THE USE OF MODERN INFORMATION TECHNOLOGY IN SOLVING NON-STANDARD PROBLEMS

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ABSTRACT

The article examines the relevance of using mathematical packages in the educational process. Universal mathematical packages provide new broad opportunities for to improving education fully, without exception, its stages. Also noted are the problems associated with the use of mathematical packages and ways to solve these problems. As an example, we consider solving non-standard equations by a graphical method using the Maple program.

Keywords: Mathematical packages, information technologies, Maple, non-standard problems, computer mathematics system.

INTRODUCTION, LITERATURE RELVIEW AND DISCUSSION

Currently, information education is a necessary component of specialist training in almost any field. Therefore, the introduction of information technologies into pedagogical practice, in particular, packages of applied mathematical programs, will increase the efficiency of the educational process and, in the future, improve the quality of training of graduates. [1] The rapid development of computer technology, the emergence of a number of mathematical packages dictate changes in the construction and study of mathematics courses both in schools and universities. The problem is especially acute in higher education: the limited number of teaching hours, on the one hand, and the growing flow of information, on the other hand, lead not only to an unreasonable reduction in the mathematics course in universities, but also to a lack of skills in working with mathematical packages, which, to Unfortunately, it affects the professional training of future specialists and scientists to work at a modern level. The use of mathematical packages would complement the study of a number of disciplines and reduce the time spent on coursework and diploma projects. [2] With their help, students could check the results of solving problems performed manually. The graphics developed in these packages allow you to visualize the results of solving problems. In addition, these packages can be successfully used not only in mathematics, but also in physics, theoretical mechanics and other disciplines. If in their professional activities university graduates will use mathematical methods, then this use in most cases involves the use of special mathematical packages. Therefore, a university graduate should have at least an elementary understanding of computer methods for solving mathematical problems and the ability to independently master new software products for use in professional activities.

In this regard, there is a need to apply information technology for these purposes already in the university course of higher mathematics. In modern conditions, in our opinion, “the teacher's task is not so much to teach how to calculate the determinant, limit, derivative, integral, etc., but to give definitions of the determinant, limit, derivative, integral and to teach students to calculate them in the simplest cases in order to more students could solve complex (computational) problems in software packages Maple, MathCad, MatLab, Wolfram ". [3] New curricula in math disciplines must take into account the use of math packages. Yes, and in term projects and theses, you should also use these packages. Of course, there are a number of problems with using math packages.

First, the licensed versions of the packages are quite expensive and not all students can purchase them to work at home, although this problem can be solved if you work with them at a university.

Secondly, the introduction of these packages is associated with the study of the rules of work in the package, the study of the interface. In the computer science course, these packages are not studied, and in other disciplines, time is not allocated for these works. Another serious, but completely surmountable obstacle to the use of packages is the lack of computers in the audience.

Thirdly, the lack of proper qualifications among teachers, although this problem can be solved by organizing courses at the faculty of advanced training. Another problem in the use of mathematical packages in teaching mathematics is their insufficient methodological support. Recently, many books have appeared describing the functionality of packages with examples from various fields of knowledge. But there are very few books that can be used as educational and methodological literature for individual courses and disciplines in the process of studying at the university. [4]

As an illustration, consider the Maple software package. Although, of course, you can use other math packages. Maple is the very first symbolic mathematics package. Currently, it is the leader among universal symbolic computing systems and is especially popular in the scientific community and provides opportunities for mathematical research at any level. Below we will look at a few examples using the Maple software package, which will make it much easier for students to master this material.
Consider a nonlinear equation:
f(x)=0 on the segment [a;b] where f(a)<0 and f(b)>0
then by the Bolzano-Cauchy theorem (or rather, from the corollary of the theorem) the function f (x) has at least one point x0 on the interval [a; b], where f (x0) = 0 This equation can be solved by approximate methods such as the "iteration method" , "Newton's method", "half-division method".
Consider one of the methods, the "half division method"
Methodology for solving the problem
Step 1. Find the initial uncertainty interval $L_0 = [a_0, b_0]$ one of the methods for separating roots is to set a small positive number ε . Put $k = 0$
Step 2. Find the middle of the current uncertainty interval:

$$c_k = \frac{a_k + b_k}{2}.$$

Step 3. If $f(a_k) \cdot f(c_k) < 0$ then put $a_{k+1} = a_k$, $b_{k+1} = c_k$ if $f(c_k) \cdot f(b_k) < 0$ to accept $a_{k+1} = c_k$, $b_{k+1} = b_k$. As a result, the current Uncertainty interval $L_{k+1} = [a_{k+1}, b_{k+1}]$.
Step 4. If $b_{k+1} - a_{k+1} \le \varepsilon$, then terminate the process $x_* \in L_{k+1} = [a_{k+1}, b_{k+1}]$

