Improvement of Methods of Mathematics Teaching Management in Educational Organizations of the Ministry of Emergency Situations of Russia in the Context of the Development of the Digital Educational Environment

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Abstract. The methods of managing the teaching of mathematical disciplines in the direction of training "Technosphere safety" with the use of modern information technologies are considered. It is shown that their application makes it possible to effectively solve various practice-oriented problems in a mathematical formulation. At the same time, the focus of attention is shifted to consideration of the mechanisms for integrating mathematical knowledge with professional aspects and informational training. Examples of solving practice-oriented problems in the environment of the mathematical package Mathcad are given.

INTRODUCTION

The relevance of mathematics in the preparation process in the areas of "Technospheric safety", "Fire safety" is due to the forecasting of fire hazards, conducting, monitoring the fire situation, forecasting natural disasters, emergency situations (ES) of a man-made nature, natural emergencies, assessing the elimination of the consequences of natural disasters, prevention of emergencies, assessment of the epidemiological situation.

Here is a list of competencies formed in the process of studying the discipline "Higher Mathematics" 20.03.01 "Technosphere Safety".

- Universal Competence. Able to search, critical analysis and synthesis of information, apply a systematic approach to solving tasks.
- General Professional Competence. Able to take into account modern trends in the development of equipment and technologies in the field of technosphere safety, measuring and computer technology, information technology in solving typical problems in the field of professional activities related to environmental protection and human security.

The introduction of innovative teaching methods in educational institutions of the Ministry of Emergency Situations of Russia, as a rule, is closely related to the development of a digital educational environment. The teaching of disciplines of the mathematical cycle is no exception.

At the same time, one of the important components of increasing the interest of cadets and students in the study of mathematical disciplines is the selection of practice-oriented tasks and the use of information technologies for modeling various practical situations.

Currently, when studying mathematical disciplines, it is possible to use various mathematical packages, which are an effective didactic tool that allows, after the traditional (classical) study of a particular mathematical method and
understanding of its essence, to shift the focus of attention from the computational aspects of solving a problem to its study.

The importance of the information and analytical competencies of specialists of the Ministry of Emergency Situations of Russia is growing, manifested in the ability to use modern software tools that implement modern mathematical methods and models focused on solving applied problems of professional activity.

Mathematics is a special educational discipline studied at a university, it serves as the foundation for the study of other general educational, general professional and special disciplines [1-4].

**METHODS**

The search for effective methods of teaching mathematics is one of the most important areas of work for teachers of the Department of Higher Mathematics and System Modeling of Complex Processes.

The traditional approach to teaching mathematics at a university has been established for a long time and is firmly held in the public mind.

The following principles form the basis of the classical technique:

- intelligible and, at the same time, mathematically quite rigorous presentation of the basic mathematical principles and methods during the lecture;
- reliable consolidation of theoretical material and the acquisition of effective skills in the use of applied mathematical methods during practical and laboratory classes;
- logically coherent and consistent presentation of theoretical material in lectures, fixed by cadets, students, undergraduates in other types of classes and forming their skills of scientific thinking, the ability to independently acquire the necessary knowledge of practical work after graduation;
- the formation of students' elements of creativity, a creative approach to the processes and phenomena being studied, a critical analysis of certain methods, the possibilities of their use and expansion of the scope of their application;
- providing students with high-quality teaching materials;
- systems for monitoring the current course of the educational process and monitoring the final knowledge and skills of students;
- activation of the cognitive interest of students.

However, the implementation of these principles is associated with certain difficulties. The abstractness of mathematical concepts, mathematical methods of cognition is difficult to assimilate, especially for first-year students; their cognitive activity is also complicated by the speed of presentation of educational material, which is much higher than that to which they are accustomed at school.

For example, one has to learn the section of differential and integral calculus in one semester. Thus, the course of mathematics turns out to be extremely concentrated in terms of saturation with concepts, ideas and methods, and many students are not able to “digest” it in the time allotted for this.

The work curriculum with the number of hours: the total labor intensity of the discipline is 8 credits, 288 hours.

The question arises: “What and how can be taught in the time allotted by the curriculum for mathematics?”.

Traditional ways of teaching mathematics need to be complemented by innovative teaching methods. It seems that, first of all, one should once again carefully select the most important concepts necessary for cadets and students for further assimilation of general professional and special disciplines.

Russian mathematician, academician Aleksey Krylov argued that the main task of the university is “To teach the ability to learn”, and no school can produce a complete specialist: a professional is formed by his own activity.

"The ability to learn" develops most fully in students during practical, laboratory classes and independent work.

