PECULIARITIES OF ORGANIZING THE PROCESS OF TEACHING MATHEMATICAL ANALYSIS IN HIGHER EDUCATIONAL INSTITUTIONS

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Abstract: This article discusses the methods that can be used in teaching the "mathematical analysis" course, and solutions to possible difficulties.

Keywords: method, information and communication technologies, innovative technologies, mathematical analysis, higher education.

INTRODUCTION

Among the disciplines of mathematical profiles, the discipline "Mathematical Analysis" is one of the main ones and contains quite a lot of sections. As practice shows, when studying it, students encounter many difficulties, which, as a rule, are associated with the level of school preparation. Therefore, it is necessary to improve the classical approach in teaching the discipline, in particular, through the use of modern innovative and information and communication technologies.

The study of mathematical analysis begins in the first year and includes quite large sections: the theory of numerical sets, the axiomatics of the theory of real numbers, the theory of numerical sequences, the theory of functions of one variable (differentiation and integration). It is worth noting that all the listed sections can be considered basic for the entire course of mathematical analysis: the main concepts of the subsequent sections are formulated precisely on the basis of those studied in the first course. Let us consider in more detail what difficulties students have in the process of studying the discipline in the first year.

MATERIALS AND METHODS

Already at the very beginning, students are faced with the problem of formulating previously known rules for working with numbers and writing these rules using mathematical symbols. In order to quickly adapt them to this process, it is advisable to start by repeating the basic symbols and the rules for making statements with their help. At the same time, for work it is worth choosing small expressions and breaking each of them into so-called logical blocks. As practice shows, the ability to highlight the key fragments in the required statement allows students to formulate it correctly. Inverse tasks are also effective exercises: to be able to "voice out" a symbolic notation of a statement, as well as to compose a negation to a statement in the form of a verbal formulation and a symbolic notation. And it is precisely when working with composing a negation that one can assess the degree of mastery of working with formulations: incorrect division into blocks or the use of symbols and quantifiers immediately leads to a different result. Training tasks can be performed both in the classroom at the blackboard, and in groups of several people.

RESULTS AND DISCUSSION

Having mastered the necessary skills of working with formulations, students proceed to study the theory of number sets and the axiomatics of the set of real numbers. They learn to write down the definitions of various types of numbers, operations on them and their properties, familiar from school, with the help of already mastered mathematical symbols. But at the same time, attention should be paid to stricter formulations with clearly pronounced conditions. For example, having studied operations on numerical sets, one can further classify the types of numbers and their relationships. "Having worked out" the basic operations and properties of rational numbers, formulate the properties of real numbers. By demonstrating similar elements at each stage, it is possible to form the general principles of number theory among students, which turns out to be very useful when studying the next section.

Theory of number sequences. This section can be considered quite advantageous in terms of the use of visualizations: each concept, each definition has a geometric illustration. The visual projection of already learned statements of the theory of sets onto the theory of sequences makes it quite easy to overcome the main difficulties of the concepts of sequences. By using the wording of the number sequence as an ordered number set, all set statements become "actual" in the new theory, even the geometric representation on the number line. The only difference is that in the formulations for sets the key is the element of the set, and for sequences it is the same element (sequence member), but determined by its ordinal number. As soon as the student learns this difference, there is no need to memorize new formulations - the general "scheme" of concepts has already been mastered. For example, the concept of a bounded (from above and below) set (in symbolic notation):

$$X\text{-}limited \Leftrightarrow \exists C \in R : \forall x \in X \rightarrow |x| \leq C$$

Let's write down the definition of a limited numerical sequence:

$$x_{n_{n=1}}^{\infty}\text{-}limited \Leftrightarrow \exists C \in R : \forall n \in N \rightarrow |x_n| \leq C$$

Please note that the structure of the definition is the same, with the only difference being the main element - an element of a set or a member of a sequence (ie, the ordinal number of the corresponding member of the sequence). The definitions of a sequence bounded from above (from below), unbounded (from above, from below), exact faces of a sequence, its minimum and maximum are formulated in a similar way.

Taking into account the alternative definition of a numerical sequence, namely, as a numerical function defined on the set of natural numbers (the key concept is "function"), we formulate such a characteristic of the sequence as monotonicity. In this case, the illustration of the numerical sequence is convenient already on the numerical plane in the form of a discrete graph. Let's take an example.

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As practice shows, it makes no sense to write down all the formulations of various limits at once. It is enough to analyze in detail the basic definition of the final limit at a point, and with a graphic illustration, and then, changing using any graphic editor on the interactive board, consider the variety of situations. For training and consolidation, you can offer exercises with different sequences of actions:

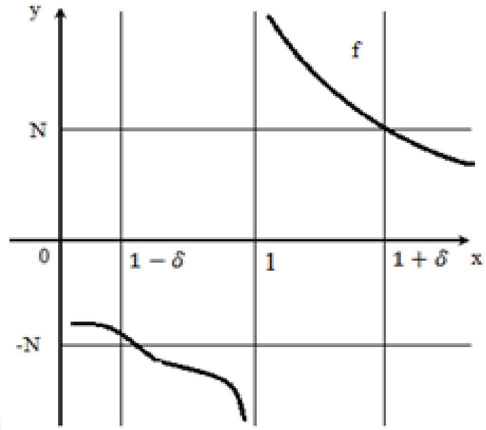
− using the notation of the definition, make a compact notation of the corresponding limit;

