

# Application of Computer Practical Batches and Animated Software in Teaching the Subject “Applied Mechanics”

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**Abstract:** *The article covers the main scientific-methodological results of new computer methods obtained in the teaching of “Applied Mechanics” subject. Methodology for solving exactly formulated problems in the teaching of “Applied Mechanics” and “Material Resistance” based on computer-assisted learning technologies has been developed.*

**Keywords:** LabVIEW, COMSOL, Cisco Trace, Solidworks, CodeSYS, Matlab, Mathcad, modern software tools, credit module system, virtual stand, Given, Find operator, Flash animation.

## INTRODUCTION

Lately our country, like other developed countries, pays great attention to the computerization of education system, to the widespread use of global information resources and creation of modern learning platforms based on information technology. Now the role of our economy and the world community in a market economy is directly related to the level of development of information and communication technologies and their widespread use in all sectors of the economy, including the formation of a competitive personnel system in education. In this regard, one of the urgent tasks is the organization of training based on computer-assisted learning technologies and the formation of professional competence of students in higher education institutions.

At present, a number of practical software tools based on computer-assisted learning technologies are widely used in the design of educational institutions in educational institutions of the country. Examples of such didactic tools are modern software tools such as LabVIEW, COMSOL, Cisco Trace, Solidworks, CodeSYS, Matlab and Mathcad.

## MATERIALS AND METHODS

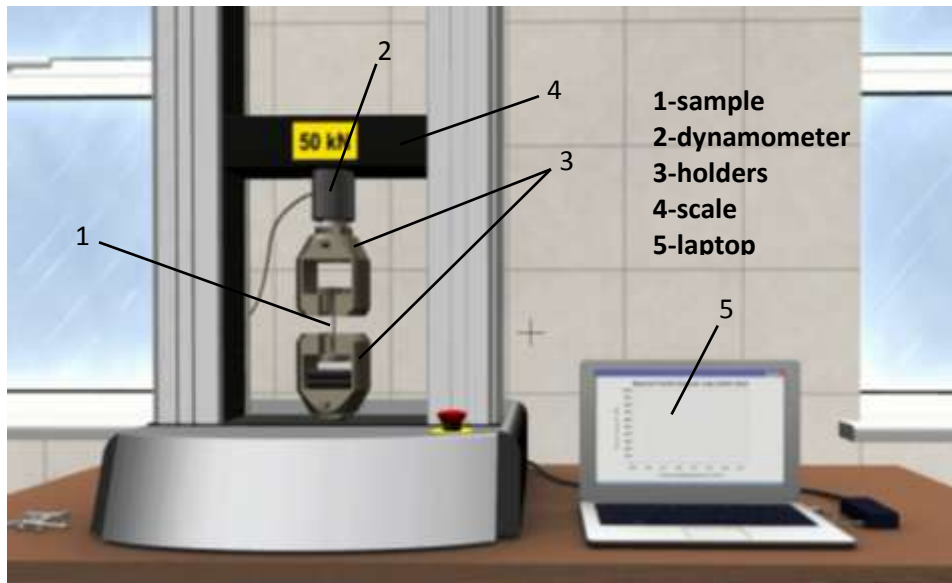
During the process of teaching the disciplines “Applied mechanics” and “Resistance of materials” at the department of “Fundamentals of mechanics” of Bukhara Engineering-Technological Institute, in the development of new technologies attention was paid to the development of two areas. First, attention was paid to reviewing the content of these disciplines, which have been studied for many years and in this regard, the design of lessons, taking into account the possibilities of mathematical modeling programs of computer training. In the second direction, attention was paid to the development of new methodological materials based on the use of video clips and animations for lectures and practical classes, as well as the development of computer control programs aimed at assessing students' knowledge and developing their creative thinking. A number of activities were also carried out to prepare virtual laboratory works for laboratory classes.

