

# **3**

# **Functions**

# Why Learning Functions?

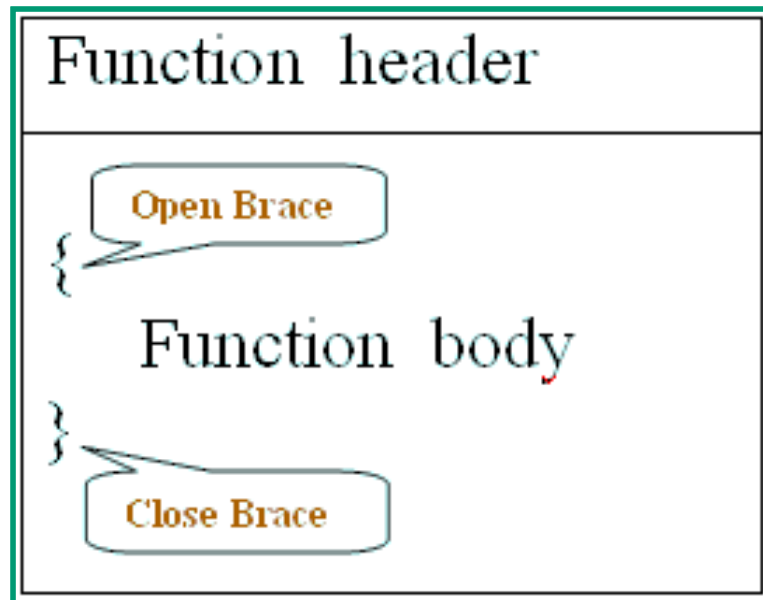
- With Sequential, Branching and Looping, you will be able to build programs for simple applications. However, for more complex applications, your programs may be long and certain code may be repeated in the program.
- Functions aim to group specific tasks, so that code will not be repeated. It also helps to improve your program readability and efficiency.
- In this lecture, we discuss the concepts on functions.

# Functions

- **Function Definition**
- Function Prototypes
- Function Flow
- Parameter Passing: Call by Value
- Storage Scope of Variables
- Functional Decomposition

# Function Definition

- A **function** is a self-contained unit of code to carry out a specific task, e.g. **printf()**, **sqrt()**.
- A **function** consists of
  - a header
  - an opening curly brace
  - a function body
  - a closing curly brace



## Example:

```
float findMax(float x, float y) // header
{
    // function body
    float maxnum;

    if (x >= y)
        maxnum = x;
    else
        maxnum = y;

    return maxnum;
}
```

# Function Header

**Return\_type** **Function\_name** (**Parameter\_list**)

- **Function\_name**

- specifies the name given to the function. Try to give a meaningful name to the function.

- **Parameter\_list**

- specifies a list of parameters which contains the data that are passed in by the calling function.

- **Return\_type**

- specifies the **type** of the data to be returned to the calling function.

# Function Header: Parameter List

- Parameters define the **data** passed into the function.
- A function can have no parameter, one parameter or many parameters.

**type** parameterName[, **type** parameterName]

**Example:** float **findMax**(float x, float y)

- Each parameter has:
  - **parameter name**
  - **data type** (such as int, char, etc.) of the parameter
- The function assumes that these parameter inputs will be supplied to the function when they are being called.

# Function Header: Return\_type

- **Return Type** is the data type returned from the function, it can be int, float, char, void, or nothing.
- The syntax for the **return** statement is **return (expression);**
- **void** – the function will not return any value.

```
void hello_n_times(int n)
{
    int count;
    for (count = 0; count < n; count++)
        printf("hello\n");
    /* no return statement */
}
```

- **nothing** – if defined with no type, the **default type** is **int**.

