining the reaction on the supports of structures, the drawings of which are shown in Figure 1. This means that we were assigned the task of determining the reaction of forces on the supports **Rax, Ray, Rb** .

From Figure 1, we can conclude:

- The structure consists of rods AC, CD, DE:
- The point of application of point forces P_1, P_2, P_3 is at points B, C and D;
- Uniformly distributed force q is applied along the rod CD;
- The length of the arms for forces P_1 - Aa, P_2 - Ab, P_3 - Ac which is measured using the above method.

Based on the statics method (1), we compose the equilibrium equations:

$$\sum np_x(\vec{F_i}) = R_{ax}cos180^0 + P_1cos135\,^o + P_2cos(180\,^o + 60^o) + P_3cos60\,^o - 25q = 0$$

$$\sum np_y(\vec{F_i}) = R_{ay}sin90^o + P_1sin135\,^o + P_2sin(180\,^o + 60^o) + P_3sin60\,^o + R_b\sin90^o \;= 0 \quad (2)$$

$$\sum M_a(\vec{F_i}) = -P_1Aa + P_2Ab - P_3Ac + \frac{25^2}{2}q + R_b(AC + DE) = 0$$

Let's compose a matrix for determining the unknowns **Rax, Ray, Rb** .

$$A = \begin{pmatrix} cos180^0 & 0 & 0 \\ 0 & sin180^o & \sin90^o \\ 0 & 0 & (AC + DE) \end{pmatrix}$$

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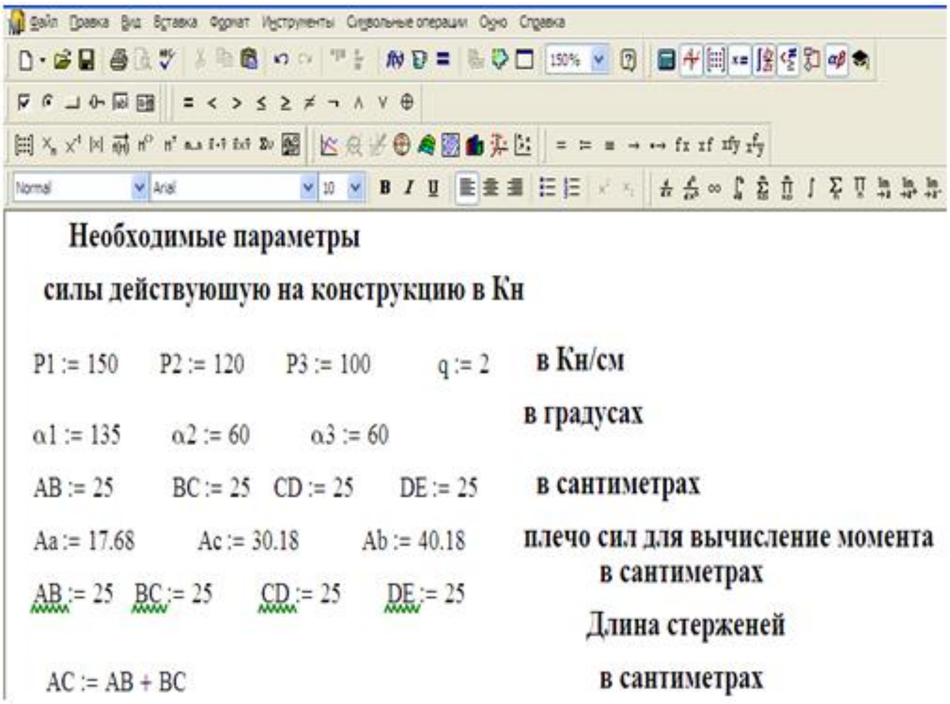
The vector of free members is:

$$B = \begin{pmatrix} -P_1 cos135\,^o - P_2 cos(180\,^o + 60^o) - P_3 cos60\,^o + 25q \\ -P_1 sin135\,^o - P_2 sin(180\,^o + 60^o) - P_3 sin60\,^o \\ P_2 Aa - P_2 Ab + P_3 Ac - \dfrac{25^2}{2} q \end{pmatrix}$$

This produces a matrix solution for determining the reaction forces on the structure supports in the form:

AX=B or $X=A^{-1}B$



We will get the solution to the problem by using MatchCad 15. Below is a screenshot of the work of the programs for solving the problem (Fig. 2).

