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Algorithms & Programming

p.2.2 – Arrays & Functions

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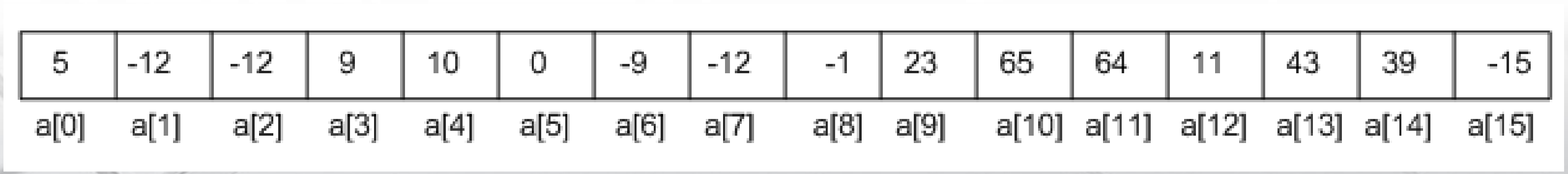
One-dimensional arrays in C++

- A one-dimensional array is an array with one parameter characterizing the number of elements of a one-dimensional array.
- In fact, a one-dimensional array is an array that can only have one row and n columns.
- The columns in a one-dimensional array are the elements of the array.
- The figure shows the structure of an integer one-dimensional array a.
- The size of this array is 16 cells



5	-12	-12	9	10	0	-9	-12	-1	23	65	64	11	43	39	-15
a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]	a[7]	a[8]	a[9]	a[10]	a[11]	a[12]	a[13]	a[14]	a[15]

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One-dimensional arrays in C++

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a[0]	a[1]	a[2]	a[3]	a[4]	a[5]	a[6]	a[7]	a[8]	a[9]	a[10]	a[11]	a[12]	a[13]	a[14]	a[15]

- Note that the maximum index of a one-dimensional array **a** is 15, but the array size is 16 cells, because array cell numbering always starts at 0.
- The cell index is a non-negative integer by which you can access each cell of the array and perform any actions on it (the cell).

```
// one-dimensional array declaration syntax in C++:
/*data type*/  /*name of array*/[/*size*/];
//an example of declaring a one-dimensional array in the figure
int a[16];
```

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One-dimensional arrays in C++

```
// one-dimensional array declaration syntax in C++:
/*data type*/  /*name of array*/[/*size*/];
//an example of declaring a one-dimensional array in the figure
int a[16];
```

- Always immediately after the name of the array there are square brackets that specify the size of a one-dimensional array, and this is what distinguishes an array from all other variables.

```
//another way to declare one-dimensional arrays
int mas[10], a[16];
```

- Two one-dimensional arrays **mas** and **a** are declared with sizes 10 and 16, respectively.
- With this declaration method, all arrays will have the same data type, in our case - int.

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One-dimensional arrays in C++

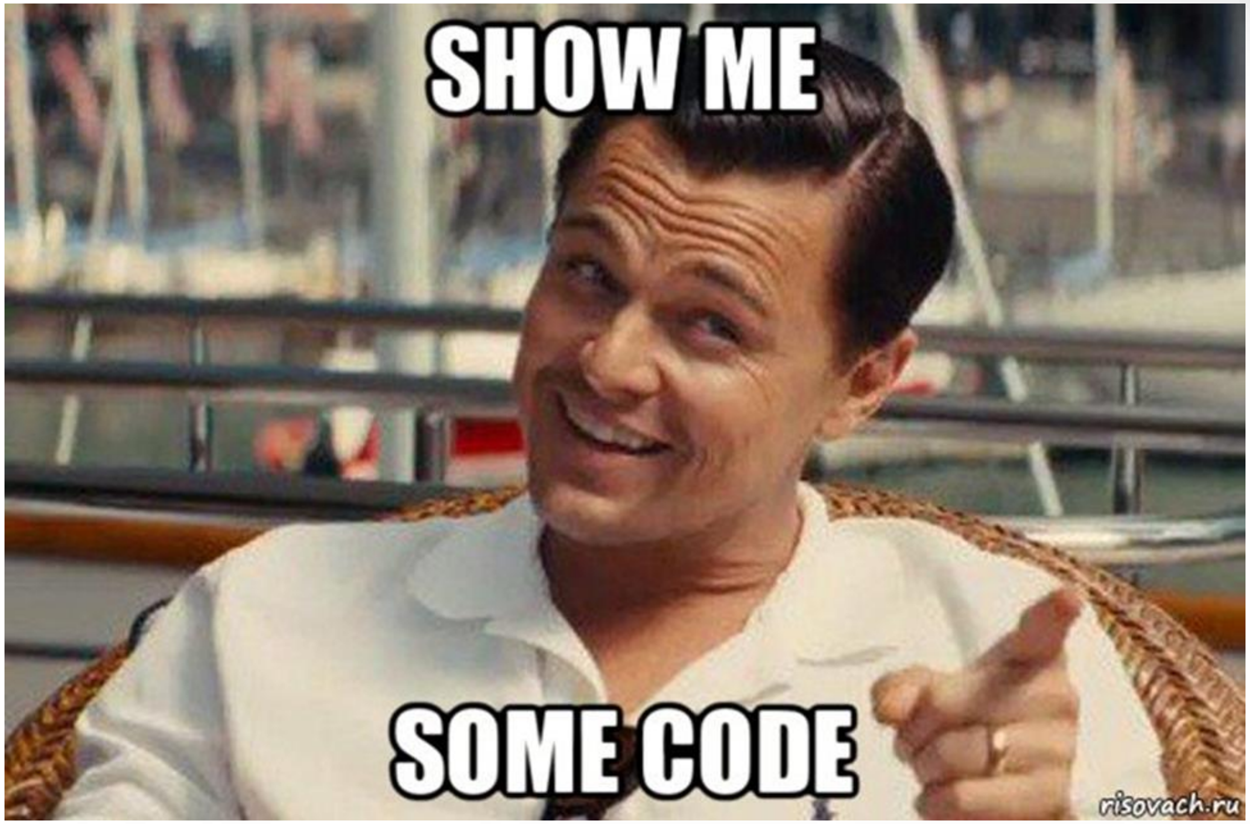
```
// arrays can be initialized when declared:
int a[10] = { 5, -12, -12, 9, 10, 0, -9, -12, -1, 7};
```

- Initialization of a one-dimensional array is performed in curly braces after the equal sign, each element of the array is separated from the previous one by a comma.

```
int a[] = { 5, -12, -12, 9, 10, 0, -9, -12, -1, 7};
```

- In this case, the compiler itself will determine the size of a one-dimensional array.
- The size of an array can be omitted only when it is initialized; when declaring an array, you must specify the size of the array.

One-dimensional arrays in C++



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Functions in C++

- Experienced programmers know that to write large programs, you need to use functions.
- The program will consist of separate code fragments, a separate code fragment is a function.
- Separate, because the work of a separate function practically does not depend on the work of any other.
- The algorithm in each function must be functionally sufficient and as independent as possible from other program algorithms.

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Functions in C++

- A function (in programming) is a piece of code or an algorithm implemented in some programming language in order to perform a certain sequence of operations.

- Once a function has been written, it can be easily transferred to other programs.