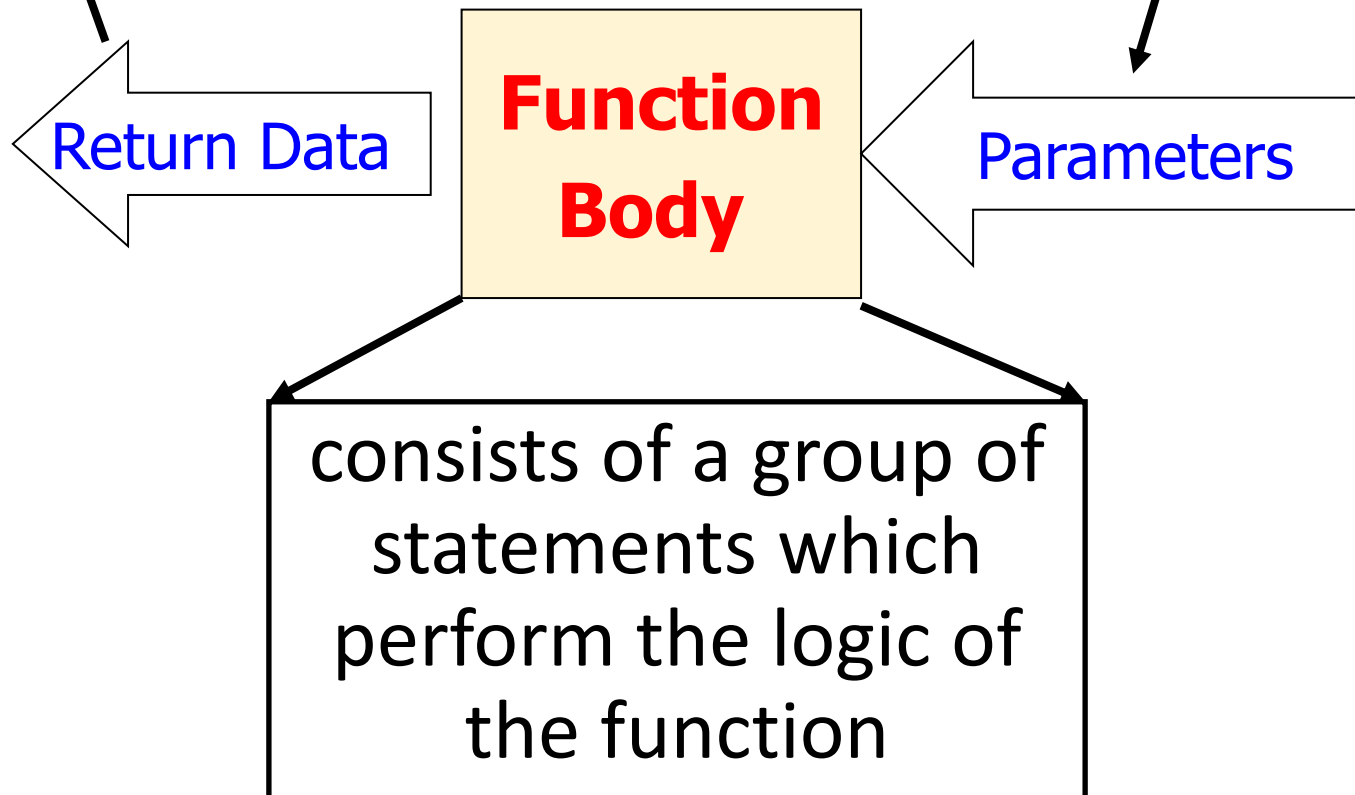
```
successor(int num) /* i.e. int successor(int num) */
{
    return num + 1; /* has a return statement */
}
```

# Function Body

Function Header:

**Return\_type** **Function\_name** (**Parameter\_list**)

Example: float **findMax**(float x, float y)



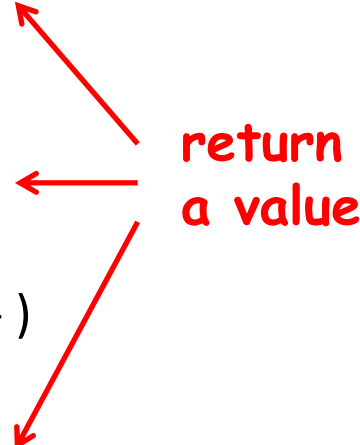


# Multiple Return Statements

- The **return** statement terminates the execution of a function and passes the control to the calling function.
- The return statement may appear in any place or in more than one place inside the function body.

```
int factorial(int n)
{
    int temp = 1;    // local variable

    if (n < 0) {
        printf("error: must be +ve\n");
        return 0;
    }
    else if (n == 0)
        return 1;
    else
        for ( ; n > 0; n-- )
            temp *= n;
        return temp;
}
```



