Fundamentals of Computer Programming

Chapter 6
Modular Programming
(Function in C++)

Outline

- Introduction to modular programming
- Function declaration and definition
- Calling a function and Return types
- Function parameters (Value Vs. Reference)
- Parameter Passing
  - ✔ *by value*
  - ✔ *by reference*
- Default arguments
- Function Overloading
- Scope of variables (revision)
- Special functions (recursive functions, inline functions)
- Array in function (array as parameter, return array, call with array)

1. Introduction Modular Programming

Modular programming

- Programming approach in a complex problem breaking down in to smaller manageable pieces
- The design of a program into individual components (modules) that can be programmed and tested independently.
- It is a requirement for effective development and maintenance of large programs and projects
- Procedures of a common functionality are grouped together into separate modules.
- A program therefore no longer consists of only one single part
- It is now divided into several smaller parts which interact and which form the whole program.

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Modular program

- A program consisting of interrelated segments (or modules) arranged in a logical and understandable form
- Modules in C++ can be classes or functions

Why Modular programming?

- Easy to write a correct small function
- Code Re-usability – Write once and use multiple times
- Code optimization – No need to write lot of code
- Maintainability – Easily to debug, maintain/modify the program
- Understandability – Easy to read, write and debug a function

2. The concepts of Function

Functions

- A function is a block of code (subprogram) that **performs a specific task.**
- Complicated tasks should be ***broken down into multiple functions***.
- Each can be called in turn when it needed

- Note:
  - Every C++ program has at least one function, main().

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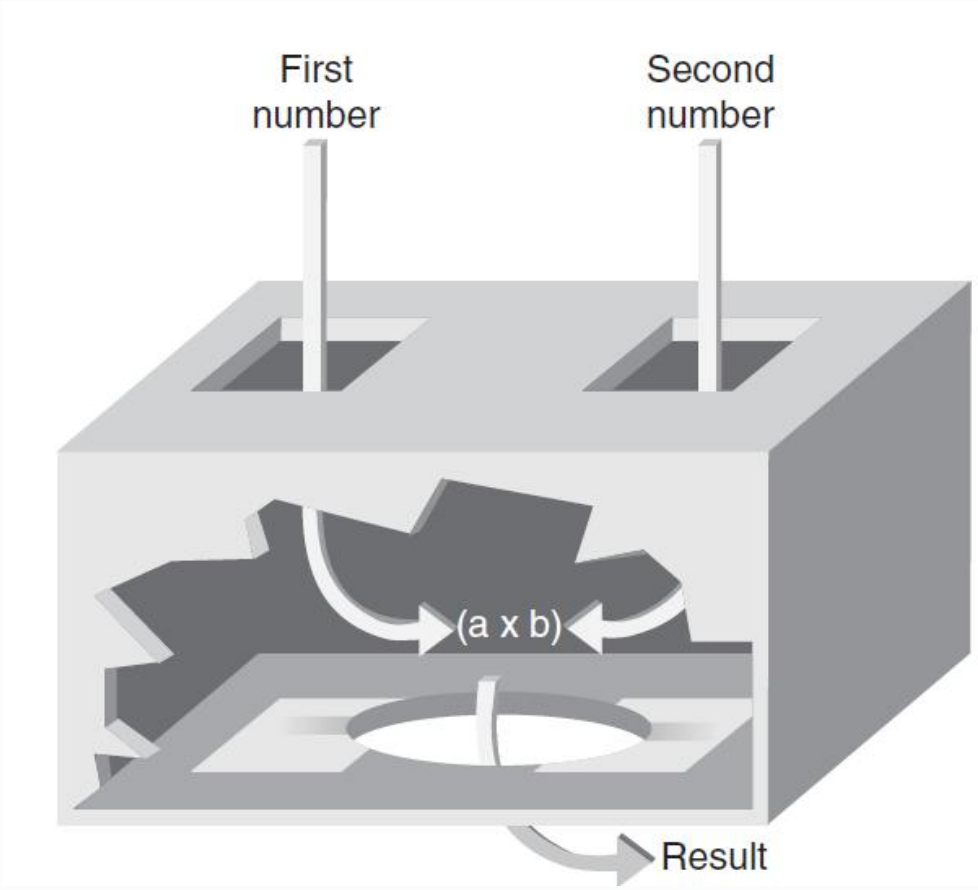
- A function can Accepts an input, act on data (process the input) and return a value (produces an output).

- A function's processing is encapsulated and hidden within the function



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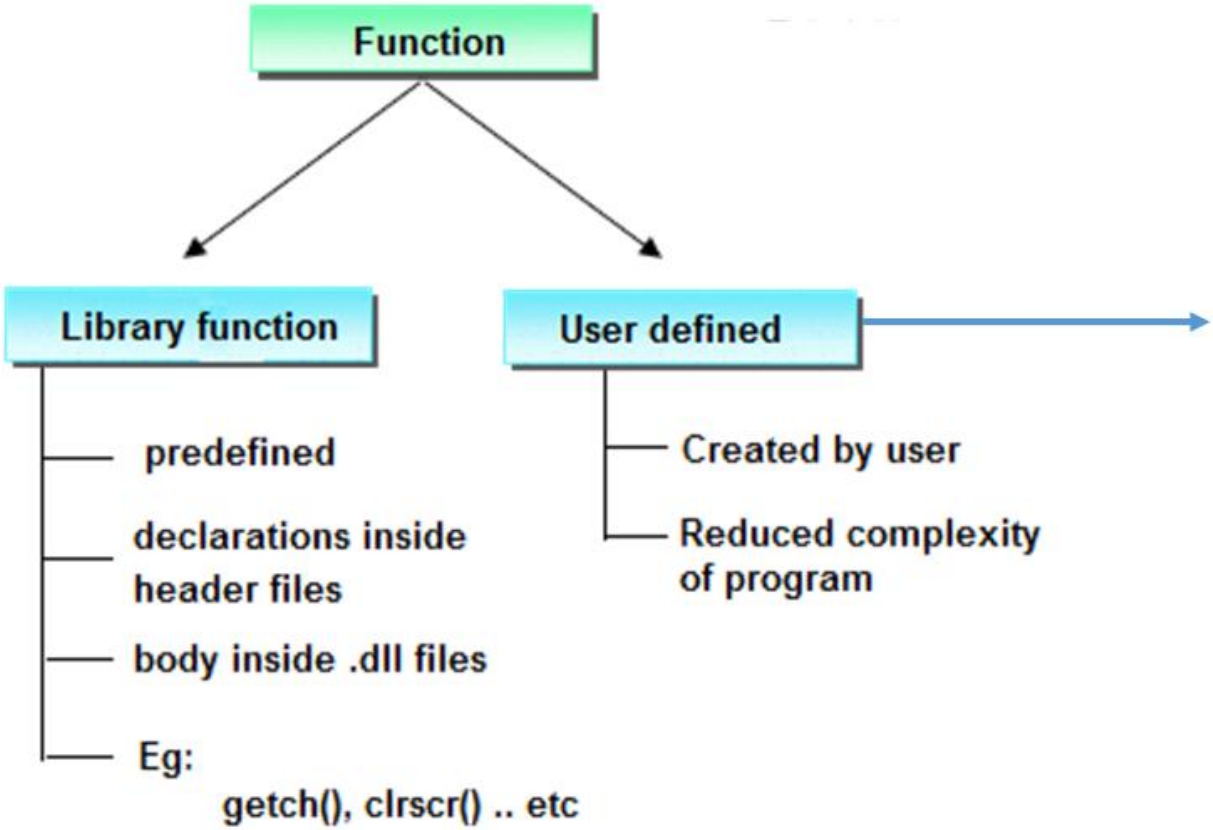
Types of Functions



- C++ allows the programmer to define their own function.
- Programmer can groups code to perform a specific task and given a name (identifier).
- When the function is invoked from any part of the program, it all executes the codes defined in the body of the function

3. Function declaration and definition

Components of a function

- Function name
- Function arguments (parameters)
- Function body
- Return type

Creation of a function

- **Function declaration**
  - The process of tells the compiler about a function name.
  - Also called function prototype creation
- **Function definition**
  - Give body of function (i.e. write logic inside function body).

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There are three ways to declare a function:

- Write your prototype into a separate file, and then use the #include directive to include it in your program.
- Write the prototype in side your program before the main() function.
- Define the function before it is called by any other function.
  - ✓ The definition act as its own declaration.