Such virtual work has allowed visualizing a real object and working in interactive communication mode because of imitating real laboratory equipment on a computer screen. In the lectures, we introduced the use of computer-generated dynamic slides. As a result, teachers were partially free from doing graphic work on the board and had additional opportunities to explain pictures and forms. In addition, before each new lecture, opportunities were created to visually briefly explain the topic covered in the previous lesson.

In order to effectively organizing the independent work of students by teachers of the department, an electronic textbook on “Applied mechanics” was created under leadership of associate professor of the department N.S. Bibutov [2]. As part of this electronic textbook, an interactive software tool for solving typical problems on computer animations and new computer methods was developed. Computer animations show the motion of the mechanical objects being studied, while creating the ability to pre- enter some variables of vector quantities that describe their motion into objects.

From the point of view of mechanics, the visual view of such animations results in the formation of the student's perception of the motion of objects and increases the level of mastery of theoretical information. Other types of animations in the electronic textbook serve to demonstrate the laws of dynamics, important effects such as resonance, material resistance, self-vibration, gyroscopic phenomena, deformation, which play an important role in instrumentation. A mirror view of an animated virtual stand for elongation testing of material samples, which consists of a special sample holders, tensile strength, and devices that draw an elongation diagram are shown in Fig. 1.

A steel material was taken as a sample on the virtual stand, and using the device it was stretch up to 10, 50 and 100 kN. The sample is attached to the handle parts of the machine using screws. Once a laptop that draws an elongation diagram is installed on a virtual stand, the sample is loaded with a slow elongation force. As the value of power increases, a straight line appears on the laptop screen that deviates from the abscissa. This condition lasts for a certain period, and as the force then increases, this line continues approximately parallel to the abscissa.



As the tensile force increases, the surface of the sample becomes blurred. As a result, no increase in impact force is required for its elongation. The virtual stand, which explains the elongation of materials, has the ability to study the occurrence of local elongation, the characteristics of forces acting on materials and parameters affecting elongation, as well as to extract a paper version of the results and determine the mechanical and plastic properties of the material [3, 4]. The organization of lessons with the help of such animated programs allows students to understand the essence of mechanical laws.

It is known that ECTS (European Credit Transfer and Accumulation) system has been implemented in the higher education institutions of the country from the 2020-2021 academic year. In the practice of the credit-module system, the ratio of classroom and independent study hours is on average 40/60 percent. This ratio, in other words, corresponds to 1/1, i.e. the student will have to prepare for one and a half hours of extracurricular study for each hour of class assigned to a particular subject. Thus, because of the reduction of classroom hours, there is a need to improve the quality of laboratory and practical training and intensify them. In other words, it is necessary to identify and implement mechanisms to maximize the use of training hours allocated to laboratory and practical training and to achieve greater learning efficiency with less time. Our pedagogical experience shows that the use of computer software such as Matlab, Maple, Mathcad, Mathematic in the organization of practical and laboratory classes on the subject of “Applied Mechanics” allows to improve the quality of training and intensify them.

## RESULTS AND DISCUSSIONS

The e-textbook on the subject of “Applied Mechanics”, which has been developed by us, provides students with theoretical knowledge, as well as the opportunity to organize practical classes based on interactive methods. Designed for science and uncomplicated matrix file-functions are created by the student himself in the Mathcad system. Such features allow shortening the procedure for solving complex problems and making efficient use of time allocated for training.

Based on the results of our research, we present examples of solving static plane and spatial problems based on the methodology developed at the department for the organization of practical classes using modeling programs. It assumes that the student independently creates two or three  $m$ -functions that are formed from the coordinates of the points of application of forces and are not complex. In the process of solving the problem, the student first theoretically analyzes the given physical model (computational scheme) and writes the problem using the variables of the Mathcad program. In the next step, the student writes the matrix algebraic equilibrium equation in a linear form. Based on this equation, the Mathcad system provides the solution to the problem to the user in the form of a line vector.