**return a value**

```
void hello_n_times(int n)
{
    int count;
    if (n < 0)
        return; ← no return value
    else
        for (count = 0; count < n; count++)
            printf("Hello!\n");
}
```

# Function: Examples

## Compute Grade:

```
char findGrade(float marks) {  
    char grade; // variable  
  
    /* function body */  
    if (marks >= 50)  
        grade = 'P';  
    else  
        grade = 'F';  
    return grade;  
}
```

# Function: Examples

## Compute Grade:

```
char findGrade(float marks) {  
    char grade; // variable  
  
    /* function body */  
    if (marks >= 50)  
        grade = 'P';  
    else  
        grade = 'F';  
    return grade;  
}
```

## Compute Circle Area:

```
float areaOfCircle(float radius) {  
    const float pi = 3.14;  
    float area;  
  
    /* function body */  
    area = pi*radius*radius;  
    return area;  
}
```

# Functions

- Function Definition
- **Function Prototypes**
- Function Flow
- Parameter Passing: Call by Value
- Storage Scope of Variables
- Functional Decomposition

# Function Prototypes

- We need to declare a function before using it in other functions.
- **Function prototype** is used to declare a function. It provides the information about
  1. the return type of the function
  2. the name of the function
  3. the number and types of the arguments
- The declaration may be the same as the function header but terminated by a semicolon.

**Example:**  
float **findMax**(float x, float y) ;
- Two ways to declare parameters in the parameter list:
  - (1) With parameter name:  
**void hello\_n\_times**(int n);
  - (2) Without parameter names:  
**double distance**(double, double);

# Function Prototypes: Where to declare it?

- The declaration has to be done **before** the function is called:
  - (1) **before** the main() header
  - (2) **inside** the main() body or
  - (3) **inside** any function which uses it

# Function Prototypes: Before the main()

- The declaration has to be done **before** the function is called:
  - (1) before the main() header
  - (2) inside the main() body or
  - (3) inside any function which uses it

## Before the main():

```
#include <stdio.h>
int factorial(int n); // function prototype

int main( )
{   int x;
    x = factorial(5); // use factorial() here
}

int factorial(int n) /* function definition*/
{
    ....
}
```

# Function Prototype: Inside the main()

- The declaration has to be done **before** the function is called:
  - (1) before the main() header
  - (2) inside the main() body or
  - (3) inside any function which uses it

## Inside the main():

```
#include <stdio.h>

int main()
{
    int x;
    int factorial(int);           // function prototype
    x = factorial(5);           // use factorial() here
    ....
}

int factorial(int n)           // function definition
{
    ....
}
```



# Functions

- Function Definition
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- **Function Flow**
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# Calling Function

- A function is executed when it is called.
- A function call has the following format:

**Function\_name** (**Argument\_list**);

Example:

```
float num1=5, num2=10, max;  
max = findMax(num1, num2);
```

Pass in

ARGUMENTS

num1, num2

Function Header:

**Return\_type** **Function\_name** (**Parameter\_list**)

Example: float findMax(float x, float y)