- **Declaration syntax:**

```
return_type    function_name(parameter);
```

- **Definition syntax:**

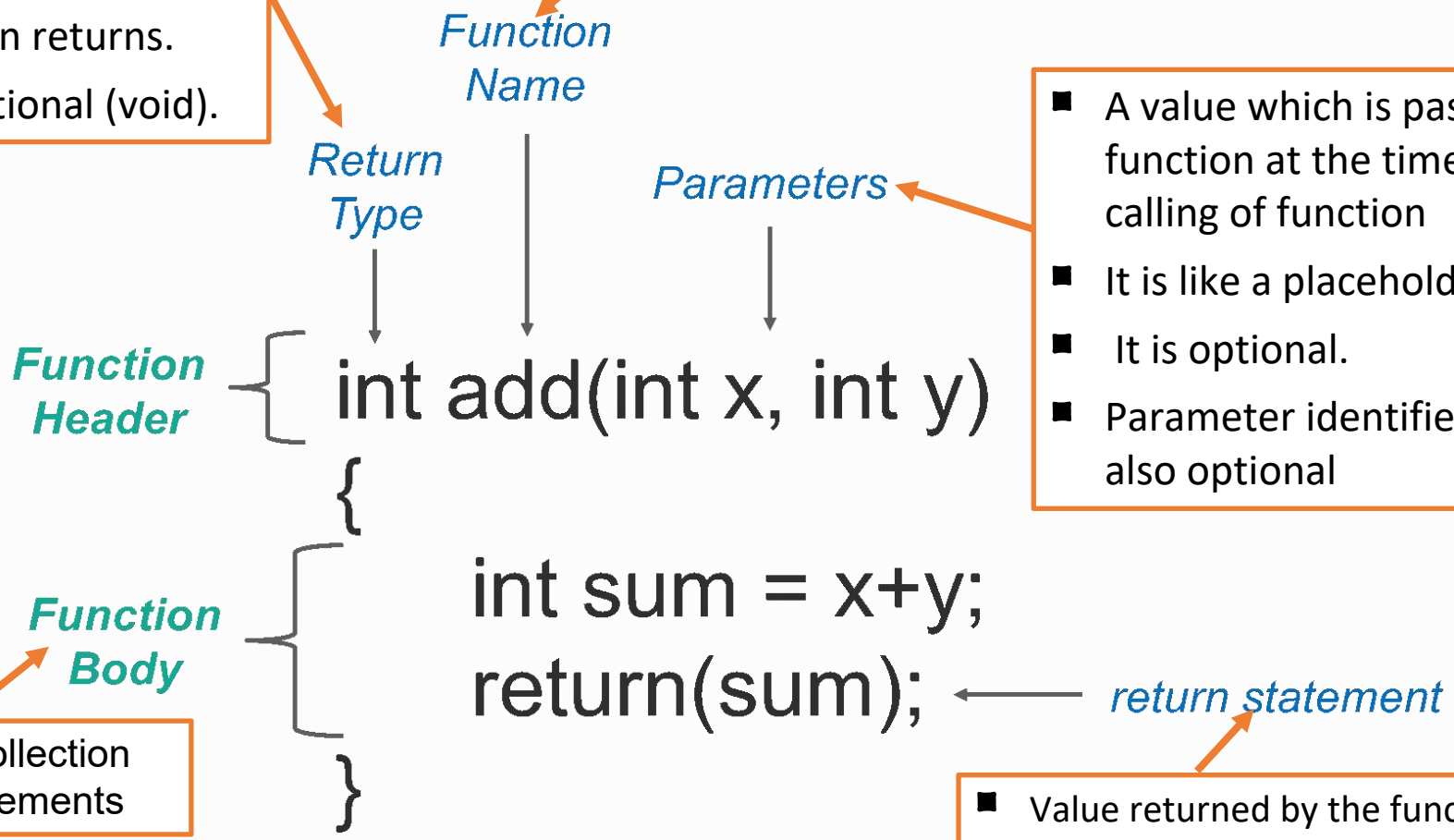
```
returnType functionName (parameter1, parameter2,...) {
    // function body
}
```

Cont'd . . .

- A function may return a value.
- It refers to the data type of the value the function returns.
- It is optional (void).

- The name of function it is decided by programmer
- Should be meaningful valid identifier

- A value which is pass in function at the time of calling of function
- It is like a placeholder.
- It is optional.
- Parameter identifier is also optional



- The collection of statements

- Value returned by the function
- Single literal or expression

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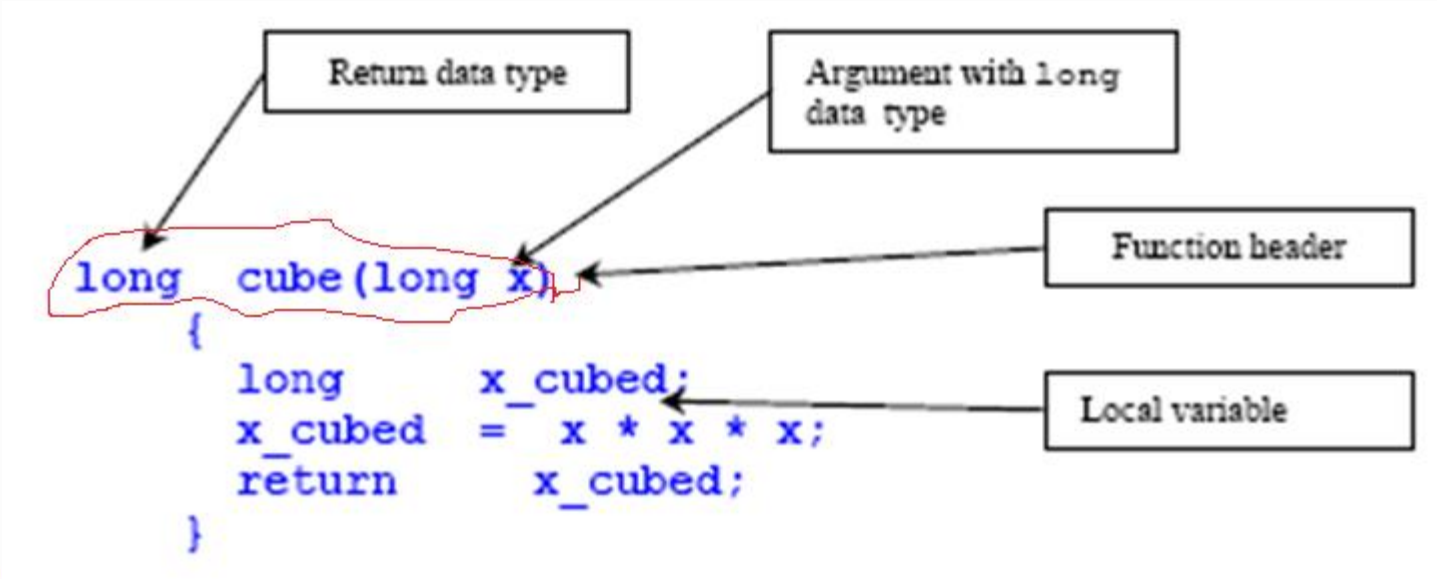
Function Header

- First line of a function, which contains:
  - The type of data returned by the function (if any)
  - The name of the function
  - The type of data that must be passed into the function when it is invoked (if any)



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Examples

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

// display a number
void displayNum(int n1, float n2) {
    cout << "The int number is " << n1;
    cout << "The double number is " << n2;
}

int main() {

     int num1 = 5;
     double num2 = 5.5;

    // calling the function
    displayNum(num1, num2);

    return 0;
}
```

```
#include <iostream>

using namespace std;

// function prototype
int add(int, int);

int main() {
    int sum;

    // calling the function and storing
    // the returned value in sum
    sum = add(100, 78);

    cout << "100 + 78 = " << sum << endl;

