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Using the Programming Language in C++ in the Numerical Integration of Functions

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Abstract: *Observing the processes of the real world, we first describe them verbally, trying to understand the essence of phenomena, then we build mathematical models. However, we do not want to limit ourselves to building formal models, but we want to get a qualitative and quantitative idea of the processes under study, to see them on graphs.*

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Numerical methods is a fascinating and extremely important area of modern mathematics, associated with computer calculations and solving complex problems. Pure mathematics studies the movement of numbers - arithmetic, the movement of figures - geometry, but how do numbers connect with the real world?

How to move from formulas to the world around us? The answer to this is given by numerical methods, mathematics, combined with the power of a computer, allows you to look deep into the real world, to model the most complex physical, technical and biological processes. Observing the processes of the real world, we first describe them verbally, trying to understand the essence of phenomena, and then we build mathematical models. However, we do not want to limit ourselves to building formal models, but we want to get a qualitative and quantitative idea of the processes under study, to see them on graphs. This is where computers and numerical methods come to the rescue. Imagine, we need to investigate some complex physical or biological process, for example, to understand the laws of blood circulation or the movement of gas in liquids. We can verbally describe these processes, highlight the main patterns, and formulate the basic laws that govern this process. This is a verbal or verbal, logical model. Then we try to express these laws as mathematical equations, like differential or integral equations, but to understand the process we have to go further and solve these equations. What is meant by the word resolve? This is where the magic begins. The computer will allow us to see the same process, but in the form of numbers. This amazing moment requires serious consideration. Most real processes are described by nonlinear equations, which can be replaced by linear ones only in the first approximation. The question arises: how to solve these equations, what is the accuracy of the solution, and here numerical methods come into their own. Only in exceptional cases, mathematical equations describing real processes can be solved explicitly. Sometimes it is said that the existence and uniqueness of a solution has been proved, but where is this solution explicitly, what are its properties, what can we say about the behavior of this process after a certain time and under certain conditions. We need to get this solution explicitly, if this is a molecular process, then up to the behavior of individual molecules. This is precisely the

frontiers of modern natural science. In a certain sense, it is surprising that the strange manipulations of the computer lead to amazing conclusions, allow you to look deep into nature, it is here that the power of computers is manifested, creating a new reality and modeling nature. It is remarkable that there are mathematical principles for finding computer solutions with a given accuracy. Numerical methods in a broad sense can be understood as the interpretation of a mathematical model in a language accessible to a computer. For example, if the mathematical model is presented as a differential equation, then the numerical method can be a difference equation that approximates the original differential equation. In order to use a computer, we must write a program that implements this numerical method. The great thing is that using a computer, we find the properties of the process, which previously could only guess. So, the basis of a computational experiment is the triad: a mathematical model - a method and a solution algorithm - a computer program. Each member of this triad is important, and without it no truly in-depth research can be done.

What is art?

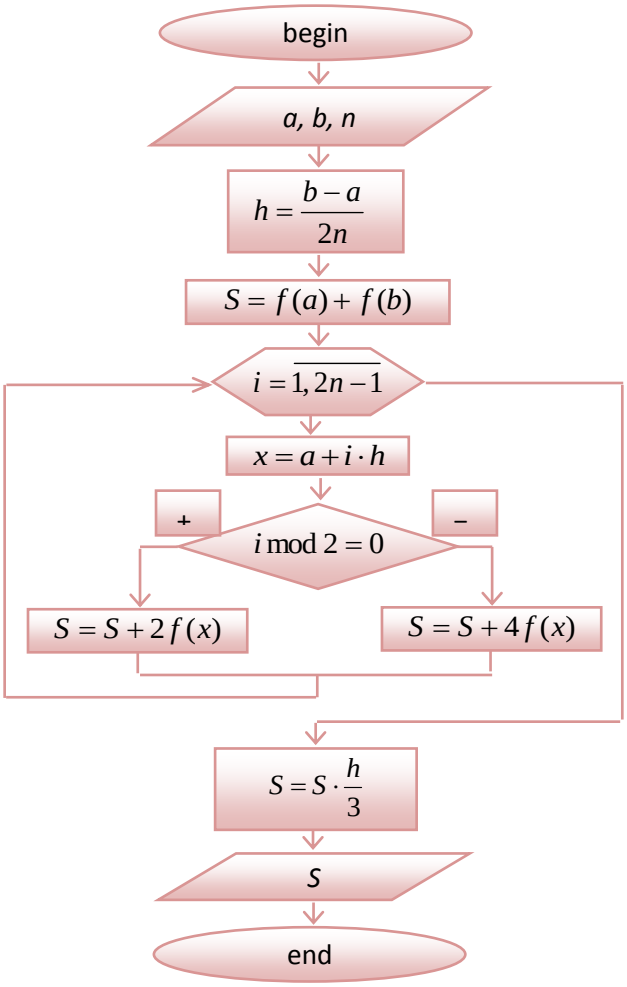
One and the same model can be associated with many different discrete models, but not all of them are suitable for practical use. Computational algorithms must satisfy certain requirements. The discrete model must be complementary to the computer. Two groups of requirements for computational algorithms can be distinguished: adequacy to the original problem and efficient computer feasibility. Adequacy includes the convergence of the method, the fulfillment of mathematical analogues of conservation laws, the qualitatively correct behavior of the method, its compliance with the model. The numerical method converges if, as the number of equations increases, the solution of the discrete problem tends to the solution of the original problem. Note that the computer operates only with a finite number of equations, so it is necessary to estimate the error of the discrete model depending on the number of equations. The art is to build a discrete model of small dimension, which is quite adequate to the original problem. Suppose we have ordinary differential equations or partial differential equations. At the beginning, we discretize the problem, replacing the region of change of the argument with a discrete set of points or a grid, continuous time is also replaced by discrete moments, then we approximate the derivatives and pass to finite difference relations. As a result, we obtain an approximate description of the real process by a system of algebraic equations. It is known that differential equations describing physical processes are consequences of conservation laws, so it is reasonable to require that the conservation laws also hold for difference schemes. Such schemes are called conservative; they most adequately reflect the behavior of the solution to the original problem. The correctness of the numerical method must correspond to the correctness of the original problem, in other words, the unique solvability and continuous dependence on the initial data. The computer implementation of the method includes memory and times requirements, the method must be implemented in a certain time on a given computer, taking into account its speed and memory.