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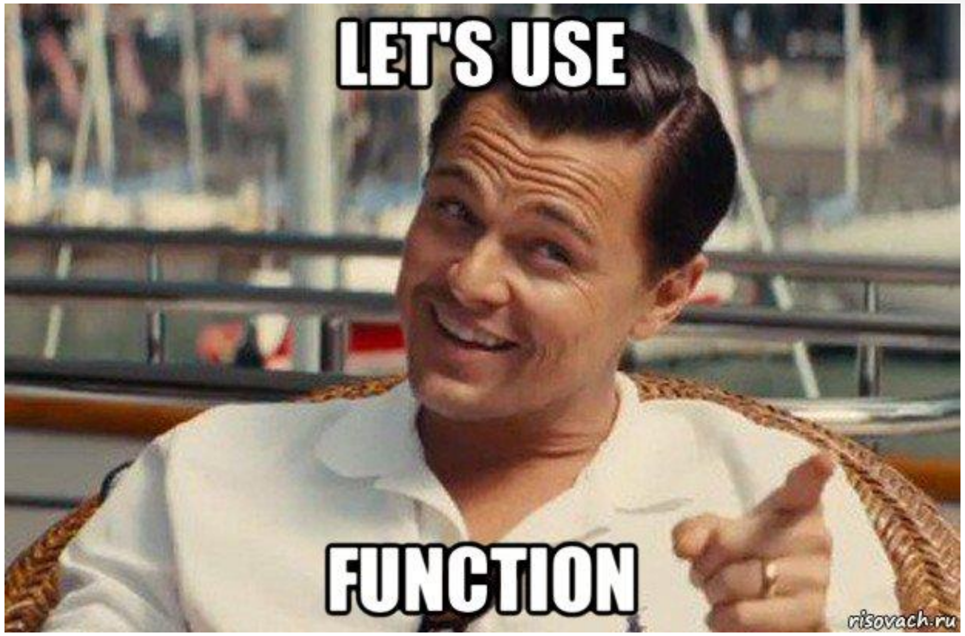
Functions in C++



- To use the function defined in the header file, you need to include it.
- For example, to use a function that raises some number to a power, you need to include the <cmath> header file and use the pow() function in the program.

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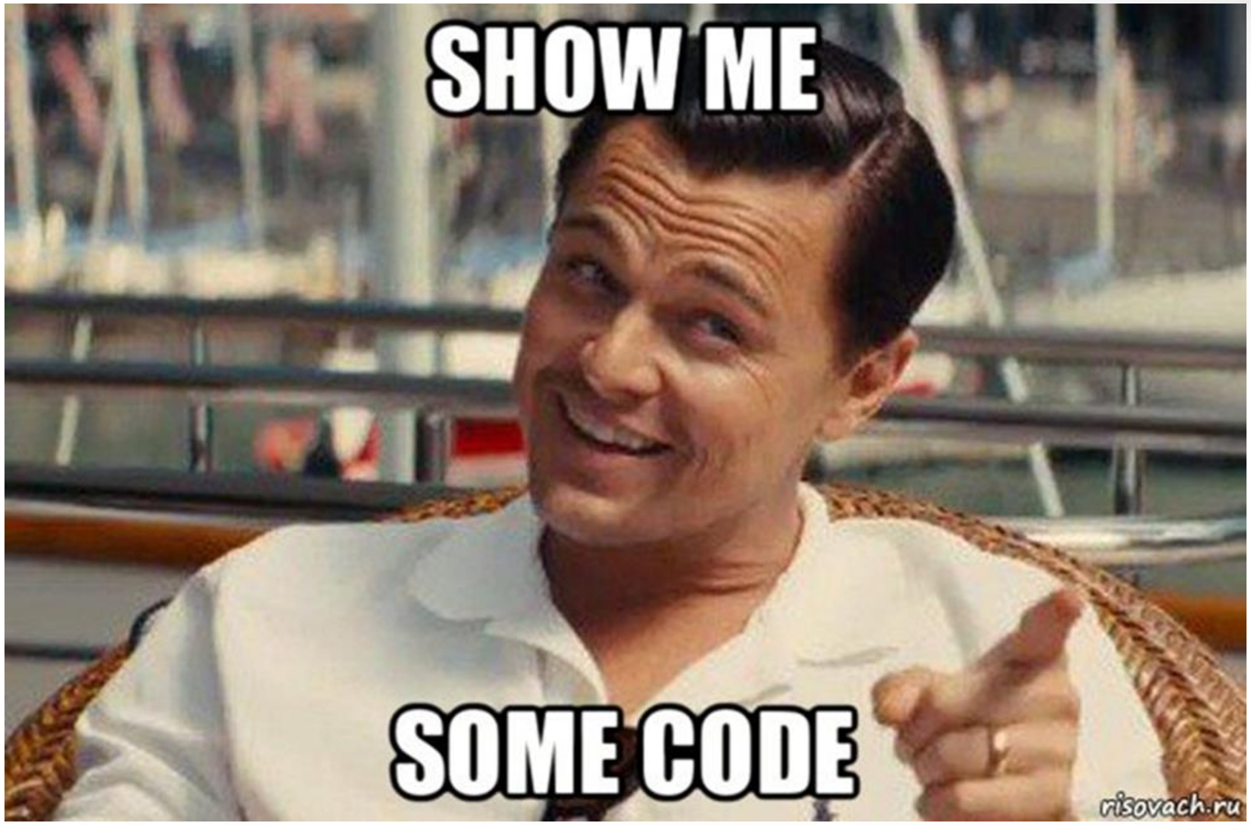
Functions in C++



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Functions in C++

- Parentheses are always placed after the function name, inside which arguments are passed to the function, and if there are several arguments, then they are separated from each other by commas.
- Arguments are needed to pass information to a function.
- For example, to raise the number 3.1415926 to the power of 0.5 using the pow() function, you need to tell this function somehow what number and to what power to raise it.
- This is what function arguments were invented for, but there are functions in which arguments are not passed, such functions are called with empty parentheses.

Functions in C++

To use a function from a standard C++ header file, you need to do two things:

- Include the required header file;
- Run the required function.

- In addition to calling functions from standard header files, the C++ language provides the ability to create its own functions.

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Functions in C++

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Functions in C++

There are two types of functions in the C++ programming language:

- Functions that return a value
- Functions that do not return values

Functions in C++

- In the function header, you first need to define the return data type, it can be an int data type if you need to return an integer, or a double data type for floating point numbers, etc.
- Since the function must return a value, a special return statement must be provided for this.
- It can be used to return a value when the function completes.
- To do this, you need to specify a variable containing the desired value, or some value, after the return statement.
- The data type of the returned value must match the data type in the header.

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Methods for passing function parameters

In C++, parameters are passed to a function in one way:

- By value
- By Link
- By pointer

Let's consider such an example.
We should develop a program which inputs two numbers, then calls a function that swaps the input numbers, and then outputs them.