    return 0;
}

// function definition
int add(int a, int b) {
    return (a + b);
}
```

4. Function calling, execution and return

Function calling

- **Syntax** :

func_name(parameters);

or

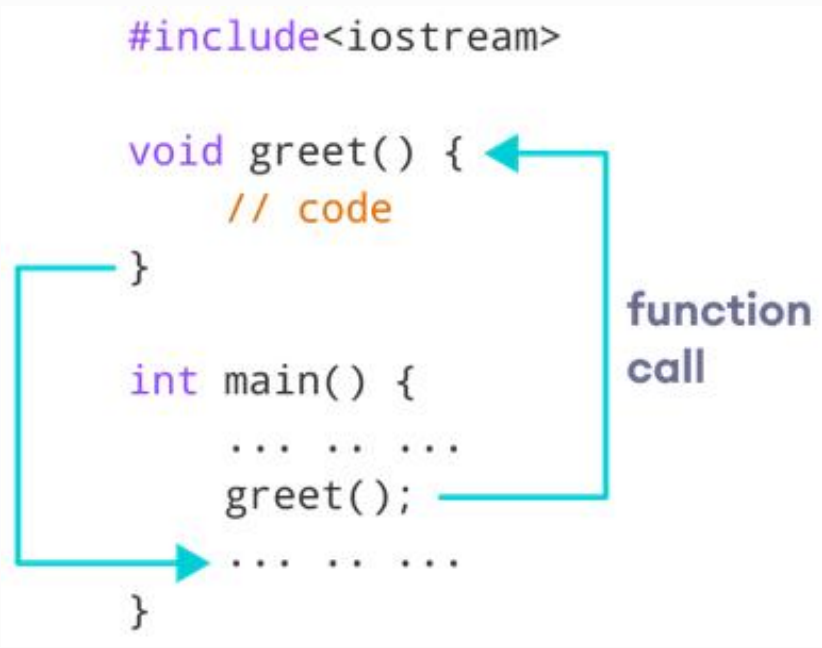
Variable = func_name(parameters);

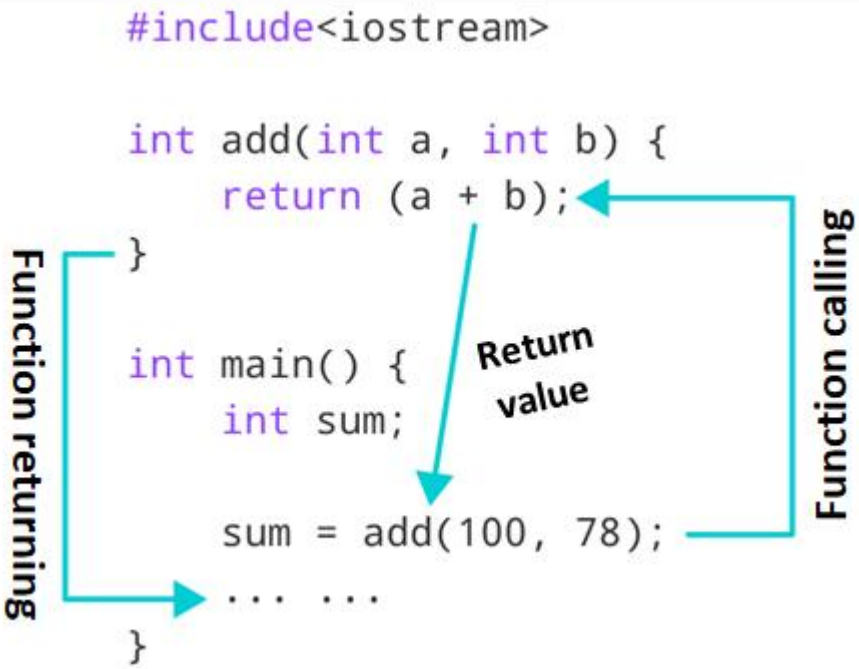
Function return

- **Syntax** :

return value/variable;

or return expression;





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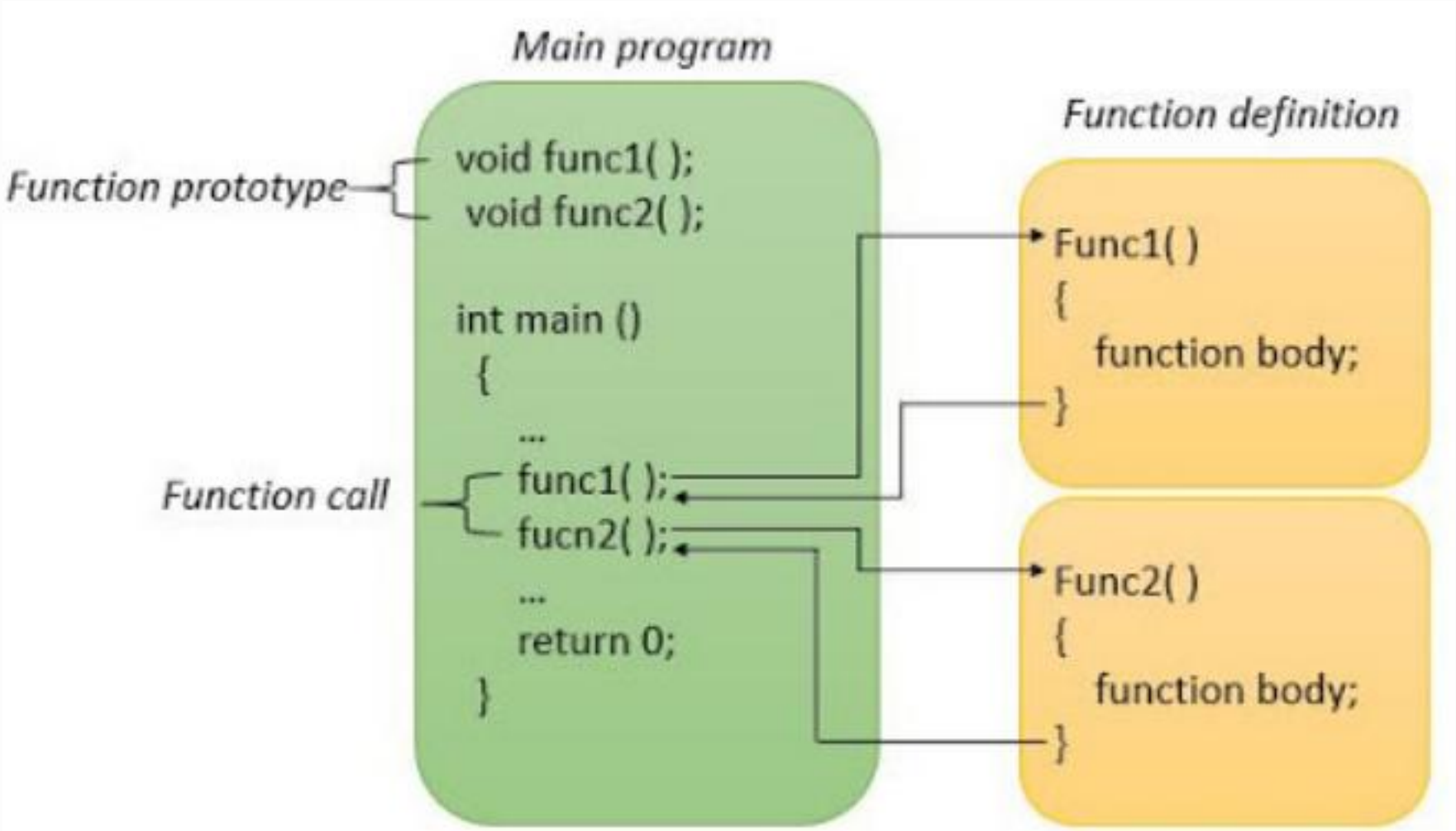
Function execution



5. Parameter passing

- Parameter is means by which functions are communicating and passing data
- Parameters are either Actual parameter or Formal Parameters

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

int add(int, int);

int main() {
     ... .. ...
     sum = add( num1 , num2 );   // Actual parameters: num1 and num2
    ... .. ...
}

int add( int n1 , int n2 ) {     // Formal parameters: n1 and n2
     ... .. ...
     result = n1 + n2;
    ... .. ...
}
```

The variable or expression corresponding to a formal parameter that appears in the function or method call in the calling environ

A variable and its type as they appear in the prototype of the function or method.

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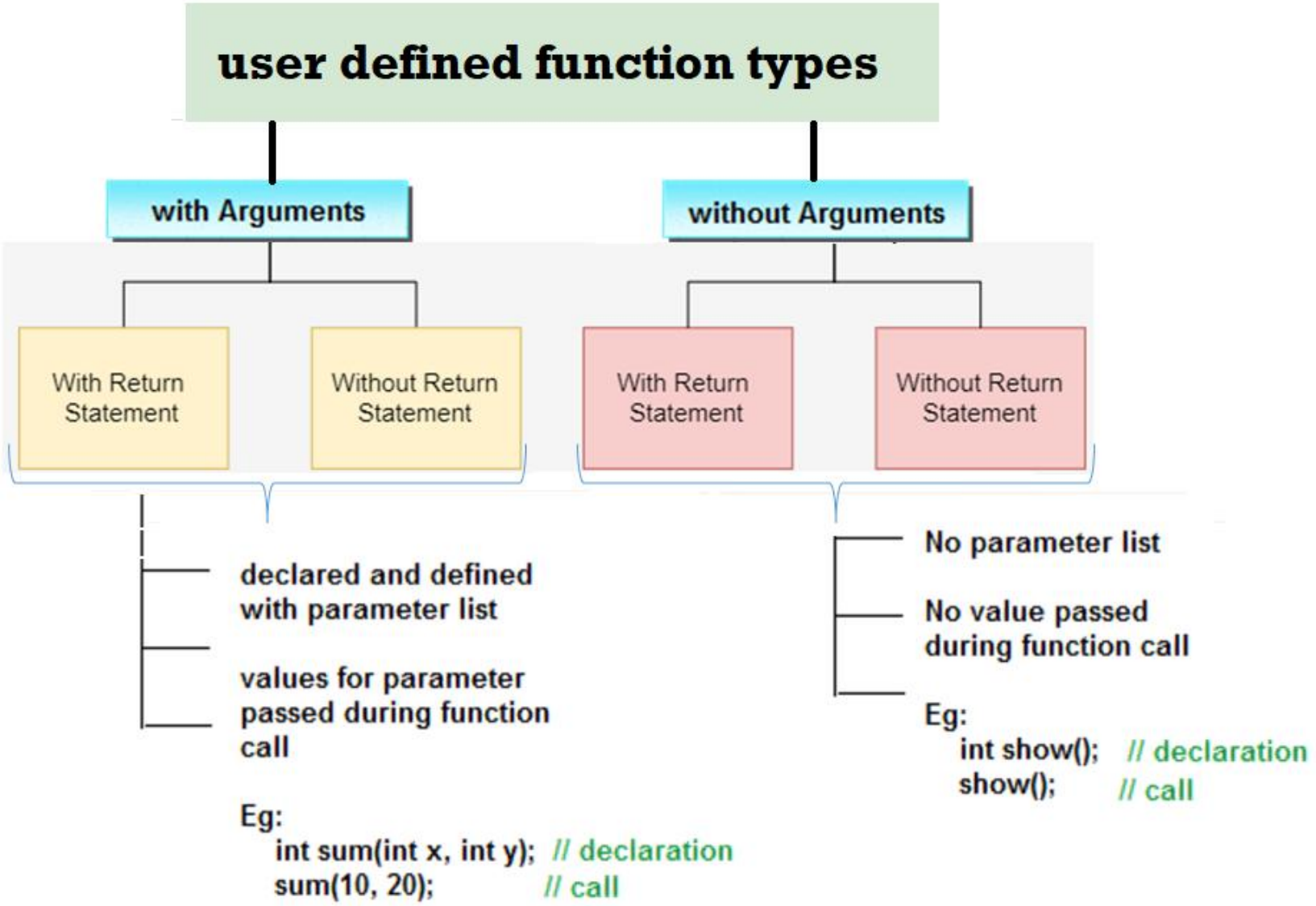
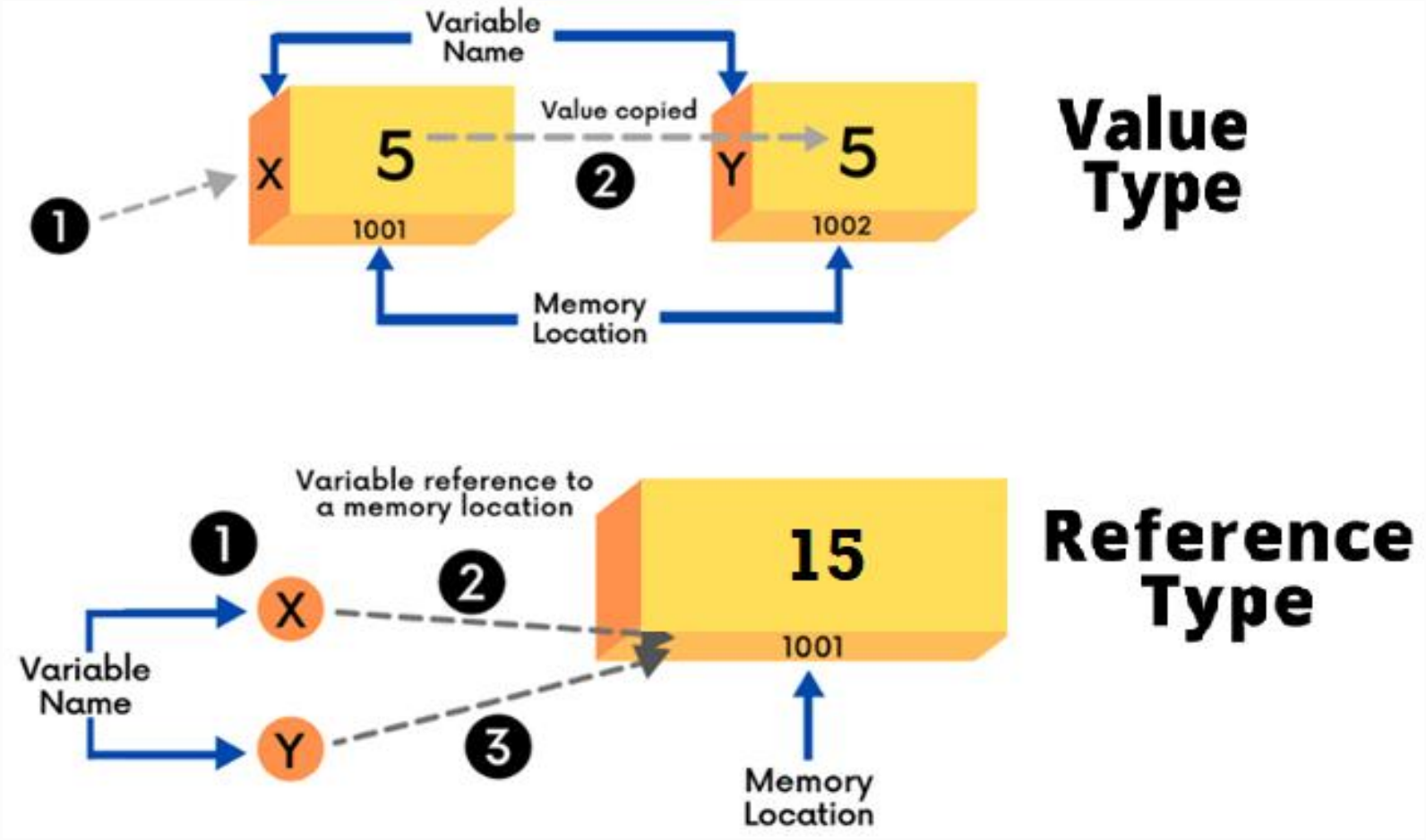