- according to the definition record, select the appropriate function graph;
- by recording the definition, construct a graph of the corresponding function;
- according to the presented graph of the function, write down all possible limits that characterize the function.

$$a)\ \lim_{x\to 2-0} f(x) = +\infty,\quad \lim_{x\to 2+0} f(x) = 0\,,\ \ f(2) = 0\,;$$

$b)\ \lim_{x\to+0} f(x) = \lim_{x\to-0} f(x) = 1,\ f(0)$ does not exist;

c) $a)\ \lim_{x\to 2-0} f(x) = 0,\ \ \lim_{x\to 2+0} f(x) = -\infty,\ \ f(-2) = 2$



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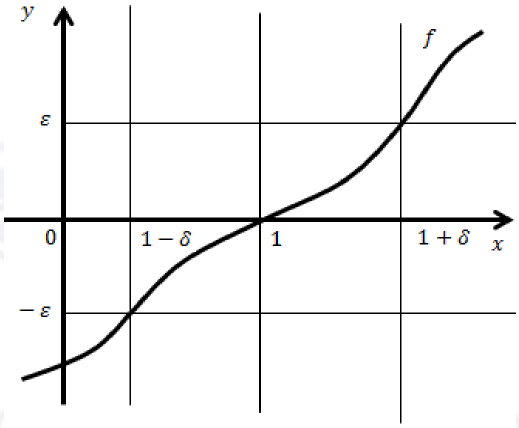

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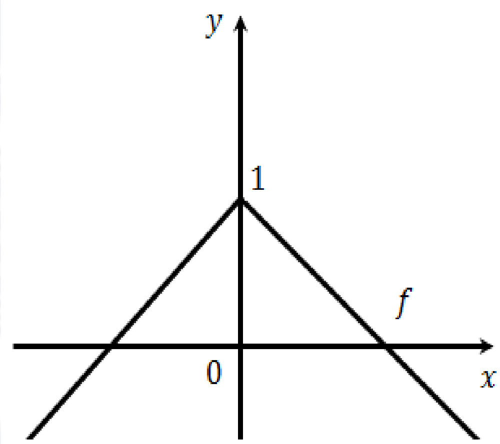

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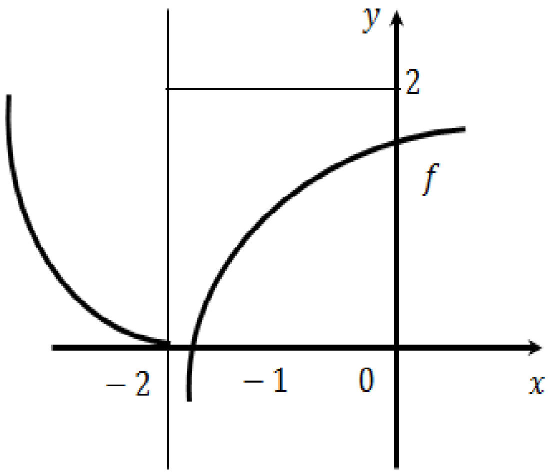

b)

Such exercises can be used for classroom and independent work, for group work of students with self-examination. In addition, such skills of “reading” graphs make it possible to easily build graphs of various complex functions and solve applied problems in the future.

When studying the subsequent sections of the first course (continuity, differentiation and integration of functions), you should definitely pay attention to the use of the concept of limit in each main definition: on the one hand, this reinforces the understanding of the limit as a fundamental concept of mathematical analysis, and on the other hand, makes it easier to learn new concepts (in some cases, taking into account the geometric interpretation of the limit). Checking functions for continuity, deriving derivatives of functions - these tasks are based on previously mastered methods for calculating limits and most often no longer cause difficulties. The construction of graphs of functions using the knowledge of graphs of elementary functions, the main characteristics of functions and the theory of limits is also mastered much better with the above skills.

The study of the topic “Integration of functions of one variable” in terms of the amount of theoretical material, as a rule, does not cause problems for students. Much more difficulties are associated with the formation of skills to solve practical problems, i.e., first of all, to find indefinite integrals. In this case, training tasks of different directions and different levels of complexity can serve as ICT tools. For example, at the first stage, you can offer tasks to check the table of integrals; then - on the simplest transformations and reductions to tabular formulas: insert the missing value, check the coefficient, compare with the tabular formula, etc. Some methods can be “worked out” by algorithms, for example, the method of integration by parts and the integration of fractional rational functions. Regularly, after studying each method, you can offer small works (3-5 examples) comparing the integral and the method.

CONCLUSION

All the material of the discipline "Mathematical Analysis" is necessary when studying subsequent disciplines and sections of higher mathematics (differential equations, partial differential equations, probability theory, etc.) [5]. Therefore, starting from the first topics, it is important to draw students' attention to the practical significance of the concepts being studied [4]. It should be noted that building a connected “chain” of topics under study helps students in their further study of teaching methods [1] and, in particular, in determining the direction of their qualifying work.

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