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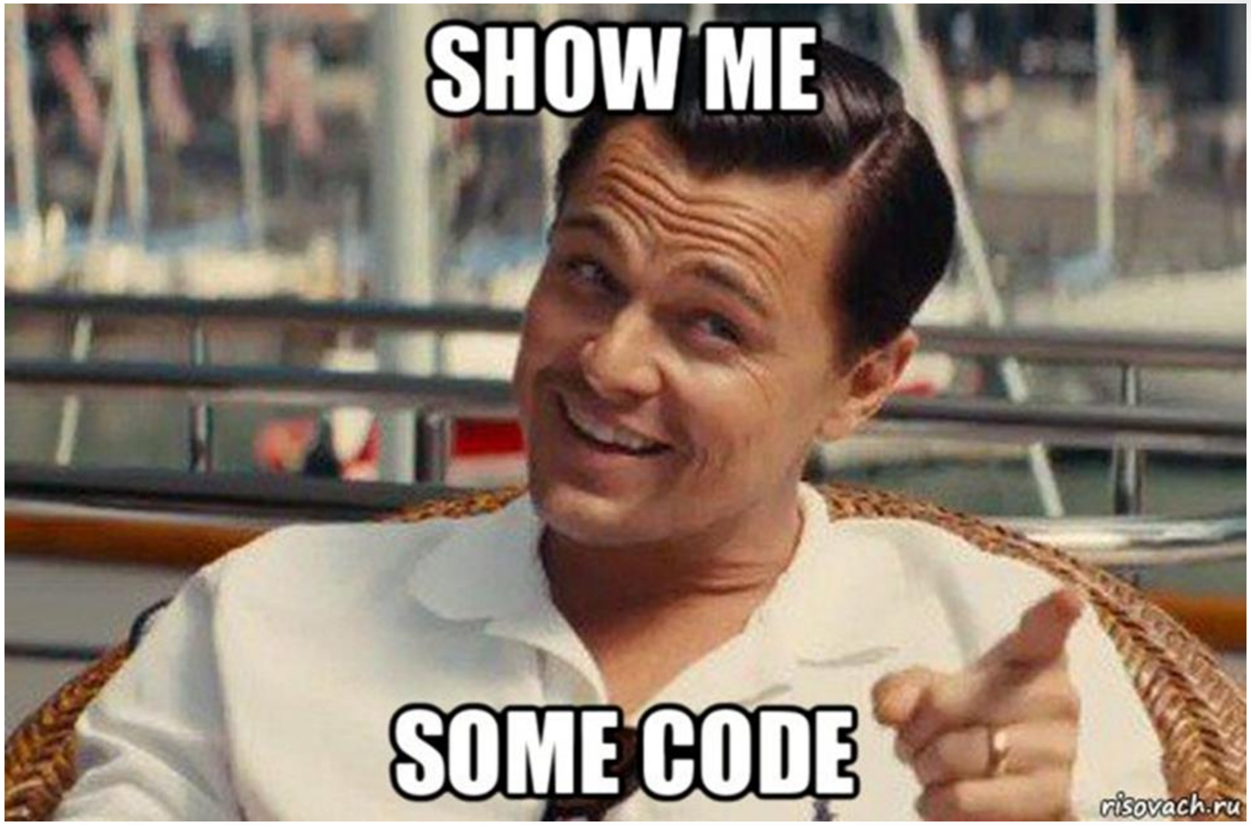
Demo



Passing an array as a function parameter

- Since passing an array by value, that is, creating a copy of the entire array, is a time-consuming operation (especially for large arrays), a reference to it is always passed instead of an array
- That is, when declaring a function

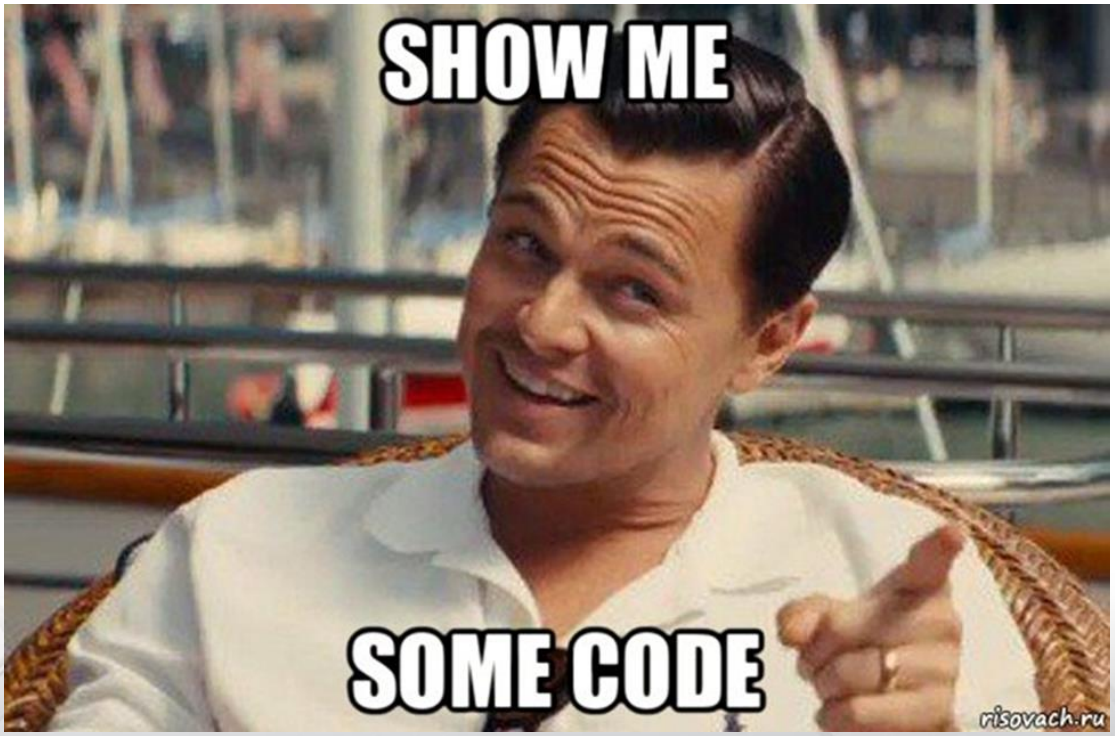
```
int f(int a[], int size)
```

- It will receive a reference to the array, which means it will be able to change the values of its elements.

Passing an array as a function parameter

Consider an example:

- Develop a function to find the number of the minimum element in an array.



Default Function Arguments

- When calling a function, you can omit some of its arguments.
- To do this, when declaring the prototype of this function, it is necessary to initialize its parameters with some values, these values will be used in the default function.
- Default arguments must be given in the function prototype.
- If the function has several parameters, then the parameters that are omitted must be located to the right of the others.
- Thus, if a parameter is omitted, then all parameters located before it may not be omitted, but after it they must be omitted.

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Default Function Arguments

```
#include <iostream>
#include <cmath>
using namespace std;

double heron(double a = 5, double b = 6.5, double c = 10.7);

int main()
{
    cout << "S = " << heron()      << endl << endl;
    cout << "S = " << heron(10,5) << endl << endl;
    cout << "S = " << heron(7)     << endl << endl;
    return 0;
}

double heron(double a, double b, double c)
{
   double p = (a + b + c) / 2;
   cout <<"a= "<< a <<"\nb= " << b << "\nc = " << c << endl;
   return (sqrt(p * (p - a) * (p - b) * (p - c)));
}
```