Основная матрица

$$A := \begin{pmatrix} \cos\left(\frac{\pi\cdot 180}{180}\right) & 0 & 0 \\ 0 & \sin\left(\frac{\pi\cdot 90}{180}\right) & \sin\left(\frac{\pi\cdot 90}{180}\right) \\ 0 & 0 & AC + DE \end{pmatrix} \qquad A = \begin{pmatrix} -1 & 0 & 0 \\ 0 & 1 & 1 \\ 0 & 0 & 75 \end{pmatrix}$$

Вектор свободных членов

$$B := \begin{bmatrix} -P1\cdot\cos\left(\frac{\pi\cdot\alpha1}{180}\right) - P2\cdot\cos\left[\pi\cdot\frac{(\alpha2+180)}{180}\right] - P3\cdot\cos\left[\frac{\pi\cdot(\alpha3+180)}{180}\right] + 2.5\cdot q \\ -P1\cdot\sin\left(\frac{\pi\cdot\alpha1}{180}\right) - P2\cdot\sin\left[\pi\cdot\frac{(\alpha2)}{180}\right] - P3\cdot\sin\left[\frac{\pi\cdot(\alpha3+180)}{180}\right] \\ P2\cdot Aa - P2\cdot Ab + P3\cdot Ac - \frac{2.5^2}{2}\cdot q \end{bmatrix}$$

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Полученные матричное уравнение имеет вид AX=B

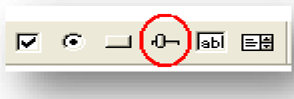
$$B = \begin{pmatrix} 221.066 \\ -123.387 \\ 311.75 \end{pmatrix}$$

$$X := A^{-1} \cdot B \qquad X = \begin{pmatrix} -221.066 \\ -127.543 \\ 4.157 \end{pmatrix}$$

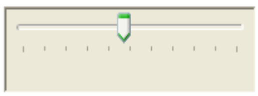
$$Ra := \sqrt{(X_0)^2 + (X_1)^2} = 255.22 \qquad Rb := X_2 \qquad Rb = 4.157$$

Figure 2. Screenshot of the solution to the problem using MathCad

In order to obtain research information from solving problems, it can be controlled by applying some features of the MatchCad package with the help of icons:



This adds a continuation to the program as follows:

$P1 :=$  $P2 :=$  $P3 :=$ 

$P1 = 25 \qquad P2 = 47 \qquad P3 = 76$

Вектор свободных членов

$$PP := \begin{pmatrix} P1 \\ P2 \\ P3 \end{pmatrix}$$

$$B := \begin{bmatrix} -P1 \cdot \cos\left(\frac{\pi \cdot \alpha 1}{180}\right) - P2 \cdot \cos\left[\pi \cdot \frac{(\alpha 2 + 180)}{180}\right] - P3 \cdot \cos\left[\frac{\pi \cdot (\alpha 3 + 180)}{180}\right] + 2.5 \cdot q \\ -P1 \cdot \sin\left(\frac{\pi \cdot \alpha 1}{180}\right) - P2 \cdot \sin\left[\pi \cdot \frac{(\alpha 2)}{180}\right] - P3 \cdot \sin\left[\frac{\pi \cdot (\alpha 3 + 180)}{180}\right] \\ P2 \cdot Aa - P2 \cdot Ab + P3 \cdot Ac - \frac{2.5^2}{2} \cdot q \end{bmatrix}$$

