Chapter 5. Blocks, Functions and Reference Variables

Programming Concepts in Scientific Programming

EPFL, Master class

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Blocks

Syntax

```
{
  // SOME CODE
}
```

Blocks

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}
```

Blocks

Scope of a variable

```cpp
// Block 1
{
  int i = 5; // local to Block 1
  // Block 2
  {
    int j = 10; // local to Block 2
    i = 10;     // inherited from Block 1
  }
  // variable j is destructed
  j = 5; // so ?
}
// variable i is destructed
```

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  j = 5; // so ?
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```

Blocks

Local vs global variables

```cpp
int i = 5; // global variable

int main() {
  int j = 7; // local variable
  std::cout << i << "\n";
  {
    int i = 10, j = 11;
    std::cout << i << "\n";   // local value of i is 10
    std::cout << ::i << "\n"; // global value of i is 5
    std::cout << j << "\n";   // value of j here is 11
  }
  std::cout << j << "\n"; // value of j here is 7
  return 0;
}
```

Blocks

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    std::cout << ::i << "\n"; // global value of i is 5
    std::cout << j << "\n";   // value of j here is 11
  }
  std::cout << j << "\n"; // value of j here is 7
  return 0;
}
```

Blocks

Local vs global variables

```cpp
namespace PCSC {

int i = 5; // global variable
}

int main() {
  std::cout << PCSC::i;
  std::cout << std::endl;
}
```

Blocks

Local vs global variables

```
namespace PCSC {

int i = 5; // global variable
}

int main() {
  std::cout << PCSC::i;
  std::cout << std::endl;
}
```

Blocks

Local vs global variables

```
namespace PCSC {

int i = 5; // global variable
}

int main() {
  std::cout << PCSC::i;
  std::cout << std::endl;
}
```

Functions

Simple Functions

Declaration/Prototype:

```
double CalculateMinimum(double x, double y);
```

- Function name
- Return type
- Typed parameters

Functions

Simple Functions

Declaration/Prototype:

```
double CalculateMinimum(double x, double y)
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- Function name
- Return type
- Typed parameters

Functions

Simple Functions

Declaration:

```
double CalculateMinimum(double x, double y);
```

Usage:

```
  double x = 4.0, y = -8.0;
  double minimum_value = CalculateMinimum(x, y);
  std::cout << "min = " << minimum_value << "\n";
```

Definition:

```
double CalculateMinimum(double a, double b) {
  if (a < b) {
    return a;
  }
  return b;
}
```

Concept of interfaces

- Describes how to use a function
- Opposed to the function body: implementation
- An interface is usually written in .hh/.hpp (header) files

Why is it important to have this concept ?

- Allow collaborative work
- Normalizes the knowledge needed to call a function
- Limits modifications in cascade

Header files

Example: CalculateMinimum.hpp

```
#ifndef CALCULATEMINIMUM_HPP
#define CALCULATEMINIMUM_HPP

double CalculateMinimum(double a, double b);

#endif
```

Header files

Example: CalculateMinimum.hpp

```
#ifndef CALCULATEMINIMUM_HPP
#define CALCULATEMINIMUM_HPP

double CalculateMinimum(double a

#endif

```

Header files

Example: CalculateMinimum.hpp

```
#ifndef CALCULATEMINIMUM_HPP
#define CALCULATEMINIMUM_HPP

double CalculateMinimum(double a, double b);

#endif
```

Usage

```
#include "CalculateMinimum.hpp"
#include <iostream>

int main(int argc, char *argv[]) {

  double x = 4.0, y = -8.0;
  double minimum_value = CalculateMinimum(x, y);
  std::cout << "min = " << minimum_value << "\n";

  return 0;
}
```

Usage

```
#include "CalculateMinimum.hpp"
#include <iostream>

int main(int argc, char *argv[]) {

  double x = 4.0, y = -8.0;
  double minimum_value = CalculateMinimum(x,
  std::cout << "min = " << minimum_value << "\n";

  return 0;
}
```

Implementation file

Example: CalculateMinimum.cpp

```
double CalculateMinimum(double a, double b) {
  if (a < b) {
    return a;
  }
  return b;
}
```

Functions

Returning an array

Return the pointer to the allocated memory!

```
double *allocateVector(int size) {
  double *v = new double[size];
  return v;
}
```

Functions

Returning a Matrix

Return the pointer to the allocated memory!

```cpp
double **allocateMatrix(int m, int n) {

  double **mat = new double *[m];
  for (int i = 0; i < m; ++i) {
    mat[i] = new double[n];
  }
  return mat;
}
```

Functions

Input with pointer

```c
void assign_by_value(double value) { value = 10; }

void assign_by_pointer(double *value) { *value = 10; }
```

What is the difference ?

- The difference is the scope (life duration) of the variable value
- Pointer argument allows to change the pointed value
- Non-Pointer arguments are simply copied

Functions

Array Input

```
double doIt(double array[]) {
  array[1] = 10.;
  return array[1];
}

  double u[10];
  std::cout << doIt(u) << std::endl;
  double *u2 = new double[10];
  std::cout << doIt(u2) << std::endl;
```

Functions

Array Input

```
double doIt(double *array) {
  array[1] = 10.;
  return array[1];
}

  double u[10];
  std::cout << doIt(u) << std::endl;
  double *u2 = new double[10];
  std::cout << doIt(u2) << std::endl;
```

Functions

Default parameter value

```
double doIt(double a, double b = 0.) { return a + b; }


  std::cout << doIt(10., 5.) << std::endl;
  std::cout << doIt(10.) << std::endl;
```

Functions

Polymorphism/Overloading

Several functions with the same name:

- They **MUST** be distinguishable by their arguments(number and types) and return type

This is possible

```
double doIt(double a, double b);
double doIt(int a, int b = 0);
```

This is not

```
double doIt(double a);
int doIt(double a); // not compiling
```

```
int doIt(int a, int b = 0);
int doIt(int a); // not usable
```

Functions

Pointer to function

The function

```
double foo(double a) { return a + 1; }
```

The pointer

```
  double (*ptr_foo)(double a) = &foo;
```

The function call

```
  ptr_foo(10);
```

References

A *practical* syntax of C++: the references

```
void foo(double &a) { a = 10.; }
```

What is the difference between pointer and references ?

References

```
int main() {
  int a = 1;
  int &b = a;
  int &c = a;
  int &d = a;
}
```

```
(gdb) x/20xw &a
```

References

```
    double a, b;
    double *ptr = &a;
    ptr = &b;
    double &ref = a;
```

- The usage: you don't need to use the '*' operator
- A reference points to a value that is 'read only'
- Not possible to change where the reference points to
- Not possible to increment the internal pointer