**CSC 600 Homework** **Dr. Jozo Dujmović**
**Procedural programming**

*Programming is similar to a game of golf.*
*The point is not getting the ball in the hole*
*but how many strokes it takes.*
*- H. Mills*

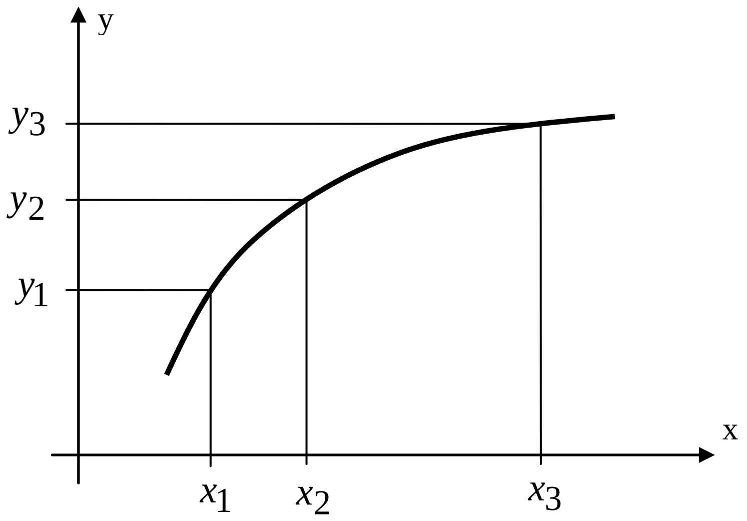
*Inside every well-written large program*
*is a well-written small program.*
*- C.A.R. Hoare*

The goal of this homework is to develop your skills in procedural programming. You should develop four efficient procedural programs and perform a simple performance measurement. Your programs should be as short and simple as possible, and as fast as possible. Each program must be documented. For each solution first explain the idea and then explain the reasons why you think it is a good procedural solution. You must show your source programs, and results of their execution. You can use any procedural programming language. We suggest the use of C++.

**1.** Plateau program (max sequence length) (a combinatorial algorithm)

The array **a(1..n)** contains sorted integers. Write a function **maxlen(a,n)** that returns the length of the longest sequence of identical numbers (for example, if a=(1,1,1,2,3,3,5,6,6,6,6,7,9) then **maxlen** returns 4 because the longest sequence 6,6,6,6 contains 4 numbers. Write a demo main program for testing the work of maxlen. Explain your solution, and insert comments in your program. The solution should have time complexity O(n).

**2.** Parabolic approximation (let us solve a numeric problem)



We know three points on a curve: $(x_1, y_1), (x_2, y_2), (x_3, y_3)$. You have to create a program that for any value $x_1 \le x \le x_3$ computes the corresponding value y assuming that the segment of curve can be approximated with the parabola $y = ax^2 + bx + c$. Write a function that can be called as `y(x1,y1,x2,y2,x3,y3,x)` and a main program that reads x1,y1,x2,y2,x3,y3 and then displays `y(x1,y1,x2,y2,x3,y3,x)` in n=40 equidistant x points between x1 and x3.

Solve this problem in the following two ways:

(a) Insert points $(x_1, y_1), (x_2, y_2), (x_3, y_3)$ in parabola $y(x) = ax^2 + bx + c$. You will get three linear equations; solve them and find a,b,c. Then, display the table of function $y(x)$ from x1 to x3.
(b) Solve the same problem using Lagrange interpolation formula.
(c) Compare your two solutions and show your conclusions.

**3.** Array processing (elimination of three largest values) (one of many array reduction problems)

The array **a(1..n)** contains arbitrary integers. Write a function **reduce(a,n)** that reduces the array **a(1..n)** by eliminating from it all values that are equal to three largest different integers. For example, if a=(9,1,1,6,7,1,2,3,3,5,6,6,6,6,7,9) then three largest different integers are 6,7,9 and after reduction the reduced array will be a=(1,1,1,2,3,3,5), n=7. The solution should have time complexity O(n).

**4.** Integer plot function (find a smart way to code big integers)

Write a program **BigInt(n)** that displays an arbitrary positive integer n using big characters of size 7x7, as in the following example for **BigInt(170):**

```
  @@    @@@@@@@   @@@@@
 @@@         @@  @@    @@
  @@        @@   @@    @@
  @@       @@    @@    @@
  @@      @@     @@    @@
  @@     @@      @@    @@
@@@@@@  @@         @@@@@
```

**5.** Iteration versus recursion (an opportunity for performance measurement)

Make a sorted integer array `a[i]=i`, i=0,…,n-1. Let **`bs(a,n,x)`** be a binary search program that returns the index i of array a[0..n-1] where a[i]=x. Obviously, `bs(a,n,x)`=x, and the binary search function can be tested using the loop

```
for(j=0; j<K; j++)
     for(i=0; i<n; i++) if(bs(a,n,i) != i) cout << "\nERROR";
```

Select the largest **n** your software can support and then **K** so that this loop with an iterative version of **bs** runs 3 seconds or more. Then measure and compare this run time and the run time of the loop that uses a recursive version of **bs**. Compare these run times using maximum compiler optimization (release version) and the slowest version (minimum optimization or the debug version). If you use a laptop, make measurements using AC power, and then same measurements using only the battery. What conclusions can you derive from these experiments? Who is faster? Why?