

CSC 600-01 (SECTION 1)  
**Homework 2 - Procedural Programming**  
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# CSC 600 HOMEWORK 2 - PROCEDURAL PROGRAMMING

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*Homework is prepared by: Ilya Kopyl.  
It is formatted in LaTeX, using TeXShop editor (under GNU GPL license).*

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

The array  $a(1..n)$  contains sorted integers. Write a function  $\text{maxlen}(a,n)$  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  $\text{maxlen}$  returns 4 because the longest sequence 6, 6, 6, 6 contains 4 numbers. Write a demo main program for testing the work of  $\text{maxlen}$ . Explain your solution, and insert comments in your program. The time complexity of the solution should be in  $O(n)$ .

The answer is listed on the pages 2 through TBD.

A code listing of implementation of maxlen function:

```
unsigned int maxlen(int *a, unsigned int n)
{
    // handling the edge cases - arrays of size 0 and 1:
    if (n < 2)
        return n;

    unsigned int max_count, current_count, i;
    i = max_count = 0;
    current_count = 1;

    printf("    a[%d]=%d; \tcurrent_count=%d; \tmax_count=%d\n",
        i, a[i], current_count, max_count);

    for (i = 1; i < n; ++i)
    {
        if (a[i] == a[i-1])           // counting the current sequence
        {
            current_count++;

            // checking whether the longest sequence is at the end of array
            if (i == n-1 && current_count > max_count)
                max_count = current_count;
        }
        else                           // starting the count of the new sequence
        {
            // before resetting the counter, save it's value if it is above threshold
            if (current_count > max_count)
                max_count = current_count;

            // exit the loop if max_count is sufficiently large
            if (max_count >= n-i)
                break;

            current_count = 1;
        }

        printf("    a[%d]=%d; \tcurrent_count=%d; \tmax_count=%d\n",
            i, a[i], current_count, max_count);
    }
    return max_count;
}
```

The result of the program execution:

```
Array a:    1  1  1  2  3  3  5  6  6  6  6  7  9
a[0]=1;      current_count=1;      max_count=0
a[1]=1;      current_count=2;      max_count=0
a[2]=1;      current_count=3;      max_count=0
a[3]=2;      current_count=1;      max_count=3
a[4]=3;      current_count=1;      max_count=3
a[5]=3;      current_count=2;      max_count=3
a[6]=5;      current_count=1;      max_count=3
a[7]=6;      current_count=1;      max_count=3
a[8]=6;      current_count=2;      max_count=3
a[9]=6;      current_count=3;      max_count=3
a[10]=6;     current_count=4;      max_count=3
Max sequence length of array a = 4

Array b:
Max sequence length of array b = 0

Array c:    12
Max sequence length of array c = 1

Array d:    16  16  16  18  18  20
a[0]=16;     current_count=1;      max_count=0
a[1]=16;     current_count=2;      max_count=0
a[2]=16;     current_count=3;      max_count=0
Max sequence length of array d = 3

Array e:     0  0
a[0]=0;      current_count=1;      max_count=0
a[1]=0;      current_count=2;      max_count=2
Max sequence length of array e = 2

Array f: 0  1
a[0]=0;      current_count=1;      max_count=0
Max sequence length of array f = 1

Array g:     1  2  3  3
a[0]=1;      current_count=1;      max_count=0
a[1]=2;      current_count=1;      max_count=1
a[2]=3;      current_count=1;      max_count=1
a[3]=3;      current_count=2;      max_count=2
Max sequence length of array g = 2
```

## 2. 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)`:

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

The answer is listed on the pages TBD through TBD.

### **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  $\text{reduce}(a, n)$  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 would be  $a=(1, 1, 1, 2, 3, 3, 5)$ ,  $n=7$ . The time complexity of the solution should be in  $O(n)$ .

The answer is listed on the pages TBD through TBD.

#### 4. Iteration versus recursion (an opportunity for performance measurement)

Make a sorted integer array  $a[i]=i$ ,  $i=0,\dots,n-1$ . Let  $bs(a, n, x)$  be a binary search program that returns the index  $i$  of the array  $a[0..n-1]$  where  $a[i]=x$ . Obviously, the result is  $bs(a, n, x)=x$ , 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 the same measurements using only the battery. What conclusions can you derive from these experiments? Who is faster? Why?

The answer is listed on the pages TBD through TBD.

## 5. Iteration versus recursion (another opportunity for performance measurement)

Write a recursive function `Frec(n)` that computes Fibonacci numbers. Then write an iterative version of Fibonacci number function `Fit(n)`. Functions `Frec(n)` and `Fit(n)` return the same value but with different performance.

Write the main program that discovers the value `N10` so that `Frec(N10)` runs on your machine exactly 10 seconds. Then measure the run time of `Fit(N10)` and compute how many times is `Fit(N10)` faster than `Frec(N10)`. Show what is `N10` on your machine.

Notes:

1. When you measure the speed, your machine should be disconnected from the Internet, it should use the AC power supply, and it should run only one program (your performance measurement program).
2. In C++ you can measure current time in seconds using the following function:

```
double sec(void)
{
    return double(clock()) / double(CLOCKS_PER_SEC);
}
```

To measure the run time of fast programs you must repeat them many times inside a loop. Take care to eliminate the overhead generated by the loop.

The answer is listed on the pages TBD through TBD.