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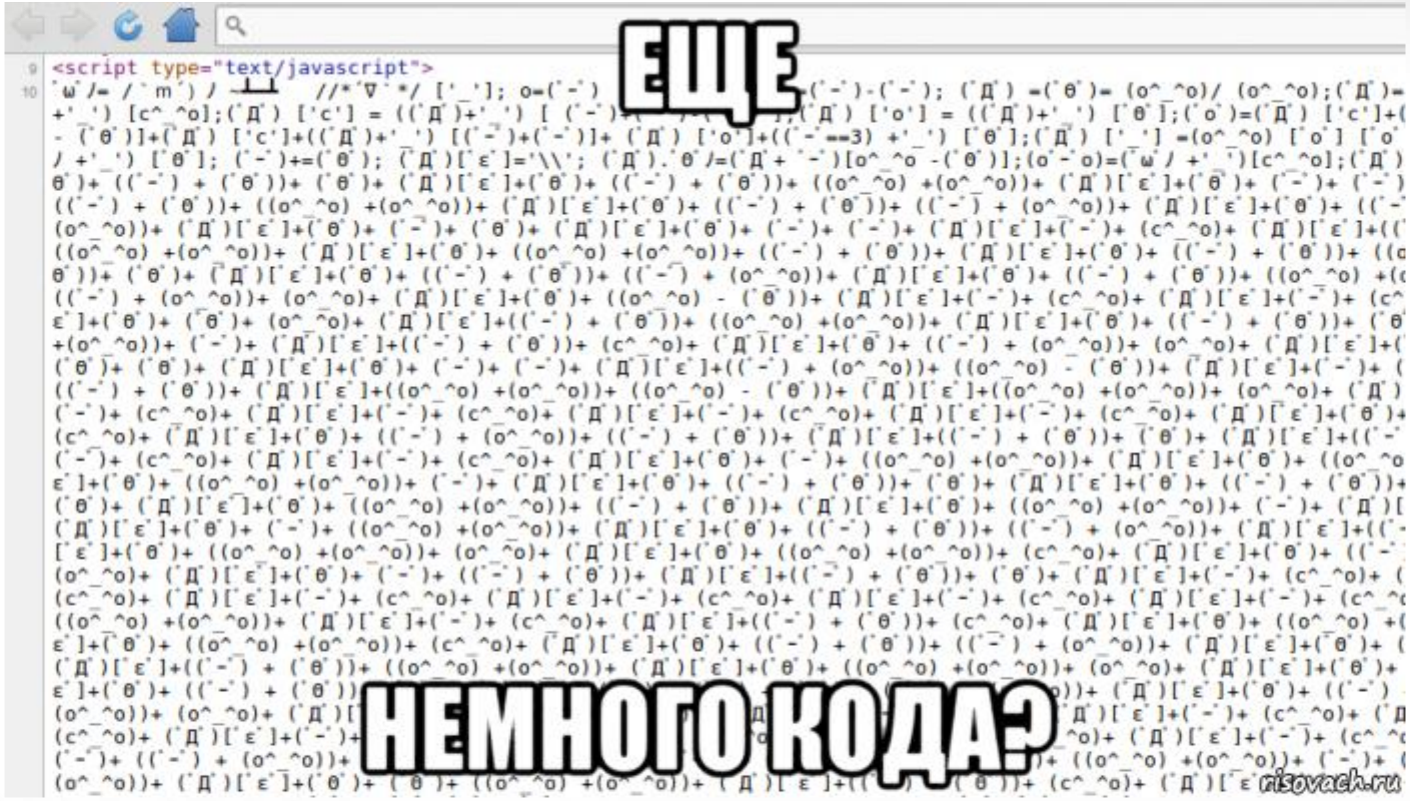
Demo



```
<script type="text/javascript">
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+'_') [c^_^o];(ﾟДﾟ) ['c'] = ((ﾟДﾟ)+'_') [ (ﾟｰﾟ)+          ;(ﾟДﾟ) ['o'] = ((ﾟДﾟ)+'_') [ﾟΘﾟ];(ﾟoﾟ)=(ﾟДﾟ) ['c']+(
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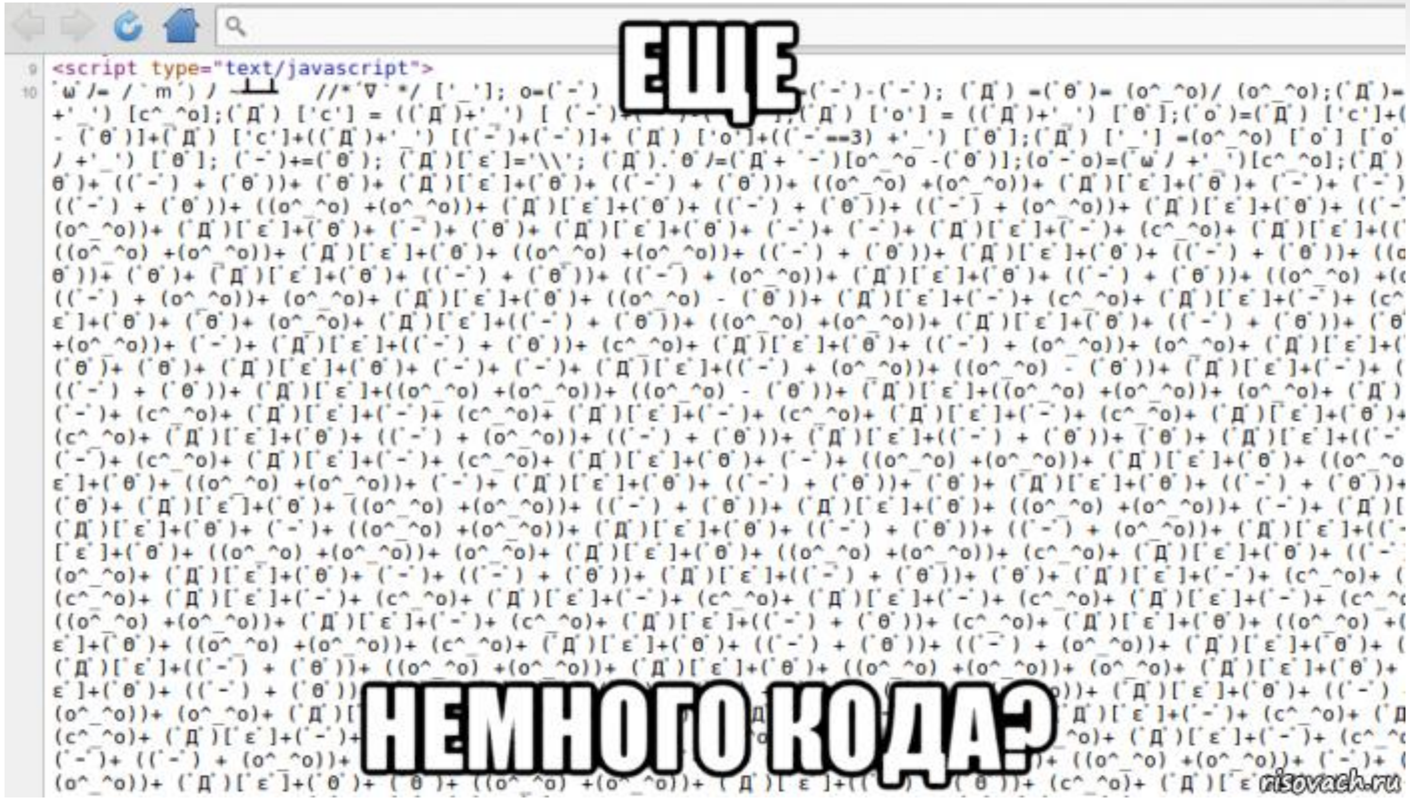
Example

Given real numbers s *and* t. *Let's calculate:*

$$f(t, -2s, 1.17) + f(2.2, t, s - t),$$

where $f(a, b, c) = \dfrac{2a - b - \sin c}{5 + |c|}$.

Demo