It is necessary to supplement the traditional way of conducting practical classes with innovative methods. Mathematical packages are a convenient tool for creating conditions for solving problems of a research nature, since they allow you to shift the focus of attention from routine computational aspects to the analysis of the results of solving a problem [5–9].

Currently, the Department of Higher Mathematics and System Modeling of Complex Processes uses the following approach: approximately half to 2/3 of the practical classes are devoted to solving typical problems manually, and the rest of the time is devoted to solving more complex research problems in computer classrooms or on a laptop with math packages.
Thus, in the process of teaching mathematical disciplines, logical thinking should develop, such skills of mental activity as the ability to explore, analyze, abstract and systematize should be acquired.

Let us consider the criteria for practice-oriented tasks [2, 4].

1. The presence of a professional plot of the problem, which contributes to creative activity in teaching the disciplines of the mathematical cycle.
2. The presence of basic and accessible problems specific to technosphere safety.
3. Technological orientation of the process, i.e. compliance with the rules and regulations requiring compliance of the result of the solution with its intended purpose.
4. Integration of mathematical knowledge, manifested either in the condition or in the process of solving a situational problem.

This raises the question: “How to apply innovative learning technologies to the subject area that was previously studied in terms of traditional methods and classical approaches? Is it effective everywhere and always?

As examples of the use of information technologies in mathematical disciplines, we present a number of problems for the solution of which intra- and interdisciplinary integrations are used [2, 4].

Categories of practice-oriented tasks of higher mathematics for the direction of training "Technosphere safety" are presented in Table 1.

**TABLE 1.** Categories of practice-oriented tasks of higher mathematics.

<table>
<thead>
<tr>
<th>Practice-oriented tasks categories</th>
<th>Intradisciplinary Integration (integration of elements of mathematical apparatus)</th>
<th>Interdisciplinary integration</th>
<th>Typical practice-oriented tasks</th>
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</thead>
<tbody>
<tr>
<td>Practice-oriented tasks using complex numbers</td>
<td>Functions of one variable, theory of complex numbers, geometric interpretation of complex numbers, MathCad functions in complex numbers</td>
<td>Higher mathematics, Information Technology, Physics, Applied mechanics, Fundamentals of Electrical engineering and electronics</td>
<td>In an alternating current circuit with a frequency $f = 50$ Hz resistor connected in series with resistance $R = 20$-ohm, inductor $L = 0.1275$ H and capacitance $C = 0.000127$ F (Fig. 1). Using Mathcad, calculate the complex and impedance of the circuit.</td>
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</table>

**FIGURE 1.** Electric circuit.
TABLE 1. Categories of practice-oriented tasks of higher mathematics (continued).

<table>
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<tr>
<th>Intradisciplinary Integration (integration of elements of mathematical apparatus)</th>
<th>Interdisciplinary integration</th>
<th>Typical practice-oriented tasks</th>
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<tbody>
<tr>
<td>Practice-oriented tasks categories</td>
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<tr>
<td>Practice-oriented tasks using complex numbers using linear programming</td>
<td>Straight line on a plane, functions of one and several variables, gradient of a function, basics of linear programming, graphical method for solving linear programming problems, simplex method, ideas for finding support and optimal plans for solving transport problems add-in &quot;Search for a solution&quot; MS Excel in optimization problems</td>
<td>Higher mathematics Information Technology Fundamentals of Economics Fundamentals of management activities Tactics of the use of forces and means of the RSChS and GO</td>
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<tr>
<td>Practice-oriented tasks using differentiation</td>
<td>Elements of analytical geometry, functions of one and several variables, differentiation operators MathCad functions in differentiation</td>
<td>Higher mathematics Information Technology Physics Applied mechanics Hydraulics Fundamentals of heat engineering Theoretical foundations of combustion and extinguishing processes</td>
</tr>
<tr>
<td>Practice-oriented tasks using differential equations</td>
<td>Functions of one and several variables, line in the plane, ordinary differential equations (ODEs), partial differential equations of MathCad functions in solving ODEs and partial differential equations</td>
<td>Higher mathematics Information Technology Physics applied mechanics Hydraulics Fundamentals of heat engineering Theoretical foundations of combustion and extinguishing processes</td>
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For a more visual representation of intra- and interdisciplinary integration, let us consider a fragment of educational and methodological materials used to conduct laboratory work on the topic "Complex Numbers". Within the framework of this laboratory work, a complex of POZ is solved, one of which is the task of calculating linear alternating current circuits.