Numerical methods are a fairly large section of higher mathematics and serious textbooks on this topic have hundreds of pages. In practice, in control papers, some problems are traditionally proposed for solving by numerical methods, and one of the common tasks is the approximate calculation of certain integrals by the method of rectangles, the trapezoid method and the Simpson method. In this article, I will consider a method for the approximate calculation of a definite integral - the Simpson method. First, let's ask ourselves the question, why do we need approximate calculations at all? It seems to be possible to find the antiderivative of the function and use the Newton-Leibniz formula, calculating the exact value of a certain integral. When solving physical and technical problems, one has to find certain integrals of functions whose antiderivatives cannot be expressed in terms of elementary functions. This led to the need to derive approximate formulas for calculating certain integrals. Simpson's method provides greater accuracy in the calculation of the definite integral without increasing the step h. This method is as follows: the curve of the

integrand is replaced by a piecewise continuous line consisting of segments of quadratic parabolas. Simpson is one of the most accurate methods for the approximate calculation of a definite integral compared to the method of rectangles and the trapezoid method. What do you need to know to apply this method using the C++ programming language? Well, firstly, you need to know the basics of the programming language and, of course, to know what the Simpson method is. In this case, the Simpson formula for numerical integration has the form:

$$\int_a^b f(x)dx \approx \frac{h}{3}\left[y_0 + y_{2n} + \sum_{i=1}^{2n-1}(3-c_i)y_i \right]$$

Algorithm for the approximate solution of a definite integral by the Simpson method:



The program for the approximate solution of a definite integral by the Simpson method in C ++:

Program text:

#include <iostream>

#include <math.h>

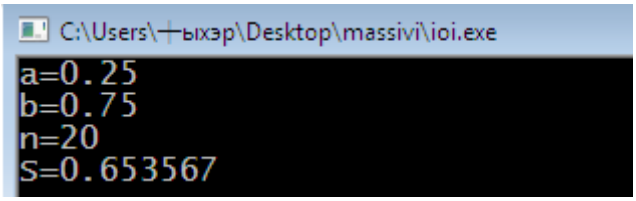
Using namespace std;

Float f(float x) {

return 1/sqrt(abs(cos(x)-pow(x,2))); }

```
int main () { float S,a,b,h,x; int n,i;
cout<<"a="; cin>>a;
cout<<"b="; cin>>b;
cout<<"n="; cin>>n;
h=(b-a)/(2*n); S=f(a)+f(b);
for (i=1;i<2*n-1;i++){ x=a+i*h;
if (i%2==0) S=S+2*f(x); else S=S+4*f(x); }
S=S*h/3;
cout<<S;
Return 0; }
```

The result of the program execution:



In conclusion, we note that this method of approximate calculation of integrals contains a clear algorithm for finding an approximate value, and also reduces the calculation time by half due to the use of the capabilities of the C++ programming language, which allows this method to be widely used for PC calculations.

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