```
<script type="text/javascript">
```

Весь код по ссылке: http://code.re/6MR

НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ КОРАБЛЕБУДУВАННЯ ІМЕНІ АДМІРАЛА МАКАРОВА

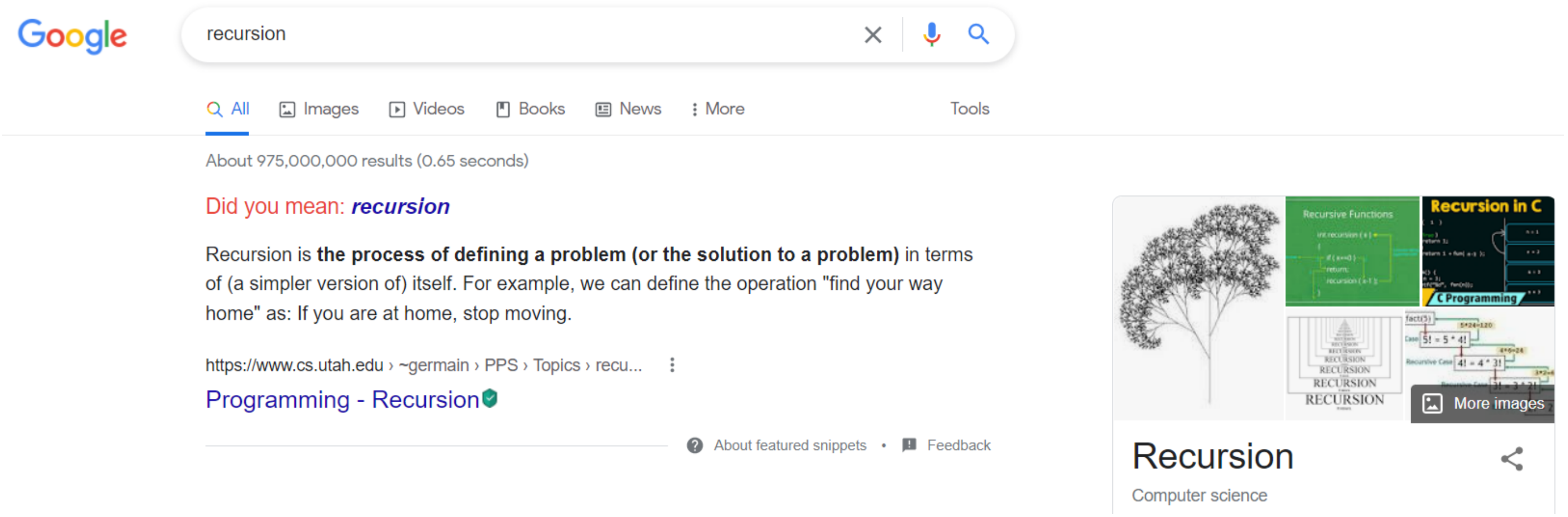
Recursion

Recursion – … ?

Ask Google?..

Recursion

Recursion – … ?



About 975,000,000 results (0.65 seconds)

Did you mean: ***recursion***

Recursion is **the process of defining a problem (or the solution to a problem)** in terms of (a simpler version of) itself. For example, we can define the operation "find your way home" as: If you are at home, stop moving.

https://www.cs.utah.edu › ~germain › PPS › Topics › recu...

Programming - Recursion

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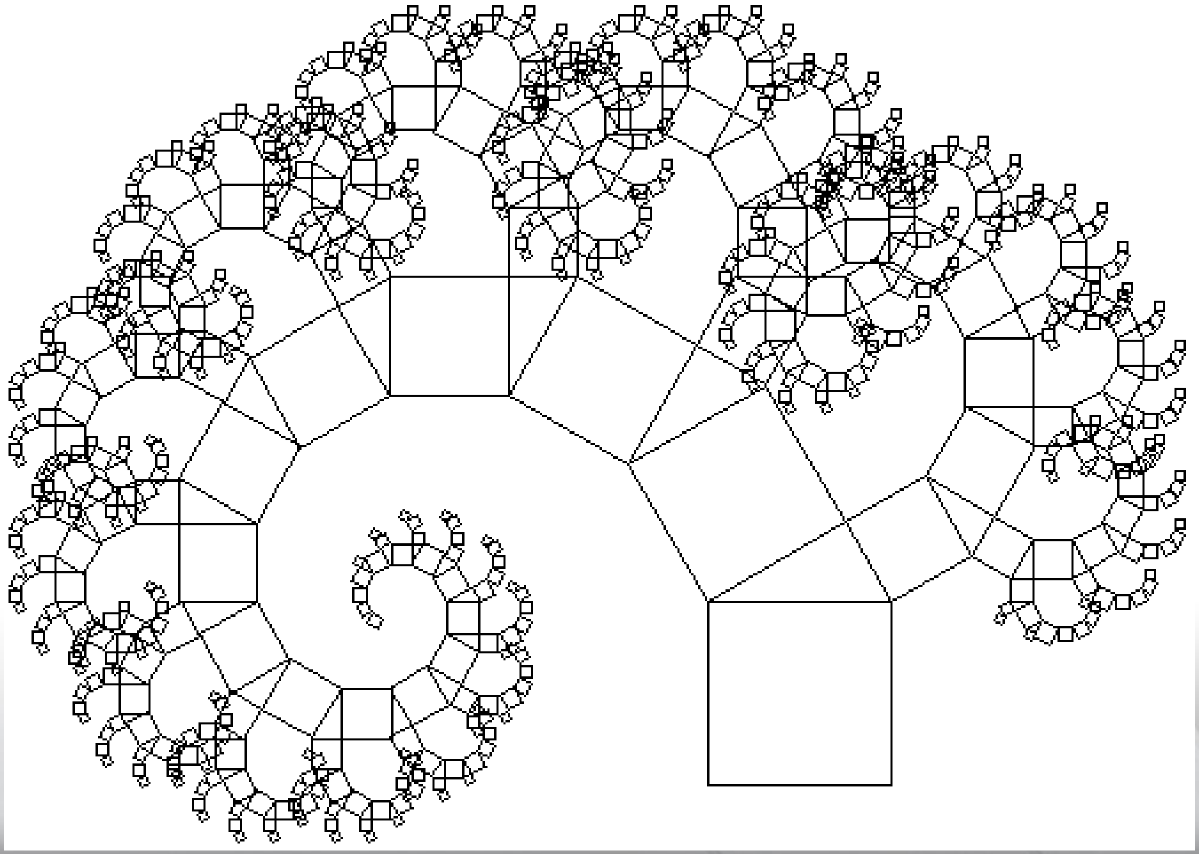
Recursion

Computer science

Recursion

Recursion is the definition of a part of a function through itself, that is, it is a function that calls itself, directly (in its body) or indirectly (through another function).



Recursion

- Typical recursive tasks are tasks:
  - Calculation of n!
  - Calculation of Fibonacci numbers.
- Such tasks have already been solved by us, but only using cycles, that is, iteratively.
- Generally speaking, everything that is solved iteratively can be solved recursively, that is, using a recursive function.

Recursion

Calculation of n!

$$n! = 1 \cdot 2 \cdot 3 \cdot \dots \cdot n$$

Iterative (cyclic) process:

```
int f = 1;
for (int i = 1; i <= n; i++) {
     f *= i;
}
```

Recursion

Calculation of n!

$$n! = \begin{cases} 1, \text{если } n = 0 \text{ или } n = 1 \\ (n-1)! * n, \text{если } n > 1 \end{cases}$$

Recursive process:

```
int f(int n) {
    if ( n == 0 || n == 1 ) return 1;
    else f = n * f(n-1);
}
```

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Calculation of n!

Recursion

Fibonacci numbers :

$$f_i = \begin{cases} 1, if\ i = 0\ or\ i = 1 \\ f_{i-1} + f_{i-2}, if\ i > 1 \end{cases}$$

НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ КОРАБЛЕБУДУВАННЯ ІМЕНІ АДМІРАЛА МАКАРОВА

Fibonacci numbers

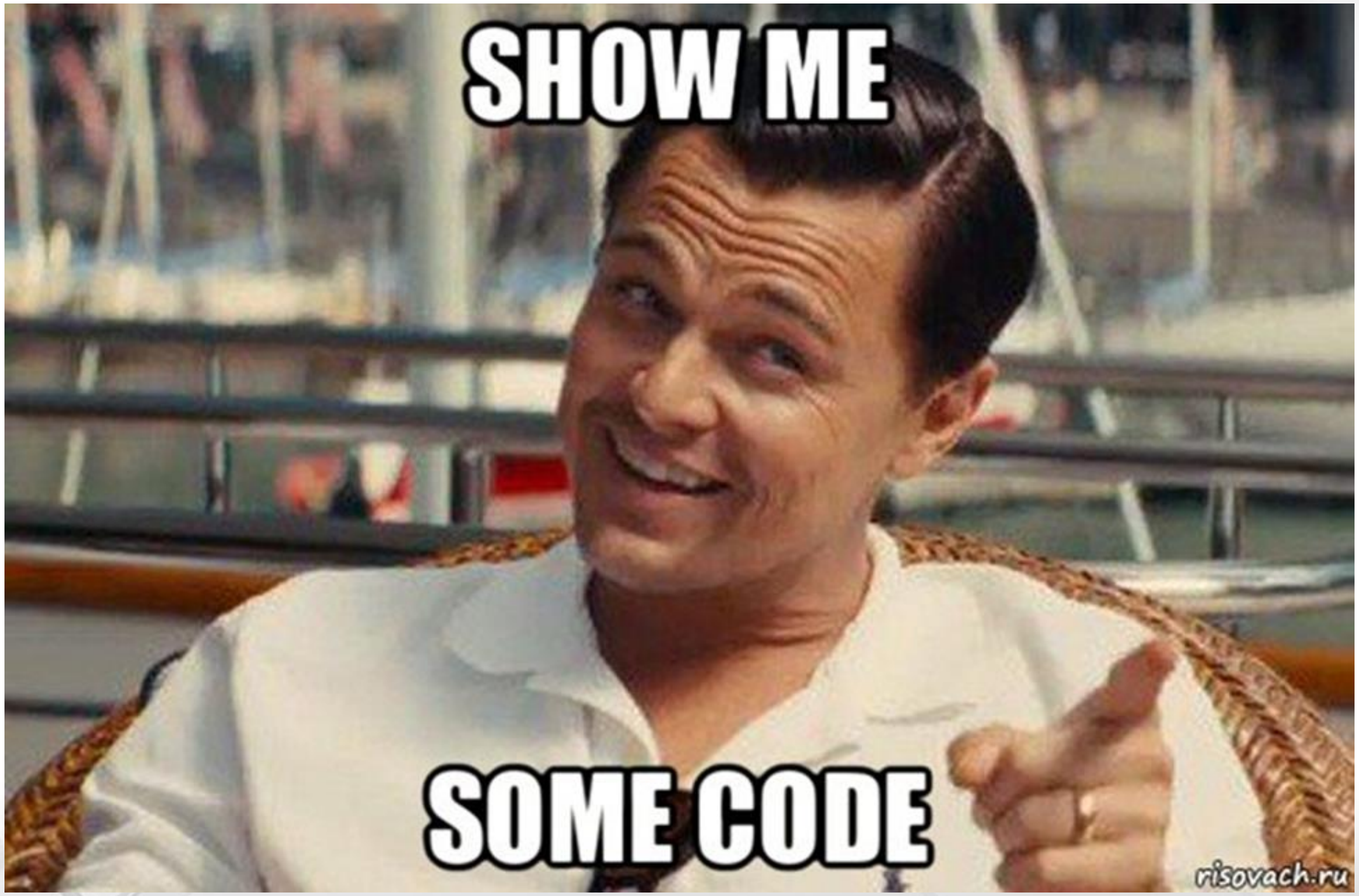
Simple Recursion:

```
int fib(int i){
    if (i == 0 || i == 1) return 1;
    else return fib(i - 1) + fib(i - 2);
}
```

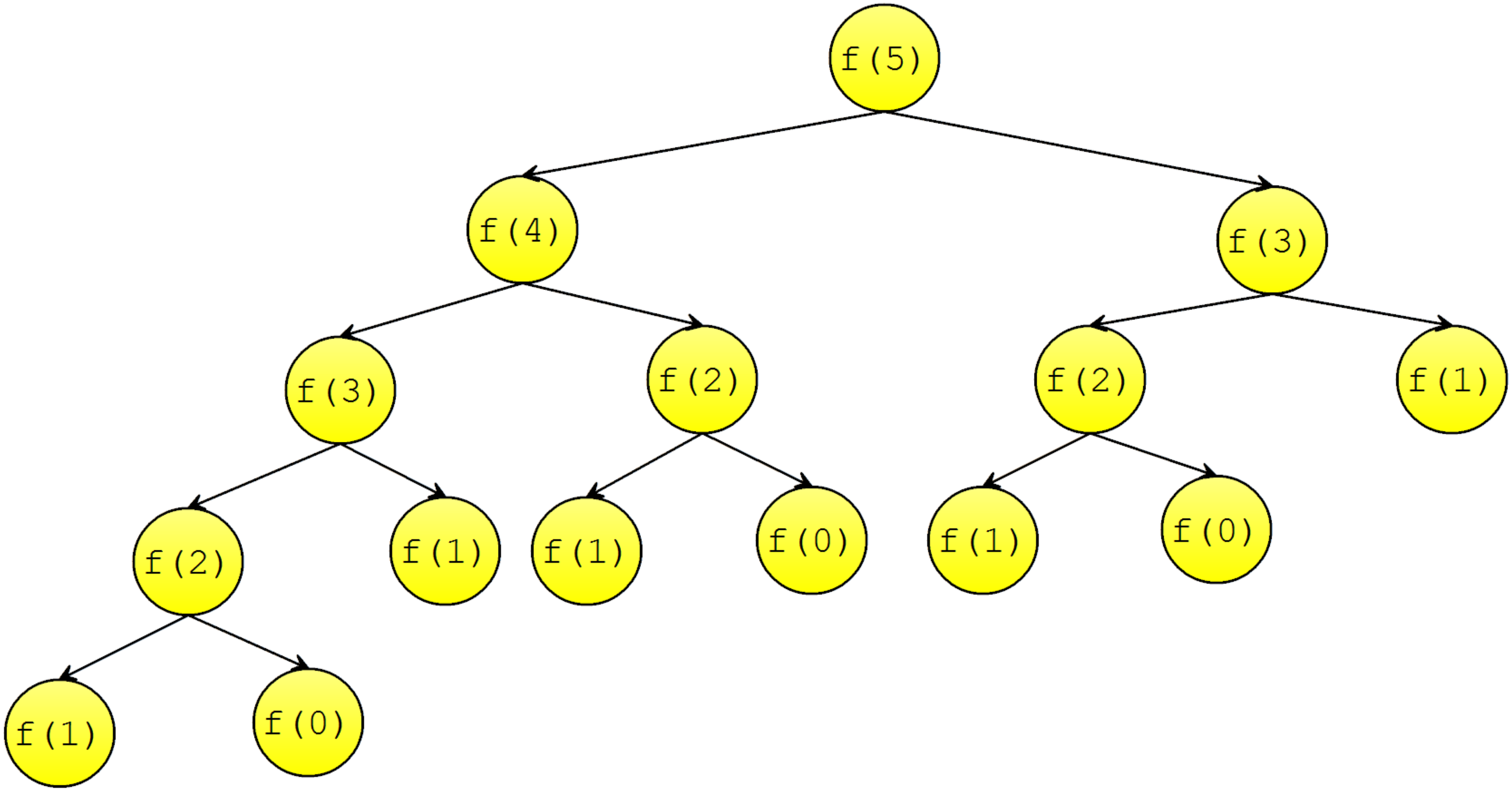
What's wrong with this algorithm?

НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ КОРАБЛЕБУДУВАННЯ ІМЕНІ АДМІРАЛА МАКАРОВА

Demo



Recursion



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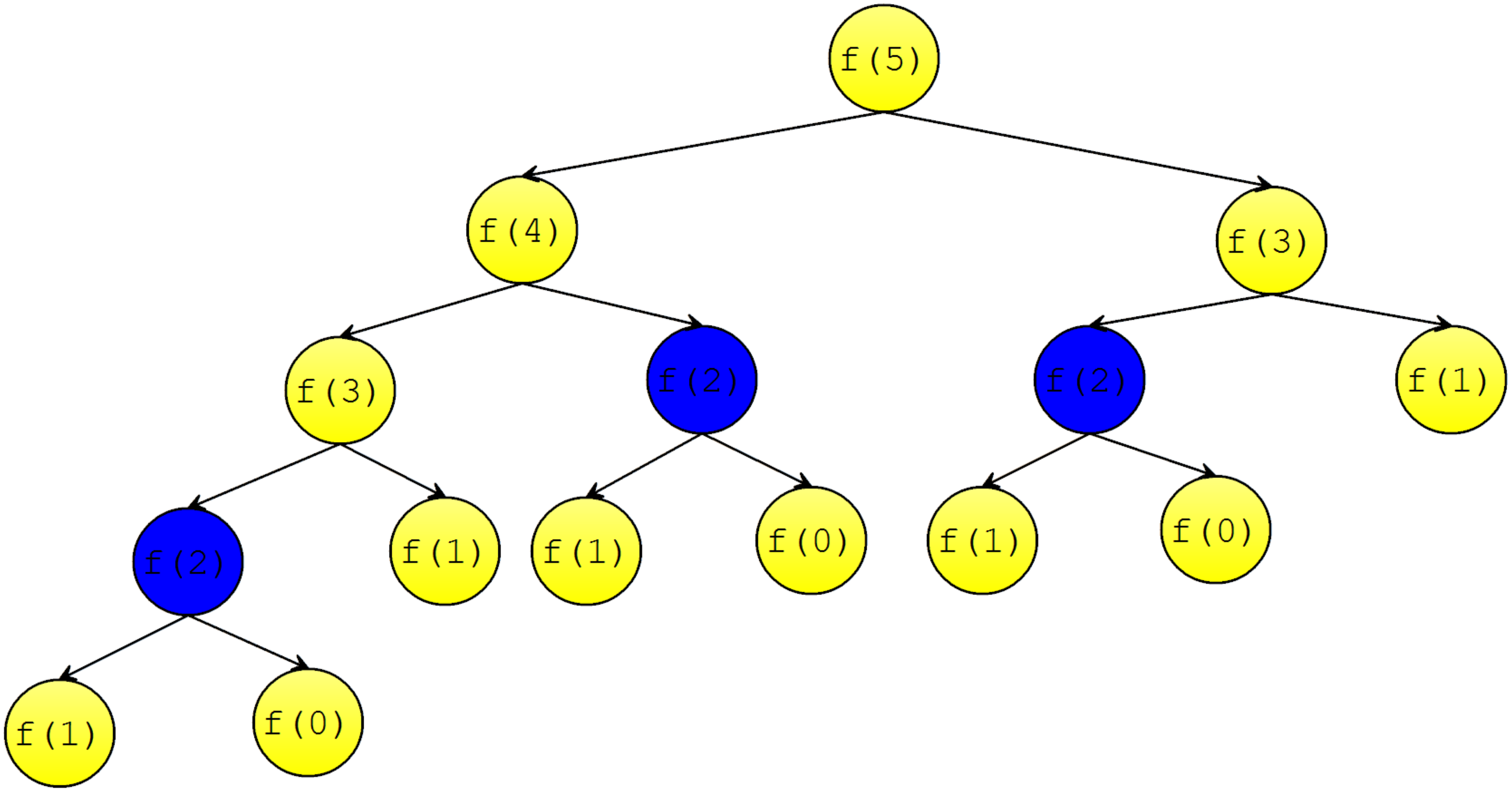
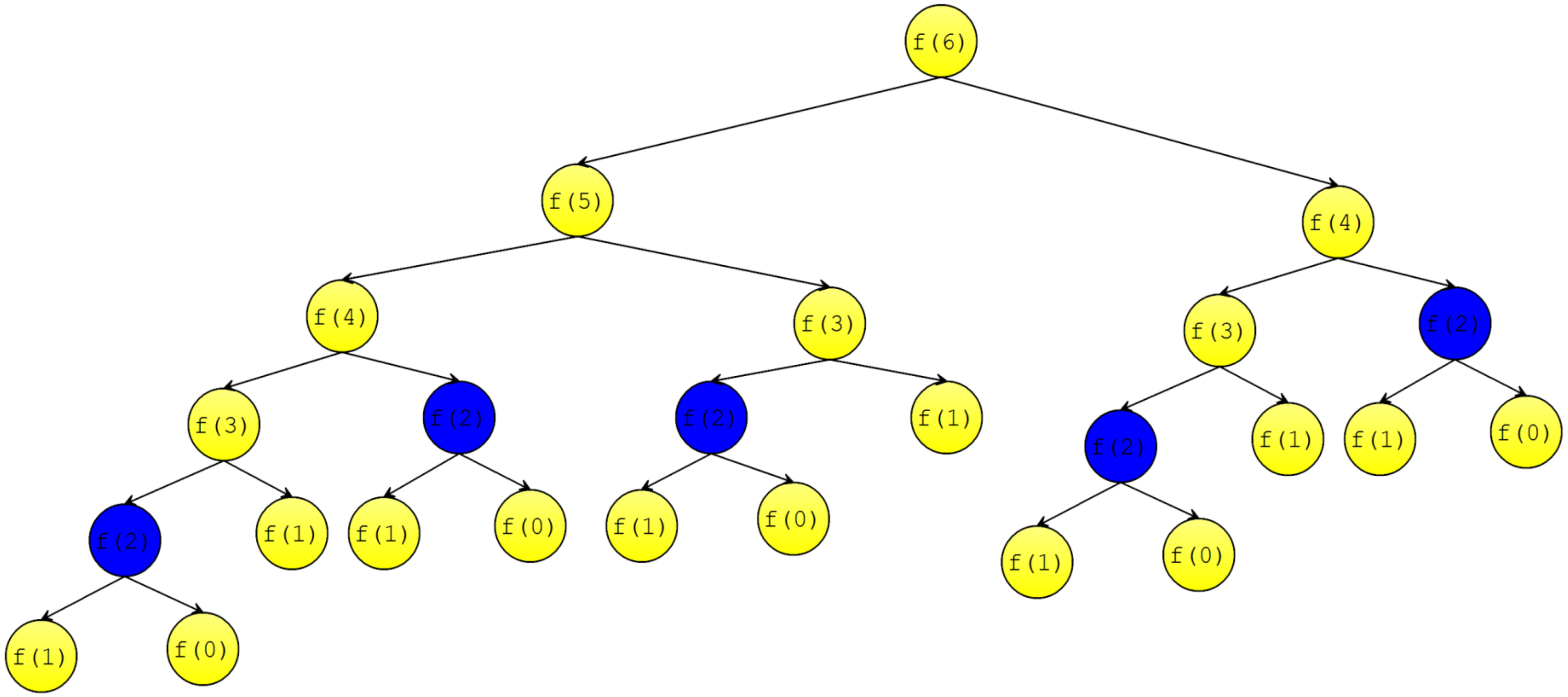
Recursion



НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ КОРАБЛЕБУДУВАННЯ ІМЕНІ АДМІРАЛА МАКАРОВА

Recursion



Как решить эту проблему?

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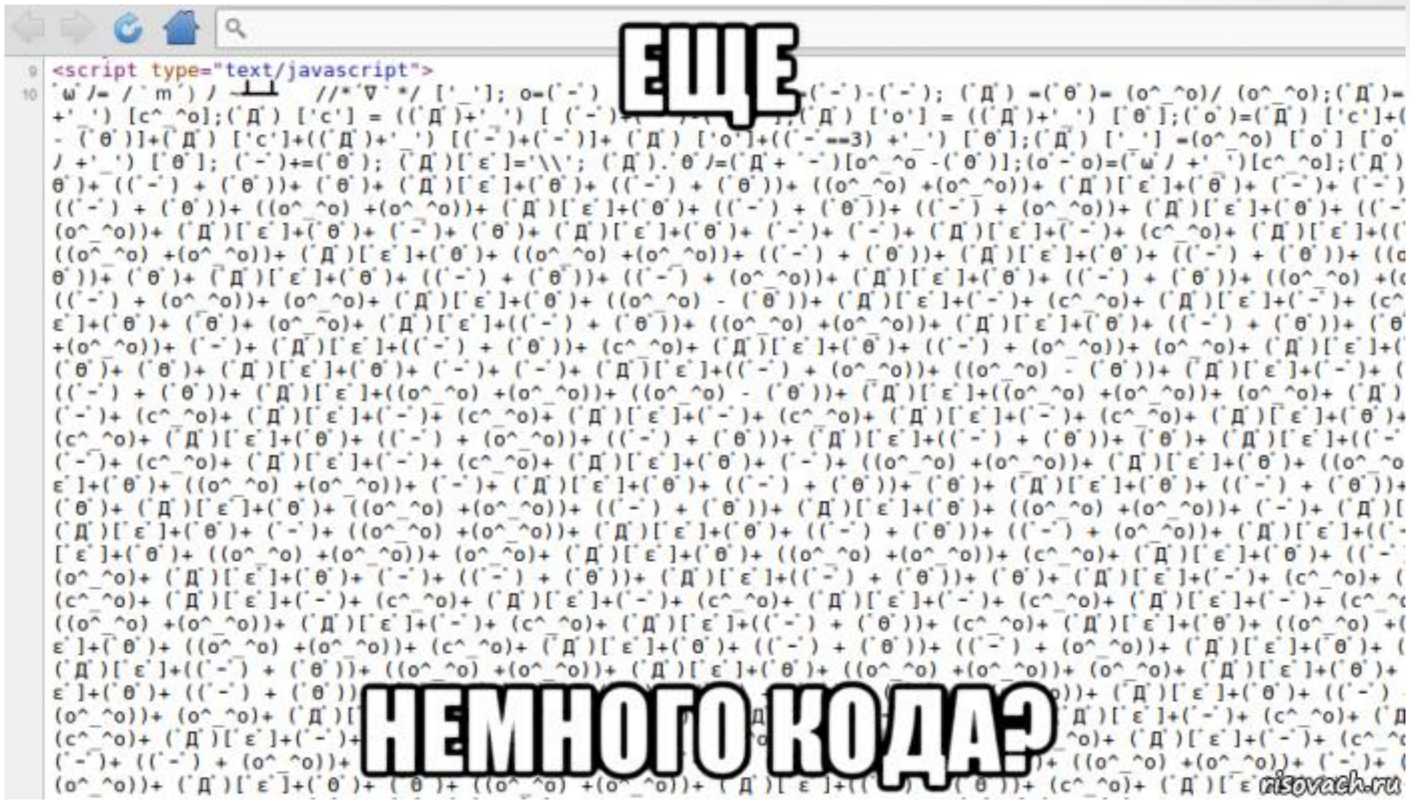
Recursion