user defined function types
with Arguments
without Arguments
With Return Statement
Without Return Statement
With Return Statement
Without Return Statement
declared and defined with parameter list
values for parameter passed during function call
Eg:
int sum(int x, int y); // declaration
sum(10, 20); // call
No parameter list
No value passed during function call
Eg:
int show(); // declaration
show(); // call

Cont'd . . .

Value Type Vs. Reference Type



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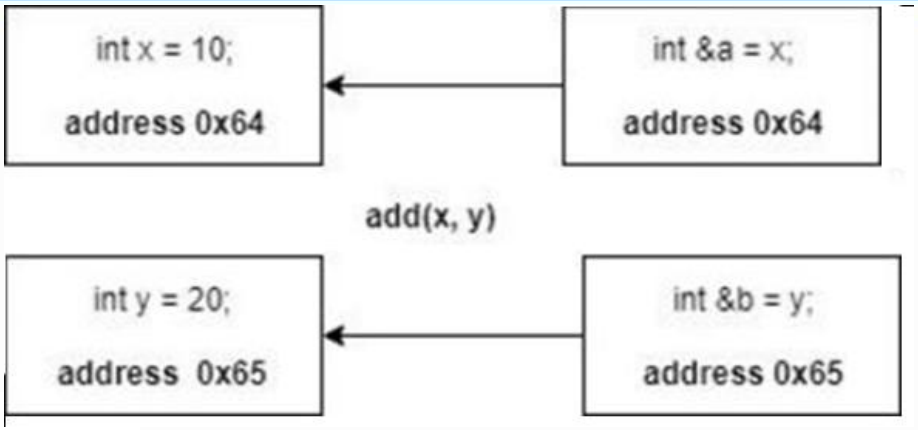
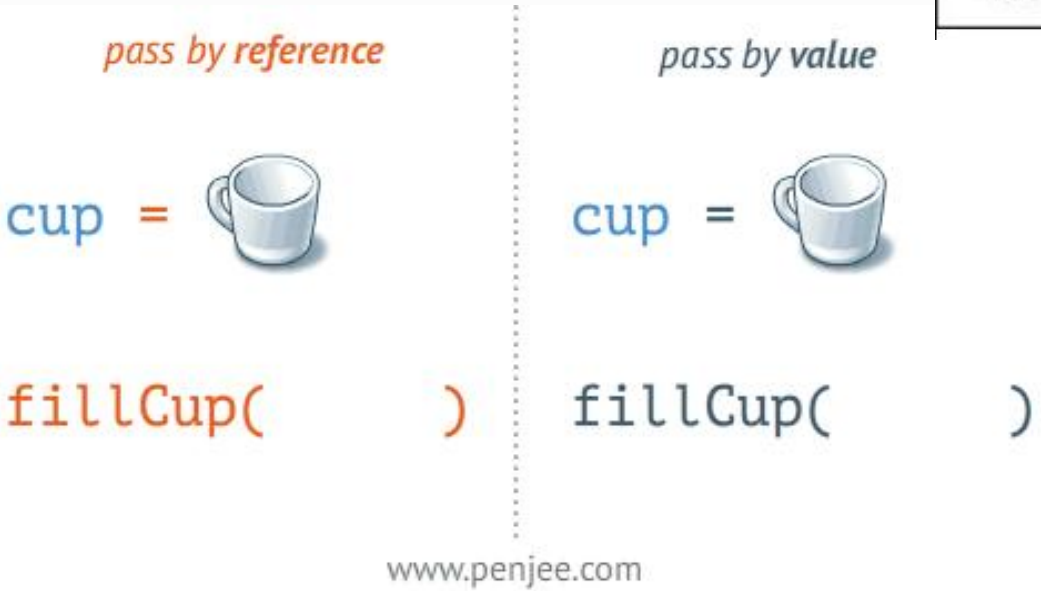
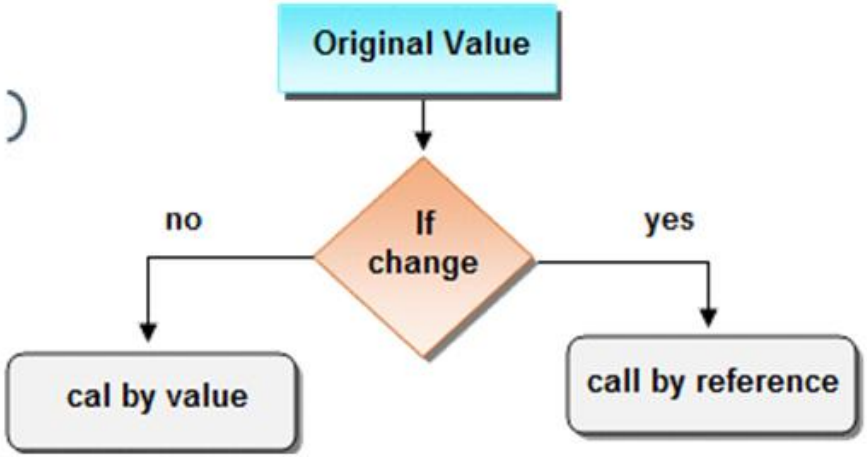
Parameter passing by Value Vs. by Reference







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Parameter passing by Value Vs. by Reference

	call by value	call by reference
1	This method copy original value into function as a arguments.	This method copy address of arguments into function as a arguments.
2	Changes made to the parameter inside the function have no effect on the argument.	Changes made to the parameter affect the argument. Because address is used to access the actual argument.
3	Actual and formal arguments will be created in different memory location	Actual and formal arguments will be created in same memory location

Note: By default, C++ uses call by value to pass arguments.

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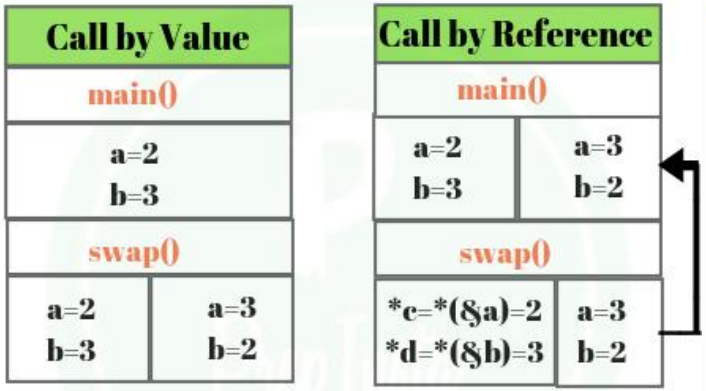
Example 1:

swapping two numbers




```
//C++ pass by value
void swap(int a, int b)
{  int temp;
   temp = a; a = b;
   b = temp;
}

int main() {
   int n = 10, m = 20;
   swap(n, m);
   /* no effect! */
```

```
// C++ pass by ref
void swap(int& a, int& b)
{  int temp;
   temp = a; a = b;
   b = temp;
}

int main() {
   int n = 10, m = 20;
   swap(n, m);
   /* n, m swapped! */
```

Cont'd . . .