The approximate value of the root can be found by the formula $x_* \cong \frac{a_{k+1} + b_{k+1}}{2}$

If $b_{k+1} - a_{k+1} > \varepsilon$ put $k = k + 1$ and go to step 2.

Example # 1 Find the root of an equation by the method of half division accurate to ε =0,001 и ε =0,0005

I. Result of separating the root of the equation $x_* \in [-2; -1]$, therefore $a_0 = -2$, $b_0 = -1$.

II. The function is continuous on a segment $[-2; -1]$ and has a single simple root. At the ends of the segment, the function has values $f(-2) = -5$, $f(-1) = 1$, opposite in sign. By the Bolzano-Cauchy theorem (or rather, from the corollary of the theorem), the function f (x) has at least one point x0, where f (x0) = 0. Then, using the half-division method, we can approximately calculate x0. The calculation results are shown in the table below.

k	$f(a_k)$	a_k	b_k	$f(b_k)$	$c_k = \frac{a_k + b_k}{2}$	$f(c_k)$	$b_k - a_k$
0	-5	-2	-1	1	-1,5	-0,875	1
1	-0,875	-1,5	-1	1	-1,25	0,2965	0,5
2	-0,875	-1,5	-1,25	0,2965	-1,375	-0,224	0,25
3	-0,224	-1,375	-1,25	0,2965	-1,3125	0,05	0,125
4	-0,224	-1,375	-1,3125	0,05	-1,34375	-0,08	0,0625
5	-0,08	-1,34375	-1,3125	0,05	-1,3282	-0,015	0,03125
6	-0,015	-1,3282	-1,3125	0,05	-1,3204	0,018	0,0156
7	-0,015	-1,3282	-1,3204	0,018	-1,3243	0,0018	0,00781
8	-0,015	-1,3282	-1,3243	0,0018	-1,3263	-0,007	0,0039
9	-0,007	-1,3263	-1,3243	0,0018	-1,3253	-0,0025	0,002
10	-0,0025	-1,3253	-1,3243	0,0018	-1,3248	-0,0003	0,001
11	-0,0003	-1,3248	-1,3243	0,0018	-	-	0,0005

If ε =0,001 root $x_* \in [-1{,}3282; -1{,}3204]$ if $\varepsilon_2 = 0{,}0005$ root $x_* \in [-1{,}3248; -1{,}3243]$

or $x_* \cong \frac{-1{,}3282 - 1{,}3204}{2} = -1{,}3243$ at 0,001 ;

$$x_* \cong \frac{-1{,}3248 - 1{,}3243}{2} = -1{,}3245 \quad \text{at} \quad \varepsilon_2 = 0{,}0005.$$

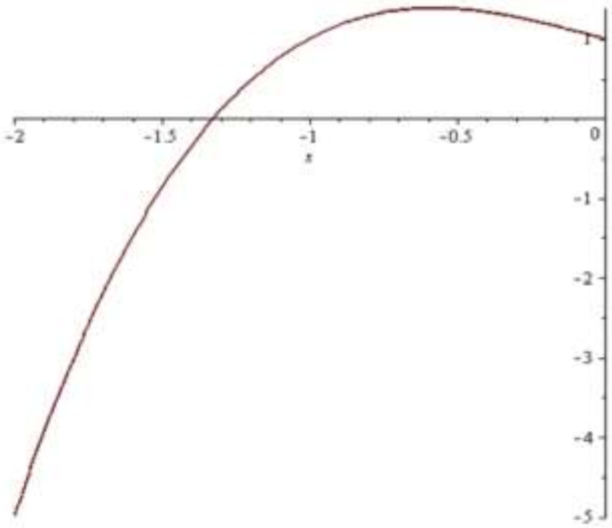
Of course, this process will be quite laborious and here we may run into some problems:
First, finding the segment where the point x0 is contained is enough difficult question, which does not have a specific rule
Secondly, it is also not easy to immediately determine how many valid solutions this or that equation has.