A fragment of teaching materials for laboratory work on the topic "Complex Numbers" looks like the following.

There are several applications of complex numbers in science and technology, in particular in the theory of alternating current circuits, in vector analysis in mechanics, in aero- and hydrodynamics.

Since the end of the 19th century, complex numbers have been widely used in calculations of alternating (sinusoidal) current circuits. By that time, there were already convenient and simple methods for calculating DC circuits, based on Ohm's laws and Kirchhoff's rules. However, nothing similar was known for AC circuits. In 1893, the American electrical engineer Ch.P. Steinmetz proposed and developed in detail a method for solving problems for the calculation of alternating current circuits. This method is based on the use of complex numbers and is called the method of complex amplitudes or the symbolic method. The method of complex amplitudes greatly simplifies the calculation of AC (sinusoidal) current circuits, eliminating the need to solve complex differential equations.

Sinusoidal current is a current that varies in time according to a sinusoidal law:

\[ I = I_m \sin(\omega t + \phi), \]

where \( I_m \) – the maximum value of the current, called the amplitude;
\( \omega \) – cyclic (angular) frequency,
\( \omega = 2\pi f \) (\( f \) – AC frequency, Hz);

in Russia, the frequency of alternating current in the power network (industrial frequency) is 50 Hz;
\( \phi \) – initial phase.

In linear circuits of alternating (sinusoidal) current, active, reactive and impedance are distinguished. Inductance and capacitance in an AC circuit have a reactance, which is written in complex form as an imaginary part (Im), a resistor has an active resistance, which is written as a real part (Re).

In accordance with the method of complex amplitudes, a coil having an inductance \( L \) has an inductive complex resistance:
\[ R_L = i \omega L. \]

A capacitor with capacitance \( C \) has a capacitive complex resistance:
\[ R_C = -i \frac{1}{\omega C}. \]

The resistor has an active resistance \( R \), expressed as a real number.

The complex resistance of an alternating (sinusoidal) current circuit is calculated by the formula:
\[ Z = R + R_L + R_C = R + i \omega L - i \frac{1}{\omega C}. \]

Полное сопротивление цепи переменного (синусоидального) тока рассчитывается по формуле:
\[ |Z| = |R + R_L + R_C| = \sqrt{R^2 + \left( \omega L - \frac{1}{\omega C} \right)^2}. \]

Practice-oriented task: In an alternating current circuit with a frequency \( f = 50 \text{ Hz} \), a resistor with a resistance \( R = 20 \text{ Ohm} \), an inductor \( L = 0.1275 \text{ H} \) and a capacitance \( C = 0.000127 \text{ F} \) are connected in series (Fig. 3).

Using Mathcad, calculate the complex and impedance of the circuit.

\[ \text{FIGURE 3. Electrical circuit.} \]

The solution of the practice-oriented task is presented in Fig. 4.

Note: When entering the initial data, set the units of measurement of physical quantities (Insert - Unit of measurement), select electrical resistance, inductance, capacitance and frequency as the dimension. In further calculations, Mathcad automatically substitutes the correct units of measurement.

Solution:

\[
\begin{align*}
R &:= 20 \Omega \\
L &:= 0.1275 \text{H} \\
C &:= 0.000127 \text{F} \\
\omega &:= 2\pi f = 314.159 \frac{1}{s} \\
\omega C &:= i \cdot \frac{1}{\omega C} = -25.064i \Omega \\
|Z| &:= 24.995 \Omega
\end{align*}
\]

\[ \text{FIGURE 4. Listing of the practice-oriented task solution.} \]
DISCUSSION

The practice-oriented task considered is one of the many examples of using the Mathcad package for an integrated approach to solving PEP in the educational process of students in the direction of training "Technospheric safety".

Based on the general theory of integrative learning, as well as the experience gained in the course of conducting integrative classes at the Department of Higher Mathematics and System Modeling of Complex Processes of St. Petersburg University of the State Fire Service of the Ministry of Emergency Situations of Russia, the methods of managing mathematics teaching in educational institutions of the Ministry of Emergency Situations of Russia are being improved.

Thus, the development of new methodological approaches in the process of teaching mathematical disciplines using innovative methods in the context of the development of a digital educational environment is an urgent task in the field of higher education.

CONCLUSION

The development of computer practice-oriented task with the use of innovative methods will be one of the directions for improving the mathematical training of specialists of the Ministry of Emergency Situations of Russia. Practice-oriented tasks will allow students to more quickly accumulate fundamental mathematical knowledge needed in the future to study situational processes and phenomena in the field of technosphere safety.

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