Thus, the simple procedure of solving the problem frees the student from complex work such as creating a system of algebraic equations and manually performing the transition to the matrix form, and the system is automatically converted directly to the matrix form. Such an approach to problem solving can also be used to solve other complex problems of dynamics, including solving problems related to the detection of dynamic reactions. Based on the above methodology, we will consider the process of solving a clearly formed problem.

**Problem.** The problem of determining the base reaction of a solid using the Mathcad application batch.

**Initial information.** Let the ABC beam, which is fixed to point B by a cylindrical hinge and held at point A by means of a vertical rod, be loaded with forces (distributed load of constant intensity  $q$ , total force  $P$ , and moment of force  $M$ ). (Fig. 2a).

If  $M = 20 \text{ kN} \cdot \text{m}$ ,  $P = 10 \text{ kN}$ ,  $q = 5 \frac{\text{kN}}{\text{m}}$ ,  $a = 3 \text{ m}$ ,  
 $b = 1.5 \text{ m}$ ,  $\beta = 60^\circ = \frac{\pi}{3}$ , determine the contact reaction at points A and B.?

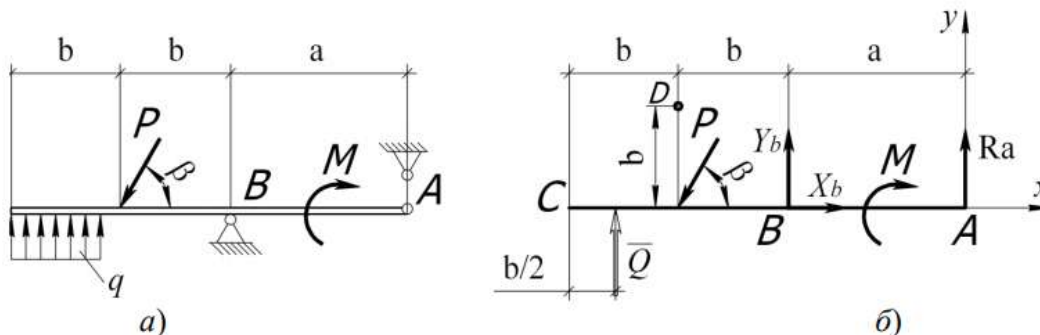


Fig. 2.

**Solution:**

1. Consider the equilibrium of a solid beam ABC.
2. We choose the coordinate axes  $xy$  (Fig. 2b).
3. We apply the active forces  $q, P, M$  to the ABC beam. Then, according to the coupling axiom, we drop their bases at points A and B by replacing their effect on the beam with the  $Ra$  and  $Rb$  reactions. We show the  $Rb$  reaction through the components  $Yb$  and  $Xb$ . We replace the distributed load  $q$  with the cumulative force  $Q$ . It is found by the following formula:  $Q=q \cdot b$
4. Now the ABC beam is free from bases A and B and is in equilibrium under the influence of random plane system of forces  $S(Q, P, M, Ra, Yb, Xb) \sim 0$ .
5. We write the equilibrium equations required for the system of forces obtained.

$$\begin{aligned} \sum F_{Xi} &= 0, & Xb - P \cos \beta &= 0 \\ \sum F_{Yi} &= 0, & Q - P \sin \beta + Yb + Ra &= 0 \\ \sum m_{Ai} &= 0, & -Q \cdot \left( a + b + \frac{b}{2} \right) + P \sin \beta \cdot (a + b) - Yb \cdot a &= 0 \end{aligned}$$

6. Using the Mathcad batch we solve a system of equations formed for unknown forces  $Ra, Yb$  and  $Xb$

To solve a system of equilibrium equations, we use the *Given* operator, which is designed to find the solution of nonlinear equations, and perform the following steps:

- Enter the values of the initial data;
- Determining the initial approximation of unknown reactions;
- Enter the keyword *Given* to write a system of equations;
- Use the *Find* procedure to find unknowns in a system of equations.

Window views and comments on how to solve the problem using the Mathcad application batch are below.