```
<script type="text/javascript">
```

Recursion

And now the task is more difficult.

And more interesting ☺

The **Tower of Hanoi**

Mathematical game or puzzle consisting of three rods and a number of disks of various diameters, which can slide onto any rod. The puzzle begins with the disks stacked on one rod in order of decreasing size, the smallest at the top, thus approximating a conical shape.

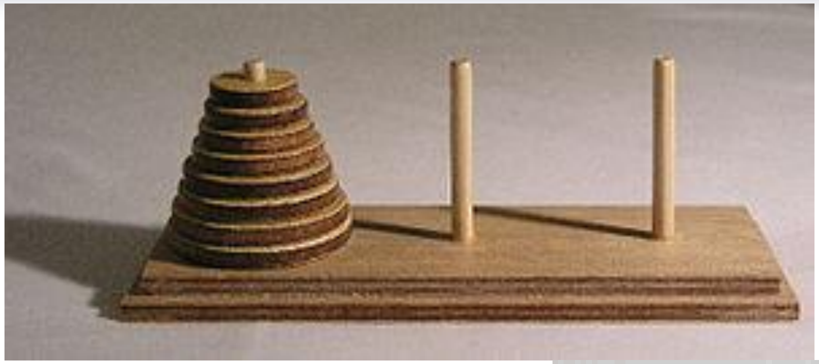
The objective of the puzzle is to move the entire stack to the last rod, obeying the following rules:

- Only one disk may be moved at a time.
- Each move consists of taking the upper disk from one of the stacks and placing it on top of another stack or on an empty rod.
- No disk may be placed on top of a disk that is smaller than it.

Recursion

- In the film Rise of the Planet of the Apes (2011), this puzzle, called in the film the "Lucas Tower", is used as a test to study the intelligence of apes
- The ape completes the four-ring puzzle in twenty moves.

Recursion «Tower of Hanoi»



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Recursion «Tower of Hanoi»

```
#include <iostream>

using namespace std;

void p(int n, int from, int to, int aux) {
    if (n == 1) {
        cout << from << "->" << to << "\n";
    } else {
        p(n-1, from, aux, to);
        p(1, from, to, aux);
        p(n-1, aux, to, from);
    }
}

int main() {
    int n;
    cin >> n;
    p(n, 1, 2, 3);
    return 0;
}
```

НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ КОРАБЛЕБУДУВАННЯ ІМЕНІ АДМІРАЛА МАКАРОВА

Recursion

QUESTIONS
& ANSWERS

НАЦІОНАЛЬНИЙ УНІВЕРСИТЕТ КОРАБЛЕБУДУВАННЯ ІМЕНІ АДМІРАЛА МАКАРОВА

Algorithms & Programming

p.2.2 – Arrays & Functions

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