This equation can be solved graphically using the Maple program, which will greatly facilitate the task. $> y := x^3 - x + 1;$

$$y := x^3 - x + 1$$

$plot(y, x=-2\,...0)$

Pic.1



From the graph of the function, it can be determined that an approximate solution to the equation
X0 = -1.325 (Picture 1)

You can check this by waving the Maple program:

$> y := x^3 - x + 1$

$$y := x^3 - x + 1$$

$> solve(y, x)$

$$-\frac{1}{6}\left(108+12\sqrt{69}\right)^{1/3} - \frac{2}{\left(108+12\sqrt{69}\right)^{1/3}}, \frac{1}{12}\left(108+12\sqrt{69}\right)^{1/3} + \frac{1}{\left(108+12\sqrt{69}\right)^{1/3}} + \frac{1}{2} I\sqrt{3}\left(-\frac{1}{6}\left(108+12\sqrt{69}\right)^{1/3} + \frac{2}{\left(108+12\sqrt{69}\right)^{1/3}}\right), \frac{1}{12}\left(108+12\sqrt{69}\right)^{1/3} + \frac{1}{\left(108+12\sqrt{69}\right)^{1/3}} - \frac{1}{2} I\sqrt{3}\left(-\frac{1}{6}\left(108+12\sqrt{69}\right)^{1/3} + \frac{2}{\left(108+12\sqrt{69}\right)^{1/3}}\right)$$

$> evalf(\%,);$

$-1.324717958, 0.6623589786 - 0.5622795125\, I, 0.6623589786 + 0.5622795125\, I$

Or

$> fsolve(y, x);$

$$-1.324717957$$

> $x := -1.324717957$

$$x := -1.324717957$$

> $y := x^3 - x + 1$

$$y := 5.\ 10^{-10}$$

Of course, this equation can be solved by an analytical method - the Cardano method,
This method also requires quite a long calculation, which makes solving the equation quite difficult. In my opinion, the graphical method is the most optimal and fastest, although knowledge of other methods is also very important.

Example 2

Consider f (x): sin (x/4) + x-1 = 0 on the segment [-π;π] this equation is non-standard and cannot be solved analytically.

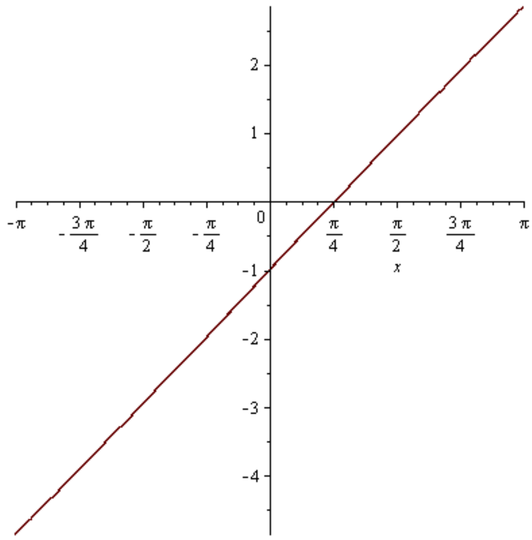
But by the cleavage f (-π) <0 and f (π)>0 then by the Bolzano-Cauchy theorem (or rather, from the corollary of the theorem) the function f (x) has at least one point x0 on the interval [-π;π] where f (x0) = 0 This equation can solve by approximate methods. We will use the graphical method by waving the Maple program

> $g := \sin\left(\frac{x}{4}\right) + x - 1;$

$$g := \sin\left(\frac{1}{4}x\right) + x - 1$$

> $plot(g, x = -\mathrm{Pi}\,...\mathrm{Pi});$

Pic 2.



The graph shows that the root of the equation is x0=π⁄4 (Picture 2)

This equation can be viewed as a collection of two functions
sin(x/4)=1- x , or sin(x/4) and 1-x can be viewed as two different functions.