"pass-by-value in C++" example:

```
#include <iostream>
using namespace std;
void swap(int first, int second); // prototype
int main()
{
    int x = 5;
    int y = 6;
    cout << "\nBefore: x = " << x << " y = "<< y;
    swap(x, y);
    //were the integers swapped?
    cout << "\nAfter:  x = " << x << " y = " << y
         << endl;
    return 0;
}
void swap(int first, int second)  {
    int temp;
    temp = first;
    first = second;
    second = temp;
}
```

Output:
Before: x = 5 y = 6
After: x = 5 y = 6

"pass-by-reference in C++" example:

```
#include <iostream>
using namespace std;
void swap(int &first, int &second); // prototype
int main()
{
    int x = 5;
    int y = 6;
    cout << "\nBefore: x = " << x << "  y = " << y;
    swap(x, y);
    //were the integers swapped?
    cout << "\nAfter:  x = " <<  x << "  y = " << y
         << endl;
    return 0;
}
void swap(int &first, int &second)  {
    int temp;
    temp = first;
    first = second;
    second = temp;
}
```

Output:
Before: x = 5 y = 6
After: x = 6 y = 5

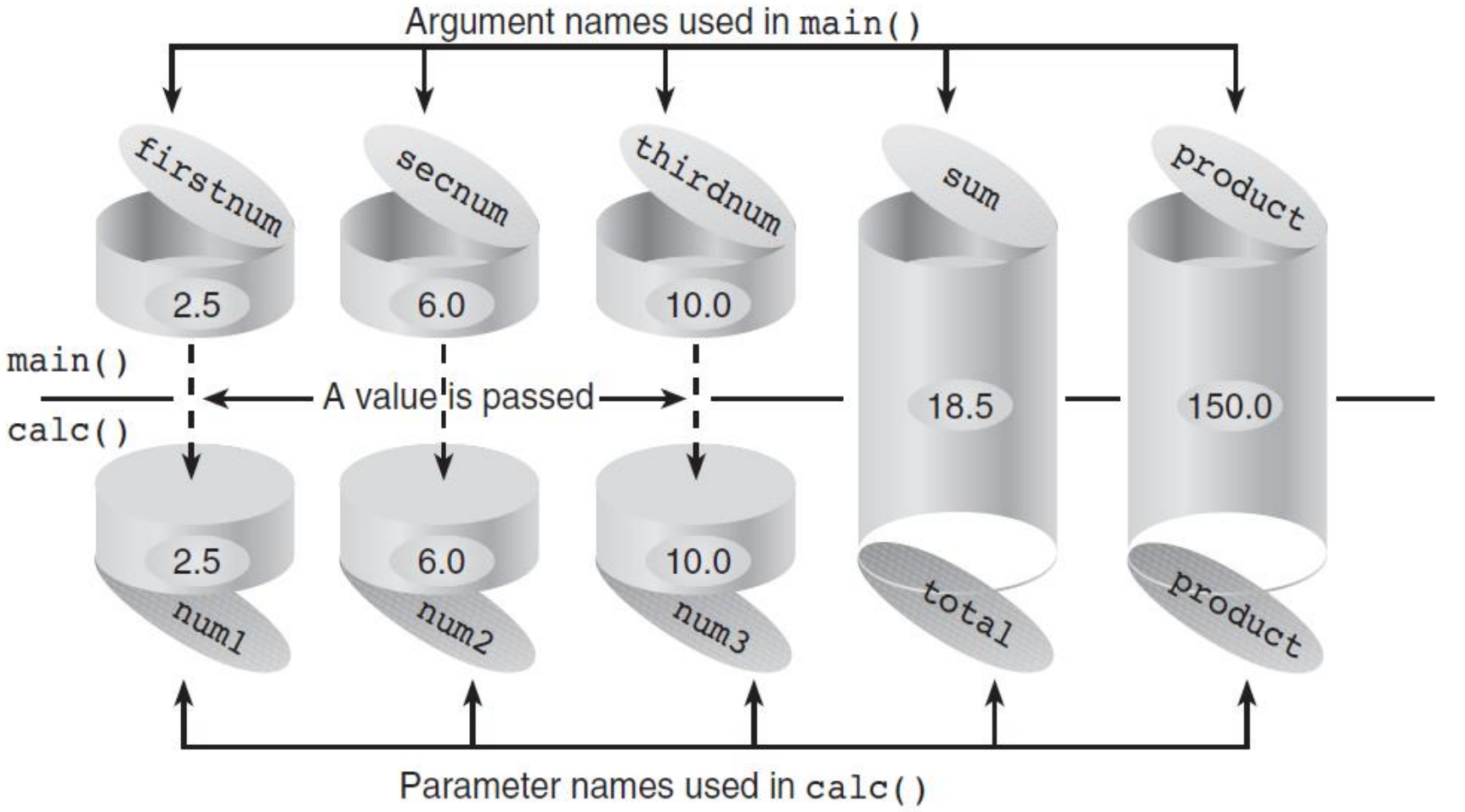
Cont'd . . .

Example 2

```
#include <iostream>
using namespace std;
void calc(double, double, double, double&, double&);   // prototype
int main()
{
   double firstnum, secnum, thirdnum, sum, product;
   cout << "Enter three numbers: ";
   cin  >> firstnum >> secnum >> thirdnum;
   calc(firstnum, secnum, thirdnum, sum, product);   // function call
   cout << "\nThe sum of the numbers is: " << sum << endl;
   cout << "The product of the numbers is: " << product << endl;
   return 0;
}
void calc(double num1, double num2, double num3, double& total, double& product)
{
   total = num1 + num2 + num3;
   product = num1 * num2 * num3;
   return;
}
```

Cont'd . . .

Example 2 . . . .



6. Default Arguments

- In C++ programming, we can provide default values for function parameters.
- If a function with default arguments is called **without passing arguments**, then the default parameters are used.
- However, if **arguments are passed while calling** the function, the **default arguments are ignored.**

Cont'd . . .

- **Example 1**

Case 1 : No argument is passed

```
void temp(int = 10, float = 8.8);

int main() {
   ... ...
   temp();
   ... ...
}

void temp(int i, float f) {
   // code
}
```

Case 2 : First argument is passed

```
void temp(int = 10, float = 8.8);

int main() {
   ... ...
   temp(6);
   ... ...
}

void temp(int i, float f) {
   // code
}
```

Cont'd . . .

- **Example 2**

Case 3 : All arguments are passed

```
void temp(int = 10, float = 8.8);

int main() {
   ... ...
   temp(6, -2.3);
   ... ...
}

void temp(int i, float f) {
   // code
}
```

Case 4 : Second argument is passed

```
void temp(int = 10, float = 8.8);

int main() {
   ... ...
   temp(3.4);
   ... ...
}

void temp(int i, float f) {
   // code
}
```

Error

Cont'd . . .

Things to Remember

- Once we provide a default value for a parameter, all subsequent parameters must also have default values.
- For example:

```
// Invalid
void add(int a, int b = 3, int c, int d);

// Invalid
void add(int a, int b = 3, int c, int d = 4);

// Valid
void add(int a, int c, int b = 3, int d = 4);
```

- If the *default arguments are provided in the function definition* instead of the function prototype, then the function must be defined before the function call