x=5, y=10

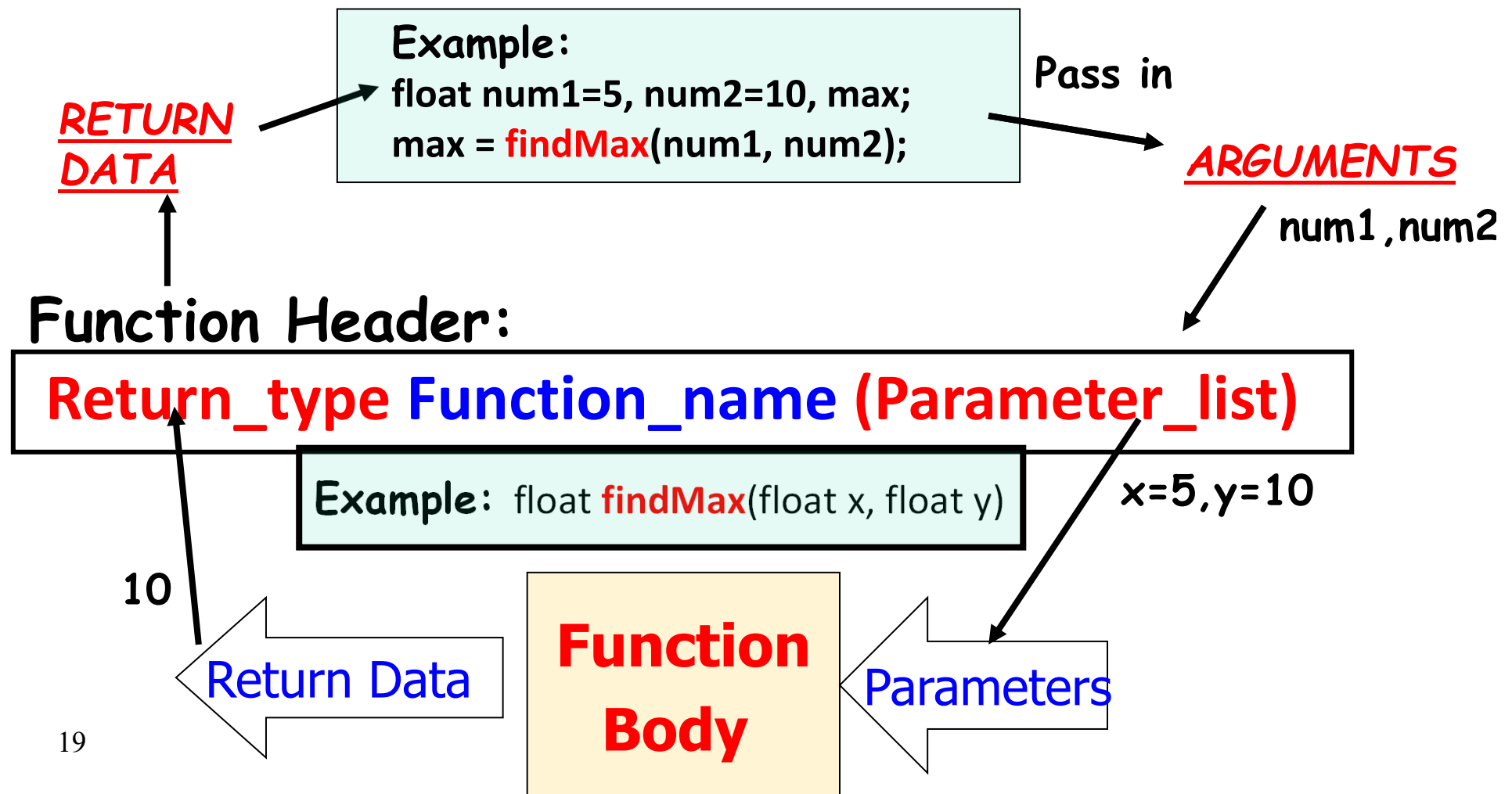
**Function  
Body**

Parameters

# Returning Value

- A function is executed when it is called.
- A function call has the following format:

**Function\_name** (**Argument\_list**);



# Function Flow

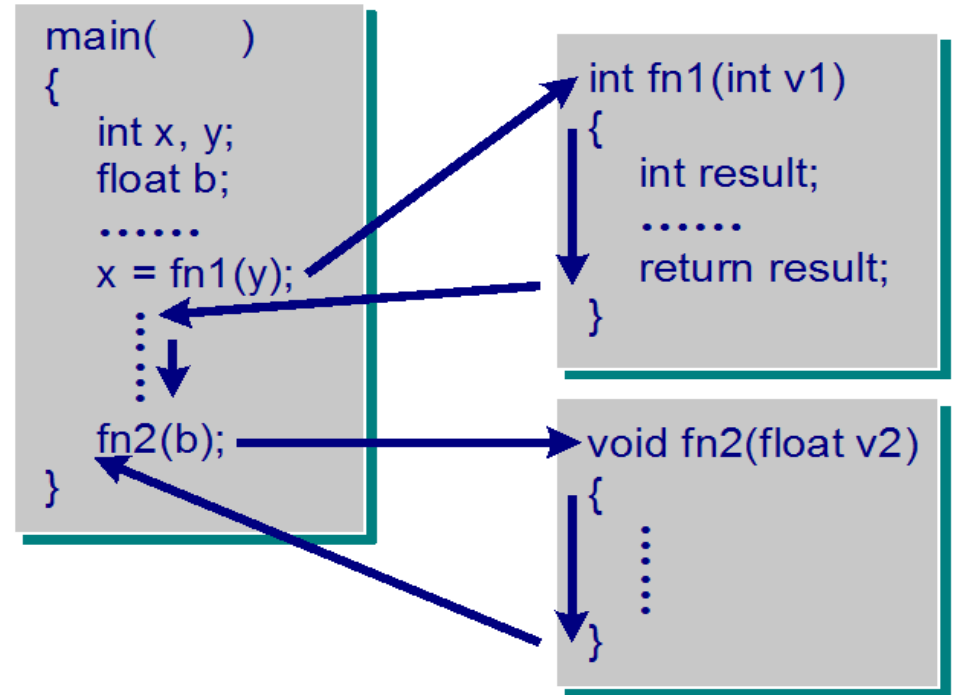
```
#include <stdio.h>

int fn1(int v1);    // fn prototype
void fn2(float v2); // fn prototype

int main( )
{
    ...
    x=fn1(y); // fn call - with return value
    ....
    fn2(b); // fn call - no return value
    return 0;
}

int fn1 (int v1) // fn definition
{
    int result; .... return result; }


void fn2 (float v2) // function definition
{
    .... }
```



# Function Flow: Example

## Compute Grade:

```
#include <stdio.h>
char findGrade(float marks);
int main( )
{
    char answer;
    answer = findGrade(68.5);
    printf("Grade is %c", answer);
    return 0;
}
char findGrade(float marks) {
    char grade; // variable
    if (marks >= 50)
        grade = 'P';
    else
        grade = 'F';
    return grade;
}
```



## Output


Grade is P

# Function Flow: Example

## Compute Circle Area:

```
#include <stdio.h>
float areaOfCircle(float);
int main( )
{
    float answer;
    answer = areaOfCircle(2.5);
    printf("Area is %.1f", answer);
    return 0;
}
float areaOfCircle(float radius) {
    const float pi = 3.14;
    float area;

    /* function body */
    area = pi*radius*radius;
    return area;
}
```



## Output

Area is 19.6

# Functions

- Function Definition
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- **Parameter Passing: Call by Value**
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# Parameter Passing: Call by Value

- **Call by Value** - **Communication** between a function and the calling body is done through arguments and the return value of a function.

---

```
#include <stdio.h>
```

```
int add1(int);
```

```
int main( )
```

```
{
```

```
    int num = 5;
```

```
    num = add1(num); // num – called argument
```

```
    printf("The value of num is: %d", num);
```

```
    return 0;
```

```
}
```

---

```
int add1(int value) // value – called parameter
```

```
{
```

```
    value++;
```

```
    return value;
```

```
}
```

---

num [ 5 ] -> [ 6 ]

**Output**

The value of num is: 6

value [ 5 ] -> [ 6 ]

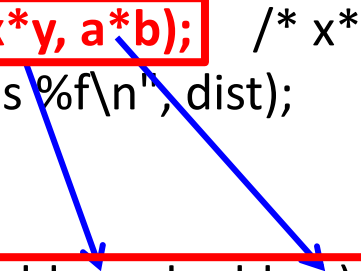


# Parameter Passing: Example

```
#include <stdio.h>
#include <math.h>
double distance (double, double); // function prototype

int main()
{
    double dist;
    double x=2.0, y=4.5, a=3.0, b=5.5;
    dist = distance(2.0, 4.5); /* 2.0, 4.5 - arguments */
    printf("The dist is %f\n", dist);
    dist = distance(x*y, a*b); /* x*y, a*b - arguments */
    printf("The dist is %f\n", dist);
    return 0;
}

double distance(double x, double y) /* x,y-parameters */
{
    return sqrt(x * x + y * y);
}
```



