

Although this exam is in English, your answers can be in Dutch. Please give the requested code in such way that it could be compiled on a compiler with adheres to the latest ANSI/ISO C++ standard. Be aware of your style and indications. Make sure that variables are defined in the header or as local variable (only exception is the definition of constants). Success!

1 Parameters and variables

- (a) When a function is declared, you can choose between *call by value* and *call by reference* for the function parameters. Explain these two concepts clearly in your own words.
- (b) When variables are declared, you can choose to make them *local* and *global*. Explain these two concepts clearly in your own words.
- (c) There is a subtle difference between **formal parameters** and **arguments**. Explain these two concepts clearly in your own words.

Look at the following code, which defines two functions:

```
#include <iostream>

using namespace std;

int range (int j, int limit)
{
    j = j + limit; limit = j - limit; j = limit - j;
    cout << "Range_" << j << "_and_" << limit << endl;
    return (limit - j);
} //range

int sample (int i, int limit)
{
    int sum = limit;
    while ( i <= limit ) { sum += range (i, limit); i++; } //while
    cout << "Sample_" << i << "_and_" << limit << endl;
    return sum;
} //sample
```

These two functions can be called from a main, which makes use of global variables:

- (d) The functions `range` and `sample` will be used with the following main:

```
int x = 0;
int y = 1;
int top = 3;

int main()
{
    x = sample (y, top) - 3;
    cout << "The_answer:_" << x << ",_" << y << "_and_" << top << endl;
}
```

What will be the output of this program (not only the last sentence)? Explain shortly why.

- (e) The function declarations are now changed to call-by-reference (`int range (int &j, int &limit)` and `sample (int &i, int &limit)`). What will be the output of this program? Explain shortly why.

- (f) Instead of `x = sample (y,top) - 3;`, now the call `x = sample (x,x) - 3;` is made in the `main()`.

What will be the output be of these programs (for both the call-by-value and call-by-reference variants of the `range` and `limit`-functions. Explain shortly why for both variants.

2 Arrays

Consider the following Boolean array `map` with size m by n . In the example below the size is $m = 5$ and $n = 7$. The character 'T' stands for the Boolean value `true`, the character 'F' for `false`.

```
F T T F F T F
T F F T F T F
T T F F T F F
F T T F T F F
T F T T F F F
```

- Design a C++-function `inbetween(map, row)` that counts how often the character 'F' is inbetween two 'T'-values, for the row `row`. For instance in the example, for the second row the answer should be 1.
- Design a Boolean C++-function `invisible(map, col)` that returns true if a column `col` consists of only the character 'F'. For instance in the example, this is only true for the last column.
- The given map can be interpreted as the result of a pathplanner. The values on the map should be interpreted as follows; in case of a value 'T' one should go the right, in case of a value 'F' one should go down. Design a C++-function `longest_path(map, r, c)` which indicates the start location `r, c` of the *longest* path possible on a given map. The function should return the length of the found path. For instance in the example, this path which starts at (0,1) has a length 8. When multiple paths have the same length, it is allowed to return one of the startlocations (your choice).

3 Structures and classes

- How many `public:` sections are required in a class for the class to be usefull?
- How many `private:` sections are required in a class.
- When you define a C++ class, should you make the member variables public or private? Should you make the member functions public or private?
- When you define a C++ class, which items are considered part of the interface? What items are considered part of the implementation?
- When does a class have a default constructor automatically?

4 Inheritance

Consider the inheritance of the following classes:

```
class LaserScan
{
public:
    LaserScan ();
    LaserScan (int nn);
    void MaxRange ();
    void NearestObject ();
private:
    int n;
};
```

```
class DepthMap: public LaserScan
{
public:
    DepthMap(int mn, double dd);
    void Skeleton();
private:
    double d;
};
```

- (a) How many public members does an object of class DepthMap have?
- (b) Will the following code work? Explain why.

```
int main()
{
    DepthMap d(180,180);

    cout << d.n;

    return 0;
}
```