To solve the problem, we enter the initial values (Fig. 3).

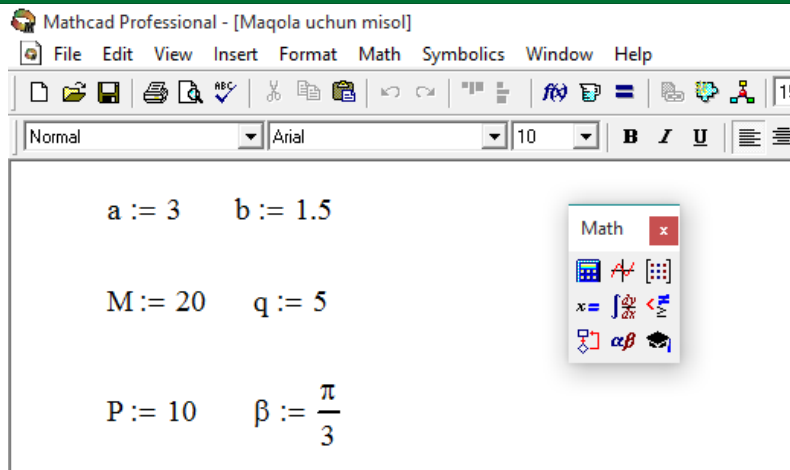


Fig. 3. Entering the initial values in Mathcad

We calculate the equally distributed load of constant intensity  $Q$ .

$$Q = qb \quad Q = 7.5$$

We give the initial approximation of unknown reactions.

The resulting system of equations is a system of linear algebraic equations of relatively unknown quantities. The initial approximation can be given optionally in the following view.

$$\begin{pmatrix} Xb \\ Yb \\ Ra \end{pmatrix} := \begin{pmatrix} 0 \\ 0 \\ 0 \end{pmatrix}$$

To solve a system of equations, we enter the *Given* operator at the beginning of the block of solutions and form a system of equations of equations. The (=) sign is used when writing equations, which is a "logical" operator that appears in bold in Mathcad software.

*Given*

$$\begin{aligned} Xb - P \cdot \cos(\beta) &= 0 \\ Q - P \cdot \sin(\beta) + Yb + Ra &= 0 \\ -Q \cdot \left(a + b + \frac{b}{2}\right) + P \cdot \sin(\beta) \cdot (a + b) - Yb \cdot a - M &= 0 \end{aligned}$$

Using the *Find* procedure, we calculate the unknown reactions of the connections, which indicates the end of the block of solutions.

$$\begin{pmatrix} Xb \\ Yb \\ Ra \end{pmatrix} := \text{Find} \left( \begin{pmatrix} Xb \\ Yb \\ Ra \end{pmatrix} \right) \quad \begin{pmatrix} Xb \\ Yb \\ Ra \end{pmatrix} = \begin{pmatrix} 5 \\ -6.801 \\ 7.962 \end{pmatrix}$$

Check the results obtained:  $Ra = 7.962 \text{ kH}$ ,  $Yb = -6.801 \text{ kH}$ ,  $Xb = 5 \text{ kH}$

To do this, we calculate the principal moment of the external forces relative to the point D (the point where the lines of motion of all unknown forces do not pass) [3].

Its value must be zero in the same case.

$$\begin{aligned} MD &:= Ra \cdot (b + a) - M + Xb \cdot b + Yb \cdot b - P \cdot \cos(\beta) \cdot b - Q \cdot \frac{b}{2} \\ MD &= 1.776 \times 10^{-15} \sim 0 \end{aligned}$$

The problem was solved correctly and with high accuracy using the numerical method.

### CONCLUSION

Therefore, it can be concluded that the use of modern computer technology modeling programs and matrix forms of demonstration of mathematical models in the teaching of “Applied mechanics” discipline shows good results. This in turn allows for a more concise demonstration of the base material in some courses in mechanics. Extensive use of Flash animations can be achieved in the visual representation of the mechanical movement of objects.

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