> $m := \sin\left(\frac{x}{4}\right):$

> $plot([m, 1 - x], x = -\mathrm{Pi}\,...\mathrm{Pi}, color = [red, blue])$

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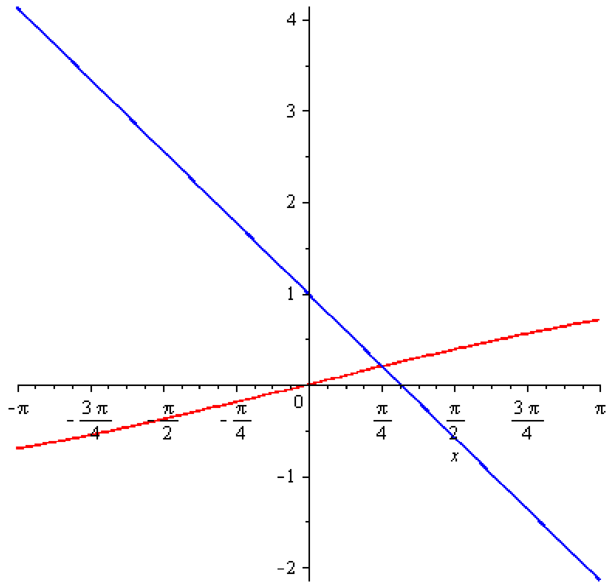
Pic 3



The intersection point of these functions x0=π/4 is a solution to the equation (Picture 3)
Example 3

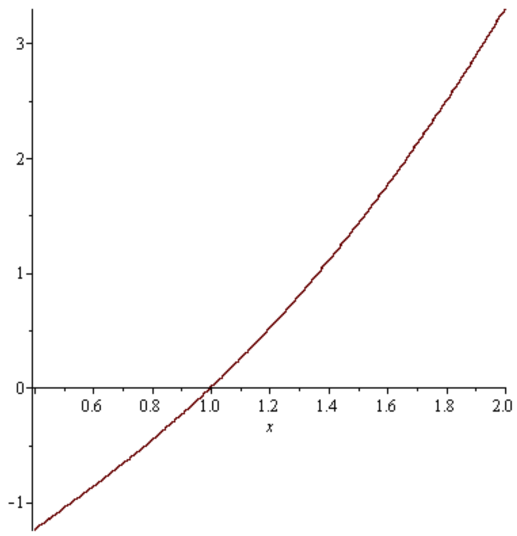
Consider the equation y (x): $\log_{10} x + x^2 - 1 = 0$ on the segment [0.5; 2]
For y(0.5) <0 y(2)> 0 then, by the Bolzano-Cauchy theorem, the function y (x) has a point x0 on the interval [0.5; 2] where y (x0) = 0

> $y := \log_{10}(x) + x^2 - 1;$

$$y := \frac{\ln(x)}{\ln(10)} + x^2 - 1$$

> $plot(y, x = 2 ...4);$

Pic 4



From the graph of the function, you can determine that the root of the equation is x0 = 1 (Picture 4) really:

> $x := 1$

$$x := 1$$

> $z := \log_{10}(x) + x^2 - 1;$

$$z := 0$$

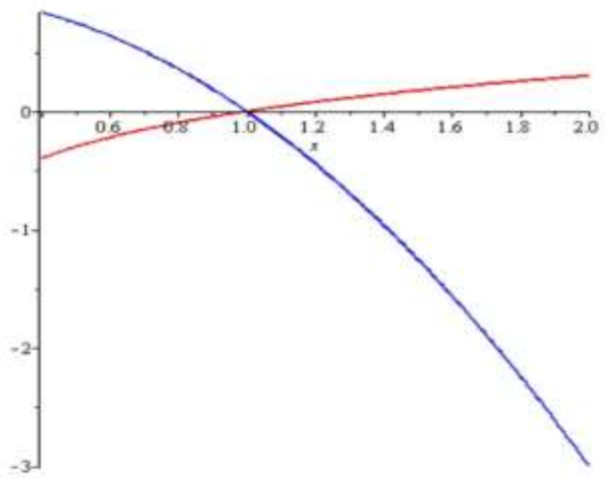
This equation can be considered as a set of two functions $\log_{10}$ x=1-x^2 или or considered $\log_{10}$ x and 1-x^2 as two different functions.

