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WAYS TO IDENTIFY THE COMPLEXITY OF LOGARITHMIC EQUATIONS

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Annotation: The purpose of this article is to reveal the content of General methods for solving logarithmic equations studied in high school of the 11th grade.
Key words: set, inequality, equation, logarithm, solution

Understanding the task as some system, they mean the following. A task as a system is a nonempty set of elements on which a given relation is defined (implemented) in advance. This relationship serves as the primary relationship. Indeed, a school mathematical problem contains a certain number of relations, for example, in textual algebraic problems this is the relation between data itself, between sought itself, between data and the sought, between the condition and the requirement of the task and, i.e. In that set of relations based on generalization, one can always single out the main, leading relation, which is usually called the main one. The main relation in the general case expresses the functional relationship between the values included in the condition and requirement of the task, and is implemented on the subject area of the problem. Under the subject area of the problem is understood the class of fixed objects (objects) that are discussed in the problem. For equations, inequalities and their systems, the subject area consists of the area of change of the variable and the numbers included in their structure. For example, for inequality $\lg^2 x - 5\lg x + 6 = 0$ subject area consists of many real numbers $x > 0$ and number 6.

The task as a complicated object has not only an external structure (information structure) but also an internal structure (internal structure). The information structure is the data sought and the relationship between them, as well as the basis (theoretical basis) of the solution and the way to solve the problem. It determines the degree of problem - one of the main components of difficulty.

The difficulty of the task is a psychological and didactic category and is a combination of many subjective factors depending on the personality characteristics, such as the degree of novelty, the student's intellectual abilities, their needs and interests, experience in solving the problem, level of knowledge of intellectual and practical skills, etc.

However, the main components of the task difficulty are the degree of problem and the task complexity.

The complexity of the task is an objective characteristic independent of the subject, it is determined by the number of elements, relationships and types of relationships that form the internal structure of the task. Elements are such minimal components of a problem (system) on which the main relation is realized.

The internal structure of the problem determines the strategy (approximate basis of the method) of solving the problem and its complexity.

The external and internal structure of the problem are interconnected, since the solution strategy is associated with the basis and method of solving the problem.

The external (informational) structure of the task is relatively easily established in the process of analyzing the text of the task, however, its internal structure is not detected.

To answer the question of what is the mechanism for revealing the internal structure of the problem, let us turn to the analytical-synthetic search for the solution of logarithmic equations.

The simplest logarithmic equations and inequalities are as follows:

$\log_a x \geq b,\ a \geq 0,\ a \neq 1,\ b \in R,\ x$ -variable,

$x > 0$ $\log_x m \geq n,\ x > 0,\ x \neq 1,\ n \in R,\ m > 0;$ $\log_a x \geq \log_a c,\ a > 0,\ a \neq 1,\ x > 0,\ c > 0;$

$A_0 \lg^2 x + A_1 \lg x + A_2 \geq 0,$ Where A_0, A_1, A_2 numerical coefficients.

The experience in teaching algebra shows that students do not always successfully cope with the task of "solving the logarithmic equation." There may be various reasons, but the main ones are the students' poor skills in performing transformations with logarithmic expressions.

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Analysis of the logarithmic equations allows us to formulate the following mechanisms for implementing the system approach in the study of these problems, namely:

- a mechanism for identifying the internal structure of the task;
- a mechanism for the analytical search for a solution to a problem;

Let us consider the mechanism of revealing the internal structure of the problem for various types of logarithmic equations.

The task. For the following logarithmic equations, search for a solution to the equation, determining for each its complexity.

Example 1

$$\frac{1}{\lg x+1}+\frac{6}{\lg x+5}=1$$

We have:

$$\frac{\lg x+5}{(\lg x+1)(\lg x+5)}+\frac{6(\lg x+1)}{(\lg x+1)(\lg x+5)}=\frac{(\lg x+1)(\lg x+5)}{(\lg x+1)(\lg x+5)} \quad (1)$$

$$\lg x+5+6(\lg x+1)=(\lg x+1)(\lg x+5), \quad (2)$$

$$\lg x+5+6\lg x+6=\lg^2 x+\lg x+5\lg x+5, \quad (3)$$

$$\lg x+5+6\lg x+6-\lg^2 x-\lg x-5\lg x-5=0, \quad (4)$$

$$-\lg^2 x+\lg x+6=0, \quad (5)$$

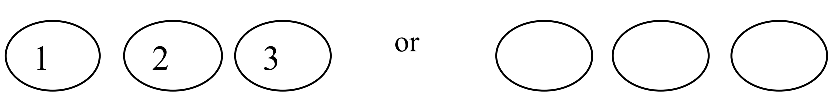
$$\lg^2 x-\lg x-6=0, \quad (6)$$

The analytical-synthetic search for a solution to this equation contains six steps. The goal, for example, of the first action is to bring this fractional equation to a common denominator, etc. After completing the sixth action, we obtain a quadratic equation, which we can solve. It allows you to get a solution to the original equation. Therefore, the goal of the sixth step is to obtain an equation that is algorithmically decidable. Finding a solution to this equation allows you to establish the following:

- actions 1,3 and 5 are identical transformations;
- actions 2,4 and 6 - equivalent transformations;

Therefore, this equation as a system has the structure shown in

Figure 1



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Knowing the structure of the equation, one can determine its complexity as an objective characteristic independent of the opinion of the subject. The complexity of this equation is equal to: $S = 3+0+1+4,$ where $m=3,\ n=0,\ 1=1$

Example 2

$$\log_x 2 - \log_4 x + \frac{7}{6} = 1$$

We have:

$$\frac{\log_2 2}{\log_2 2} - \frac{\log_2 x}{\log_2 4} + \frac{7}{6} = 0, \qquad (1)$$

$$\frac{1}{\log_2 2} - \frac{\log_2 x}{2} + \frac{7}{6} = 0, \qquad (2)$$

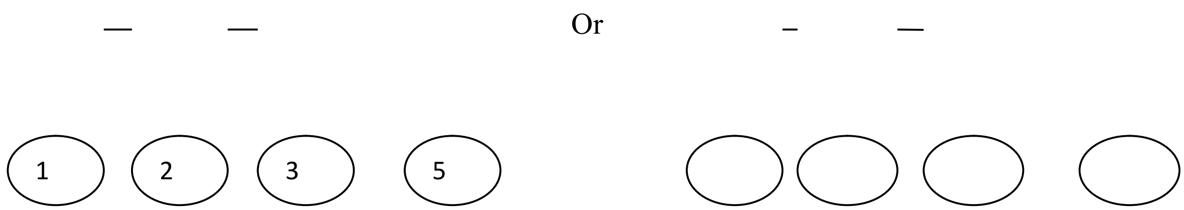
$$\frac{6}{\log_2 2} - \frac{3\log_2 x \cdot \log_2 x}{6\log_2 x} + \frac{7\log_2 x}{6\log_2 x} = 0 \qquad (3)$$

$$6 - 3\log_2 x \cdot \log_2 x + 7\log_2 x = 0, \qquad (4)$$

$$-3\log_2^2 x + 7\log_2 x + 6 = 0, \qquad (5)$$

$$3\log_2^2 x - 7\log_2 x - 6 = 0. \qquad (6)$$

The search for a solution to the equation is completed, because an algorithmically solvable quadratic equation is obtained. Actions 1,2,3 and 5 are identical, actions 4 and 6 are equivalent transformations, therefore, its structure will look like: Figure 2.



The complexity of this equation is equal to: $S = 4+2+2 = 8,$ where $m=4,\ n=2,\ 1=2$

To obtain unambiguous results in identifying the minimum complexity of the internal structure of logarithmic equations, we use the following analytical-synthetic search technique:

1) if necessary, then in all terms of the equation go to a common basis;

2) if necessary, then prologarithm both parts of the equation for a given base of the logarithm;

3) if necessary, then in the equation, using the properties of the logarithms, perform the corresponding identical transformations;

4) if among the terms of the equation there are logarithms of numbers, then perform the corresponding calculations;

5) if all or some members of the equation are written in the form of a fraction, then bring the fraction to the lowest common denominator;

6) if necessary, open the brackets taking into account the signs of actions in front of them;

7) in the resulting equation with integer coefficients, further transformations can be performed in different ways, but in accordance with the instructions given to the original equation;

✓ either, if possible, transfer the terms of the equation containing the unknown to one side (for example, to the left), but not containing the unknown to the other side of the equation (for example, to the right);

✓ either, if possible, bring such terms separately on the left and separately on the right side of the equation;

8) in the resulting equation, further transformations must be performed in the following sequence:

a) if the previous action was action 7a, then in each part of the equation give similar terms (terms);

b) if the previous action was action 7b, then transfer the members of the equation containing the unknowns to one part, and not containing the unknown to the other;

9) complete the transformation, having obtained the simplest equation of the form:

$\log_a x \geq b,\ \log_a x \geq \log_a c;\ \log_x m \geq n;\ A_0 \lg^2 x + A_1 \lg x + A_2 \geq 0,$ or reduced to view:

$ax + b \geq 0,\ ax(ax + b) \geq 0;\ ax^2 + bx + c \geq 0$ and others.

So, we have revealed the content of generalized methods for finding solutions to the logarithmic equations studied in the 11th grade of high school.

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