## Output

The dist is 4.924429

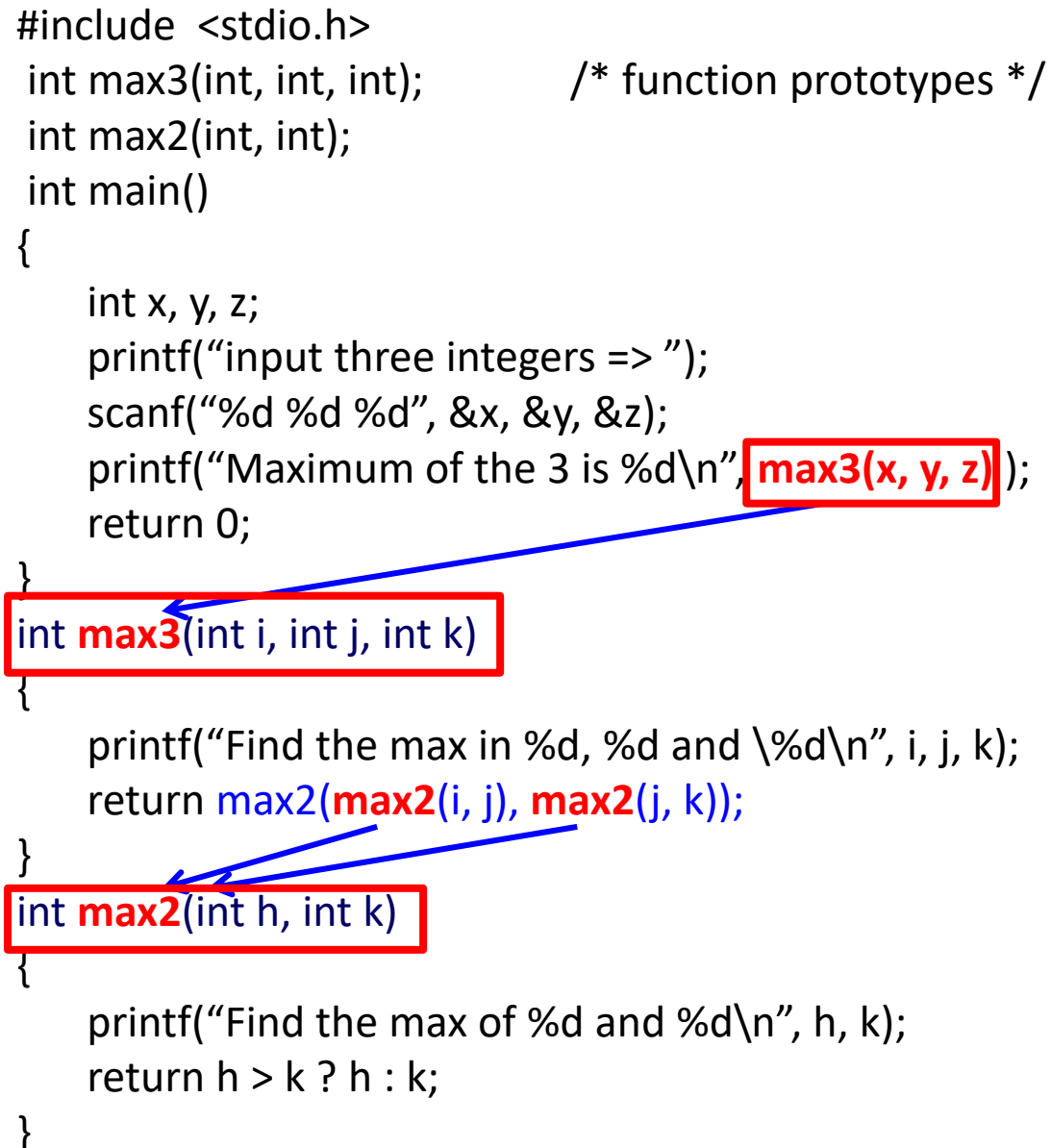
The dist is 18.794946

# Function Calling Another Function

```
#include <stdio.h>
int max3(int, int, int);      /* function prototypes */
int max2(int, int);
int main()
{
    int x, y, z;
    printf("input three integers => ");
    scanf("%d %d %d", &x, &y, &z);
    printf("Maximum of the 3 is %d\n", max3(x, y, z));
    return 0;
}

int max3(int i, int j, int k)
{
    printf("Find the max in %d, %d and %d\n", i, j, k);
    return max2(max2(i, j), max2(j, k));
}

int max2(int h, int k)
{
    printf("Find the max of %d and %d\n", h, k);
    return h > k ? h : k;
}
```