> $f := \log_{10}(x)$

$$f := \frac{\ln(x)}{\ln(10)}$$

> $plot([f, 1 - x^2], x = 2 ...4, color = [red, blue]);$

Pic 5.



From here, you can define the root of the equation as the intersection of two functions at the point x0 = 1 (Picture 5)
Example 4

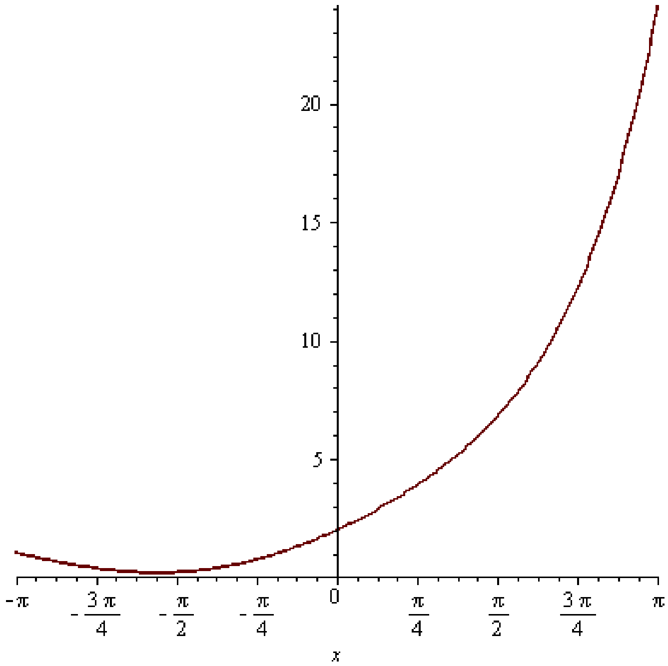
Let the equation k (x): e^x+sin x+1=0 be given on the segment $[-\pi;\pi]$ check the value of the function on the boundary of the segment к$(-\pi) > 0$ and k$(\pi) > 0$ then we cannot determine whether this equation has real roots on this segment. We cannot solve this equation by the analytical method Approximate methods will not give a result either. Let's use the graphical method. This question can be easily solved with the help of the Maple program.

> $k := e^x + \sin(x) + 1;$

$$k := e^x + \sin(x) + 1$$

> $plot(k, x = -\mathrm{Pi}\,..\,\mathrm{Pi});$

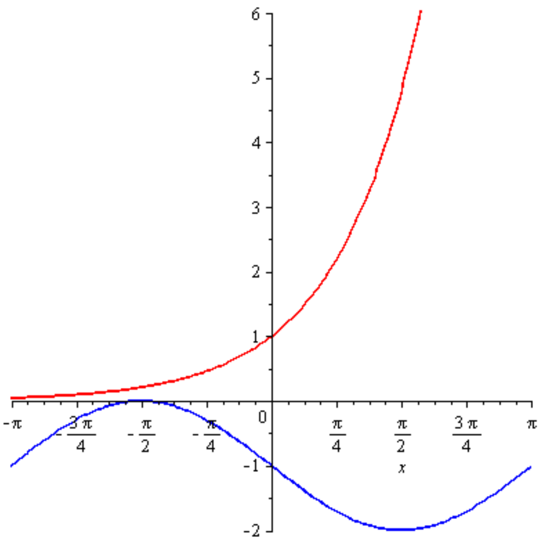
Pic 6



It can be seen from the graph of the function that this equation has no real roots on the segment $[-\pi; \pi]$ (Picture 6). Or, this equation can be considered as a combination of two functions. e^x and -sin x-1 Then the graphs of these functions are as follows:

> $l := e^x$:
> $plot([l, -1 - \sin(x)], x = -Pi...Pi, color = [red, blue]);$

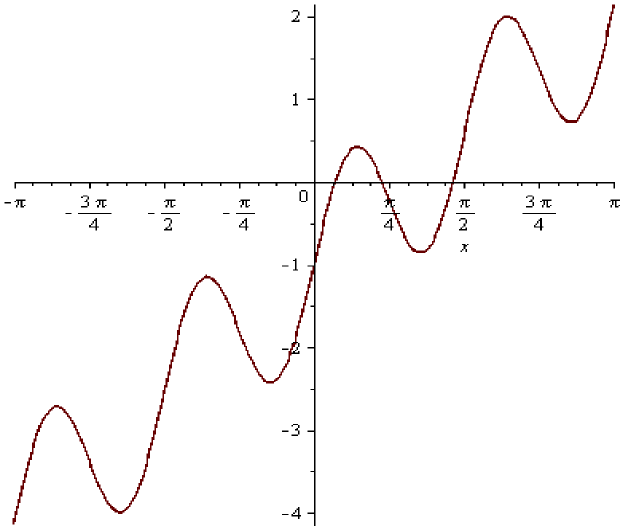
Pic 7



From this graph of the function, it is possible to determine that this equation has no real roots on the segment $[-\pi; \pi]$, the graphs of these functions do not intersect by the chip. (Picture 7)
Example 5
Let the equation f (x)sin=(4x) + x-1 = 0 on the segment . $[-\pi; \pi]$.
This equation cannot be solved analytically. Let's solve this equation graphically. From the graph of the function, you can determine that this equation has three real roots on this segment. (Picture 8)

> $plot([\sin(4x) + x - 1], x = -Pi...Pi)$

Pic 8



This equation can be considered as a combination of two functions sin (4x) and 1-x.

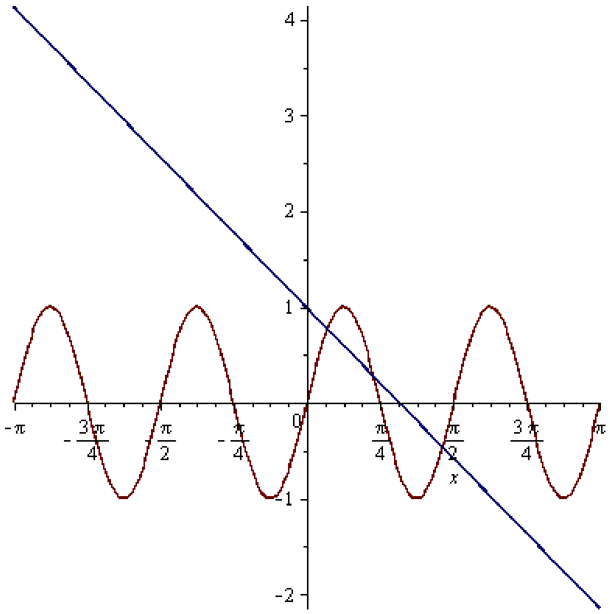
Then the graphs of these functions are as follows:

> $f := \sin(4x)$

$f := \sin(4x)$

> $plot([f, 1 - x], x = -\text{Pi} ... \text{Pi})$

Pic 9



> $fsolve(\sin(4x) + x - 1, x)$

0.2226217702

> $fsolve\left(\sin(4x) + x - 1, x = 0 .. \frac{\text{Pi}}{2}\right)$

0.7124922336

> $fsolve(\sin(4x) + x - 1, x = 0 .. \text{Pi})$

1.453206523

From this graph of the function, it is possible to determine that this equation has three real roots on the segment $[-\pi; \pi]$ along the chip, the graphs of these functions intersect at three points (Picture 9).

This example clearly shows that when you wave the Maple program, you can very easily solve a rather complex problem.

Analysis of the solutions to the proposed problems shows the effectiveness of the use of modern information technologies in the study of mathematics. We examined the use of modern information technologies using the example of the Maple software product. The introduction of this computer system into the process of teaching algebra and the beginnings of mathematical analysis will significantly reduce the time for solving problems with cumbersome calculations and transformations or check the solution of these problems.

The specifics of the functioning of the SCM (computer mathematics system) "Maple" suggests that its use will increase the effectiveness of teaching algebra and the principles of mathematical analysis at the profile level. Moreover, the use of computer systems in the future can contribute to a gradual transition to solving non-standard creative problems and bringing school mathematics closer to university mathematics, and university mathematics - to modern mathematics. However, the substantiation of these statements requires detailed pedagogical research.
The relevance of the topic lies in the fact that the use of the methodological system of teaching students mathematics based on the SCM "Maple" package contributes to the development of cognitive activity of students, the formation of critical and analytical thinking, the development of creativity and the integration of mathematical knowledge. The SCM methodology is focused on the individualization of training and the intensification of the educational process.

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