7. Function Overloading

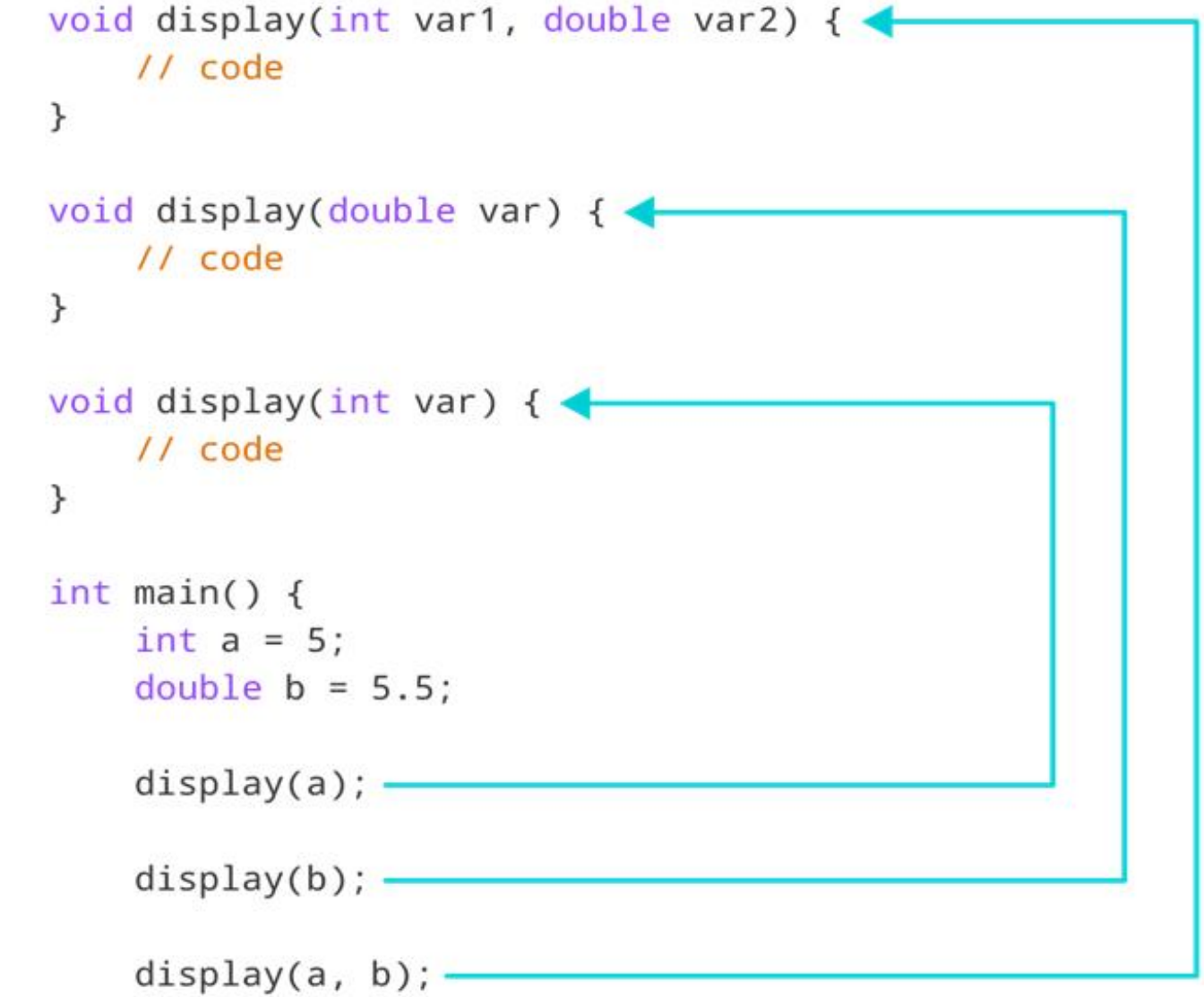
- In C++, two functions can have **the same name** if the *number and/or type of arguments passed is different*.
- These functions having the same name but different arguments are known as **overloaded functions**.
- For example:

```
void myFunction()
void myFunction(int a)
void myFunction(float a)
void myFunction(int a, float b)
float myFunction (float a, int b)
```

Cont'd . . .

Example

```
void display(int var1, double var2) {
    // code
}

void display(double var) {
    // code
}

void display(int var) {
    // code
}

int main() {
    int a = 5;
    double b = 5.5;

    display(a);

    display(b);

    display(a, b);

    ... ...

}
```



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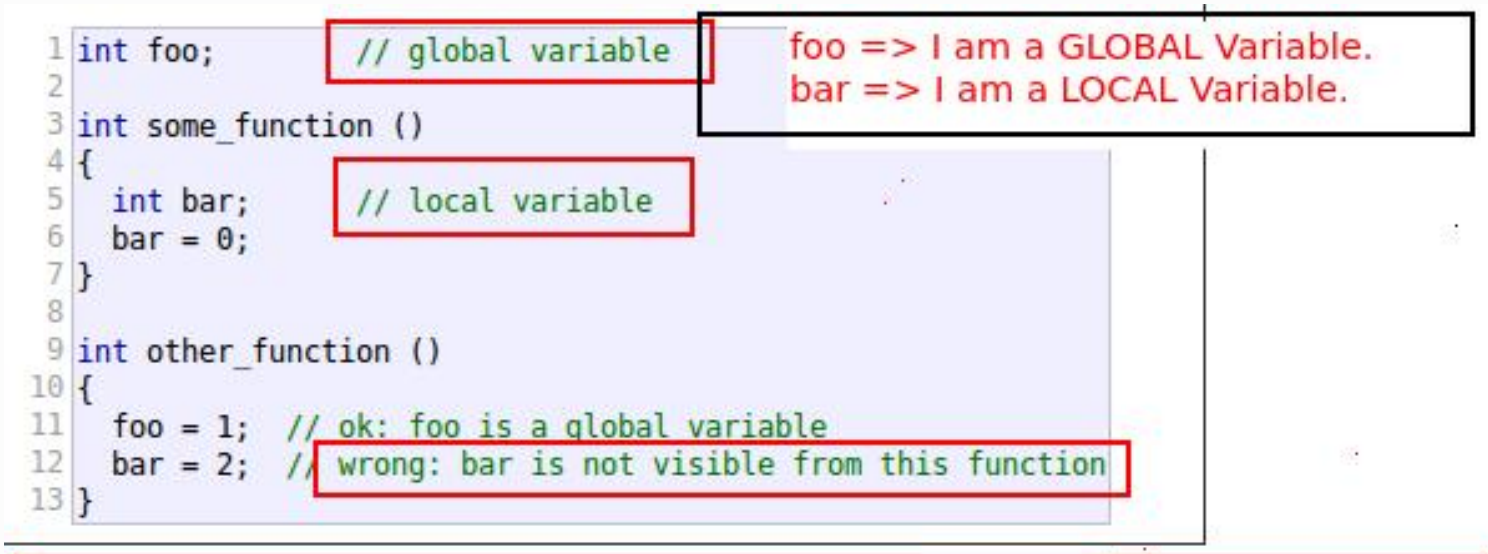
- **Example**

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

int addNumbers(int, int);    // add ints
double addNumbers(double, double); // add doubles

int main(){
    cout <<"Sum of ints: "<<addNumbers(10, 20) << endl;
    cout <<"Sum of doubles: "<< addNumbers(10.2, 20.5) << endl;

    return 0;
}

int addNumbers(int a, int b){
    return a + b;
    }
double addNumbers(double a, double b){
    return a + b;
}
```

8. Revision on variable scope

- The scope of a variable is the portion of the program where the variable is valid or "known".



=> As You know in C++ scope of any variable is dependent on blocks or group of statement blocks (Usually grouped by { } and use ; to seperate multiple statements.)

=> GLOBAL Variable, can be used and looked for any-where in code.
=> LOCAL Variable exists only in their scopes until you make them GLOBAL , You can declare any LOCAL Variable as GLOBAL.

Cont'd . . .

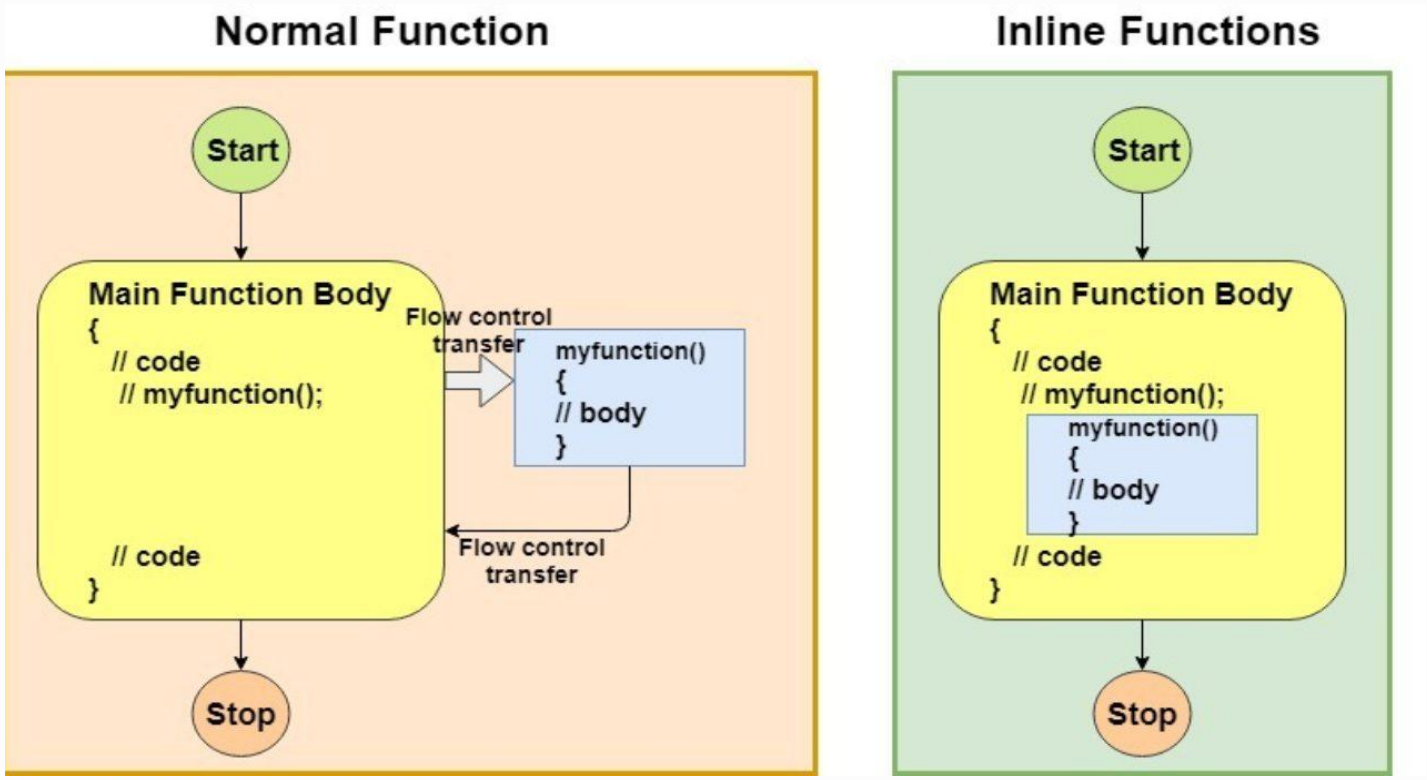
- What is the output of the following code fragment?