Полученные матричное уравнение имеет вид AX=B

$$B = \begin{pmatrix} 84.178 \\ 7.437 \\ 1.23 \times 10^3 \end{pmatrix} \qquad X := A^{-1} \cdot B \qquad X = \begin{pmatrix} -84.178 \\ -8.962 \\ 16.399 \end{pmatrix}$$

$$Ra := \sqrt{(X_0)^2 + (X_1)^2} = 84.653 \qquad Rb := X_2 = 16.399$$

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After applying this pictogram, we have the opportunity to answer the following questions:

- How the reaction of forces on the supports changes when the forces P1, P2, P3 are distributed in ascending order;
- How does the reaction of forces on the supports change when the forces P1, P2, P3 are distributed in descending order;

How the reaction of forces on the supports changes when the forces P1, P2, P3 are randomly distributed;

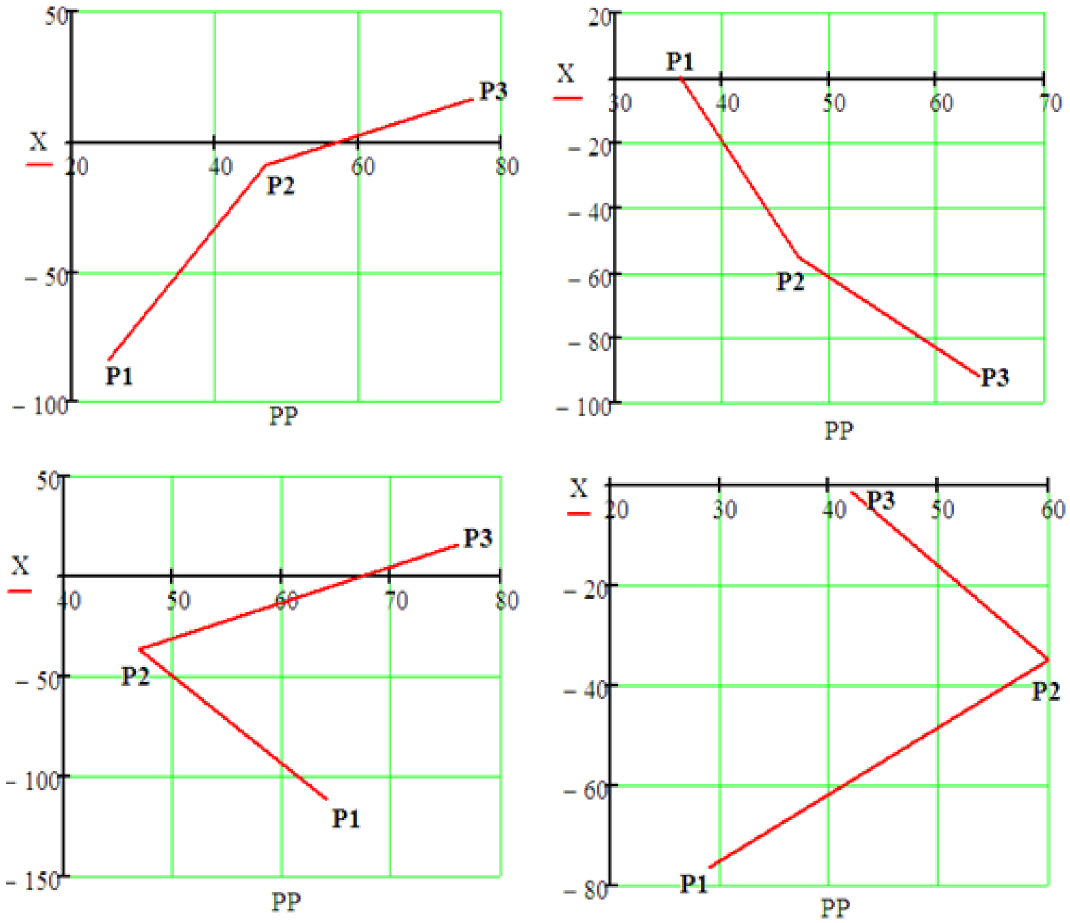

Figure 3. Graph of the change in the reaction of forces on the supports of structures.

Conclusion: With the use of modern information technology, it is possible not only to train professional specialists, but to implement the results of the design of engineering structures.

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