```
void  thisFunc(int);
int m2;

int main()
{
  int  m1;
  m1 = 1;   m2 = 21;
  thisFunc(m1);
  cout << m1 << "   " << m2 << endl;
  return 0;
}

void thisFunc (int a)
{
  int   m2;
  m2 = a + 9;   a++;
  cout << a << "   " << m2 << ", ";
}
```

Output:

9. Inline function

- If a function is **inline**, the compiler places a copy of the code of that function at each point where the function is called.
- To make any function inline function just preceded that function with **inline** keyword.



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Why use Inline function

- Whenever we call any function many time then, it take a lot of extra time in execution of series of instructions such as saving the register, pushing arguments, returning to calling function.
- To solve this problem in C++ introduce inline function.
- The main advantage of inline function is it make the program faster.
- **Example**

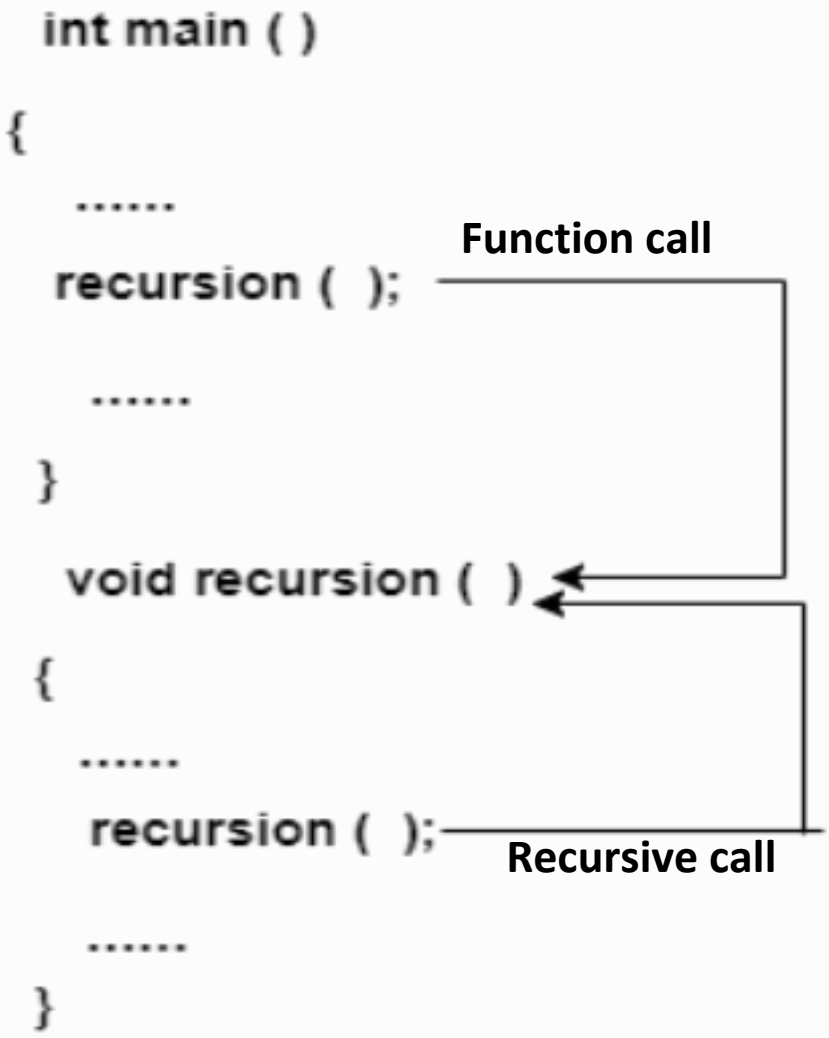
```
#include<iostream.h>
using namespace std;

inline void show()
{
  cout<<"Hello world";
}

int main()
{
      show();     //Call it like a normal function
      return ;
}
```

10. Recursive function

- A function that calls itself is known as a recursive function.
- The technique is known as recursion.



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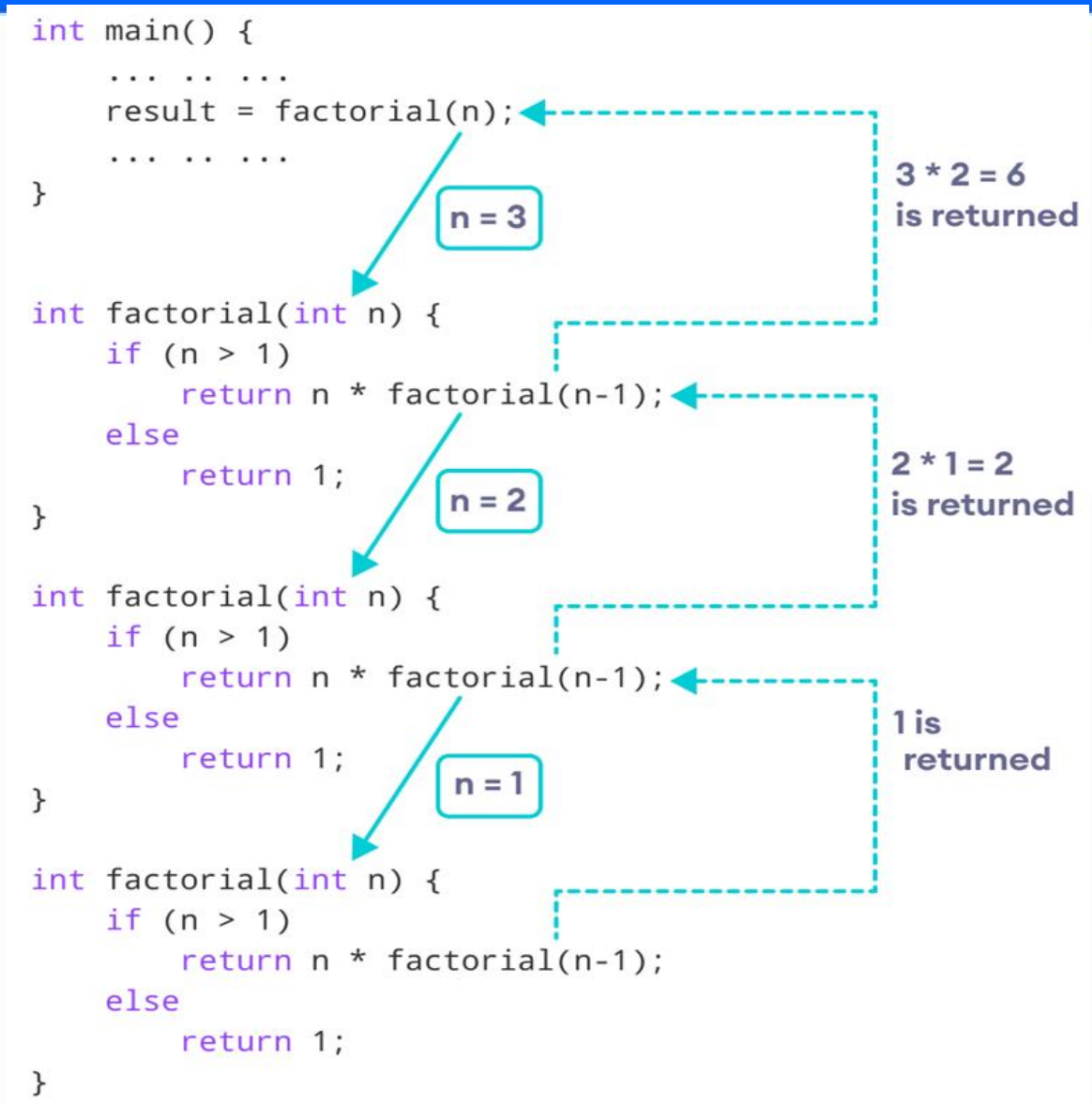
- **Example:**

  factorial finder function



10. Function with Array

(a) Calling function with array element

- Indexed variables can be arguments to functions
- Example: If a program contains these declaration

```
int i, n, a[10];

void my_function(int n);
```

- An array elements **a[0] through a[9]** are of type int, and calling the function as follow is legal:

```
my_function( a[ 0 ] );
my_function( a[ 3 ] );
my_function( a[  i ]  );
```

Note:

- It also works the same for 2D array and string

Cont'd . . .

(b) Array as formal parameter

- An entire array can be used as a formal parameter
- Such a parameter is called an **array parameter**
  - It is neither a call-by-value nor a call-by-reference parameter
  - However, behave much like call-by-reference parameters
- An array parameter is indicated using empty brackets or with array size in the parameter list

```
void fill_up(int a[ ], int size);   or
void fill_up(int a[5 ], int size);
```

Note:

- Because a function *does not know the size of an array argument*, the programmer should include a formal parameter that specifies the size of the array as shown in the example above

Cont'd . . .

Example 1: passing 1D arrays to function

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

 //function declaration:
void readArray(int arr[], int size);
void printArray(int arr[5], int size);
double getAverage(int arr[5]);

int main () {

   int balance[5];

   //calling function with array as an argument.
   readArray(balance, 5);
   printArray(balance, 5);
   double avg = getAverage(balance) ;

   // output the returned value, average
   cout<<"\n\nAverage value is: "<<avg<<endl;

   return 0;
}
```

Function declaration:
To receive an array of int, arr[] as argument

```
C:\Users\Habesh\Documents\zz Exercises\array
Enter the 1 element: 57
Enter the 2 element: 94
Enter the 3 element: 61
Enter the 4 element: 37
Enter the 5 element: 85

The array elements are:
57 94 61 37 85

Average value is: 66.8

--------------------------------
Process exited after 9.555 seconds
Press any key to continue . . .
```

Cont'd . . .

Passing arrays to function ……

```
//function definition
void readArray(int arr[], int size){
    for (int i = 0; i< size; ++i)
    {
        cout<<"Enter the "<<i+1<<" element: ";
        cin>>arr[i];
    }
}

void printArray(int arr[5], int size){
    cout<<"\nThe array elements are: "<<endl;
    for (int i = 0; i< size; ++i)
    {
        cout<<arr[i]<<" ";
    }
}

double getAverage(int arr[5]){
   int sum = 0;
   for (int i = 0; i < 5; ++i) {
      sum += arr[i];
   }
   return (double(sum) / 5);
}
```

Cont'd . . .

(c) Returning an Array *(is it possible?)*

- Recall that functions can return **a value (single data element)** of type int, double, char, . . .
- Because array consist a set of the same type data elements, ***functions cannot return array.***
- However, an individual array element (single array element specified by index) can be returned.
- For example:

```
int myFunc(){
        int myArray[10];
        - - - - --
   return myArray;   //invalid
}
```

```
//instead this is valid
return myArray[1];
```

Cont'd . . .

Example 2: Passing 2D array to function

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

const int row=3, col=4;

void Read2Array(int arr[][col] );
void writing(int arr[row][col]);

int main ()
{
    int a[row][col];

    Read2Array(a);
    writing(a);

   return 0;
}
```

Note:

- With 2D arrays, You can specify both dimensions
- However, the first dimension (number of rows) may be omitted, like you see on the **Read2Array() function**
- But the second dimension (number of columns) cannot be omitted.

Cont'd . . .

2D array as parameter example …

```
void Read2Array(int arr[][col] )  {
    int i,j;
    for (i=0; i<row; i++)
        for ( j=0; j<col; j++)
        {
            cout<<"Enter "<<i*j+1<<" Element: "
            cin >> arr[i][j];
        }

}

void writing(int arr[row][col])  {
    int i,j;
    cout<<"Array Elements are:\n"
    for (i=0; i<row; i++)
    {
        for ( j=0; j<col; j++)
            cout << arr[i][j] << '\t';
        cout << endl;
    }
}
```

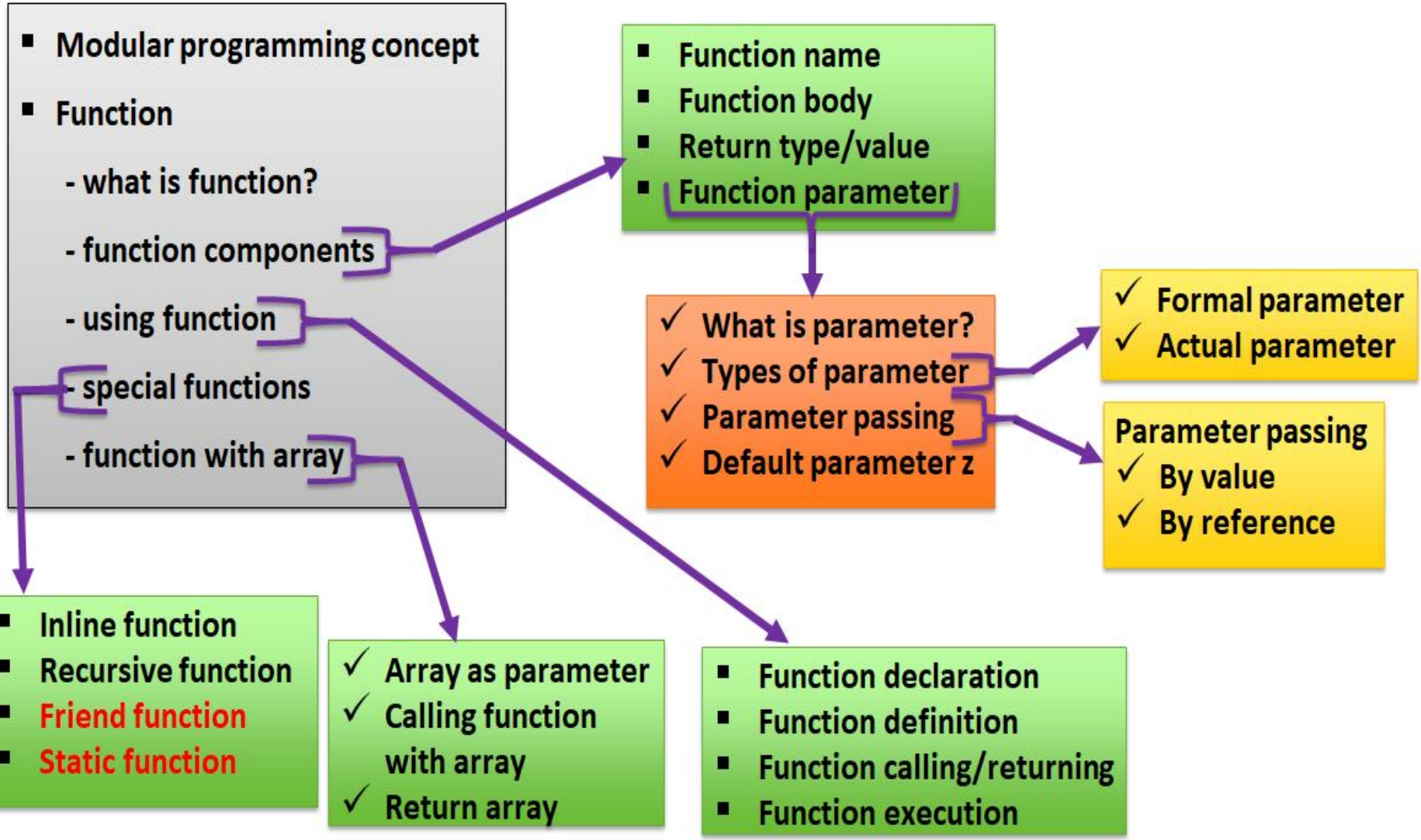
Cont'd . . .

Example 3:

- **Passing string to function as argument**

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

void display(char s[]){
    cout<<"Entered char array is: "<<s<<endl;
}

void display(string s){
    cout<<"Entered string is: "<<s<<endl;
}

int main(){
    char str1[100];
    string str2;
    cout << "Enter a string: ";
    getline(cin, str1);
    cout << "Enter another string: ";
    cin.get(str, 100, '\n');

    display1(str1);
    display2(str2);
    return 0;
}
```

Summary of Function



Practical Exercise

1. For a function named **getProduct** and that has parameters namely **num1 and num2** which their data type is integer and double respectively and that should multiply the integer value by the double number and then return the result as a double number.
   - Write a *function declaration (prototype)* for the getProduct function.
   - Write the *function call statement* to the getProduct function, and assigning its return value to a *product variable*.
   - Name the actual arguments firstNum and secondNum.

2. Write a function-based C++ statement that adds the cube of the number stored in the **num1** variable to the square root of the number stored in the **num2** variable. The program should prompt the user to enter the two number inside *main()* function. The statement should assign the result to the **answer** variable and return to the *main()* function. All of the variables have the double data type. (Tip: use built in library to find the cube and square of the numbers)
3. Modified the program of Ex. 1 to define a void function with three parameter. The sum is stored on the third parameter and the result is printed inside main function.

Practical Exercise

4. Write a function based C++ program that find the **Fibonacci series** of a given number. Define a function named **fibonacci** that has one argument with default argument and returns integer. The function is called both with parameter and without parameter.

5. Write a program that print the **right angle triangle** pattern of minimum length 5 using '*' as a default symbols. The program should prompt the user to choose either to print default pattern or enter his/her own by entering different symbol and size.

6. Write a function based program to find the square of integer and rational number. Use two function of the same name that accept integer and double parameters by reference.

7. Write an application that read low & high temperature and find daily, weekly, and monthly average temperature. Define two functions named tempFinder with no parameter and 1 integer parameter-length respectively. The program should prompt the user to read number of days in a week and month inside main function. Call the functions with and with out parameter.

Practical Exercise

8. Write a program that find a factorial of a number and also generate a Fibonacci series about it using

    a) Loop

    b) Function

Quiz

1. Write an overloaded function **max** that takes either two or three parameters of type double and returns the largest of them.
2. Write a function based program to find the square of integer and rational number. Use two function of the same name that accept integer and double parameters by reference.
3. Write a program function based program that read the two sides of right angle triangle and find the length of the third side. The function accepts the two sides as a parameter by value and third side by reference and print inside main function.
4. Develop a function based program that read an integer number and find the square, if it is -ve and otherwise square root. Define a function that accept the number as a parameter and return either the square or the square root.

Quiz

4. Write the C++ program for a void function that receives **three double variables**: the first two *by value* and the last one *by reference*. Name the formal parameters **n1, n2, and answer**. The function should divide the n1 variable by the n2 variable and then store the result in the answer variable. Name the function calcQuotient. Also write an appropriate function prototype for the calcQuotient function. In addition, write a statement that invokes the calcQuotient function, passing it the actual parameters **num1, num2, and quotient** variables.

Reading Resources/Materials

Chapter 9 & 10:

- ✔ Diane Zak; An Introduction to Programming with C++ (8th Edition), 2016 Cengage Learning

Chapter 5:

- ✔ Walter Savitch; Problem Solving With C++ [10th edition, University of California, San Diego, 2018

Chapter 6:

- ✔ P. Deitel , H. Deitel; C++ how to program, 10th edition, Global Edition (2017)

Thank You
For Your Attention!!