The diagram illustrates the recursive calls between the functions. Red boxes highlight the function calls: 'max3(x, y, z)' in the main function, 'int max3(int i, int j, int k)' as a function definition, and 'int max2(int h, int k)' as a function definition. Blue arrows show the flow of calls: one arrow points from 'max3(x, y, z)' to the 'max3' function definition, and two arrows point from 'max2(max2(i, j), max2(j, k))' to the 'max2' function definition.

## Output

input three integers => 7 4 9  
Find the max in 7, 4 and 9  
Find the max of 7 and 4  
Find the max of 4 and 9  
Find the max of 7 and 9  
Maximum of the 3 is 9

# Functions

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- **Storage Scope of Variables**
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# Scope of Variables in a Function

- Scope of a variable
  - the section of code that can use the variable. In other words, the variable is visible in that section.
- Variables declared in a function is ONLY visible within that function. We call it block scope.
- Example below: variables **radius**, **pi** and **area** are NOT visible **outside** this function.

```
float areaOfCircle(float radius) {    // parameter – block scope
    const float pi = 3.14;           // const variable – block scope
    float area;                      // local variable – block scope
    area = pi*radius*radius;
    return area;
}
```

# Local and Global Variables

- **Local variables:**
  - They are variables defined **inside** a function.
- **Global variables:**
  - They are variables defined **outside** the functions.
- Should **global variables** be used in your programs?
  - **Advantages** of using global variables:
    - simplest way of communication between functions
    - efficiency
  - **Disadvantages** of using global variables:
    - less readable program
    - more difficult to debug and modify
- **Strongly discouraged to use global variables** – instead you should use **parameter passing between functions** to achieve the same effect. So that **errors** will be **localized** within each function for easy debugging.

# Local and Global Variables: Example

```
#include <stdio.h>
```

```
int g_var = 5;
```

```
int fn1(int, int);
```

```
float fn2(float);
```

```
int main( ) {
```

```
    char reply;
```

```
    int num;
```

```
    ...
```

```
}
```

```
int fn1(int x, int y)
```

```
{
```

```
    float fnum;
```

```
    int temp;
```

```
    g_var += 10;
```

```
    ...
```

```
}
```

```
float fn2(float n) {
```

```
    float temp;
```

```
    ...
```

```
}
```

// **global** variable – has **file scope**

// **local** - these two variables are only

// known inside main() function - block scope

// **local** x,y - formal parameters are only

// known inside this function – block scope

// **local** - these two variables are known

// in this function only – block scope

// **local** and block scope

# Static Variables

- Static variables can be defined inside or outside a function using the static keyword.
  - The duration of a static variable is fixed.
  - Static variables are created at the start of the program and are destroyed only at the end of program execution. That is, they exist **throughout program execution** once they are created.
- If a **static** variable is defined and initialized, it is then initialized once when the storage is allocated. If a static variable is defined, but not initialized, it will be initialized to zero by the compiler.
- Static variables are very useful when we need to write functions that retain values between functions.
- We may use global variables to achieve the same purpose. However, **static variables** are preferable as they are **local variables** to the functions, and the shortcomings of global variables can be avoided.

# Static Variables

```
#include <stdio.h>
void function();
int main()
{
    int i;
    for (i=0; i<3; i++)    // calling the fn three times
        function();
    return 0;
}
void function()
{
    static int static_var = 0;    /* static variable */
    int local_var = 0;            /* local variable */
    ++static_var;
    ++local_var;
    printf("Static variable: %d\n", static_var);
    printf("Local variable: %d\n", local_var);
}
```

## Output

**Static variable: 1**

**Local variable: 1**

**Static variable: 2**

**Local variable: 1**

**Static variable: 3**

**Local variable: 1**

## Note:

**Local variable** – the variable disappears after each function execution.

**Static variable (like global)** – the variable stays until the end of program execution.



# Functions

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- **Functional Decomposition**

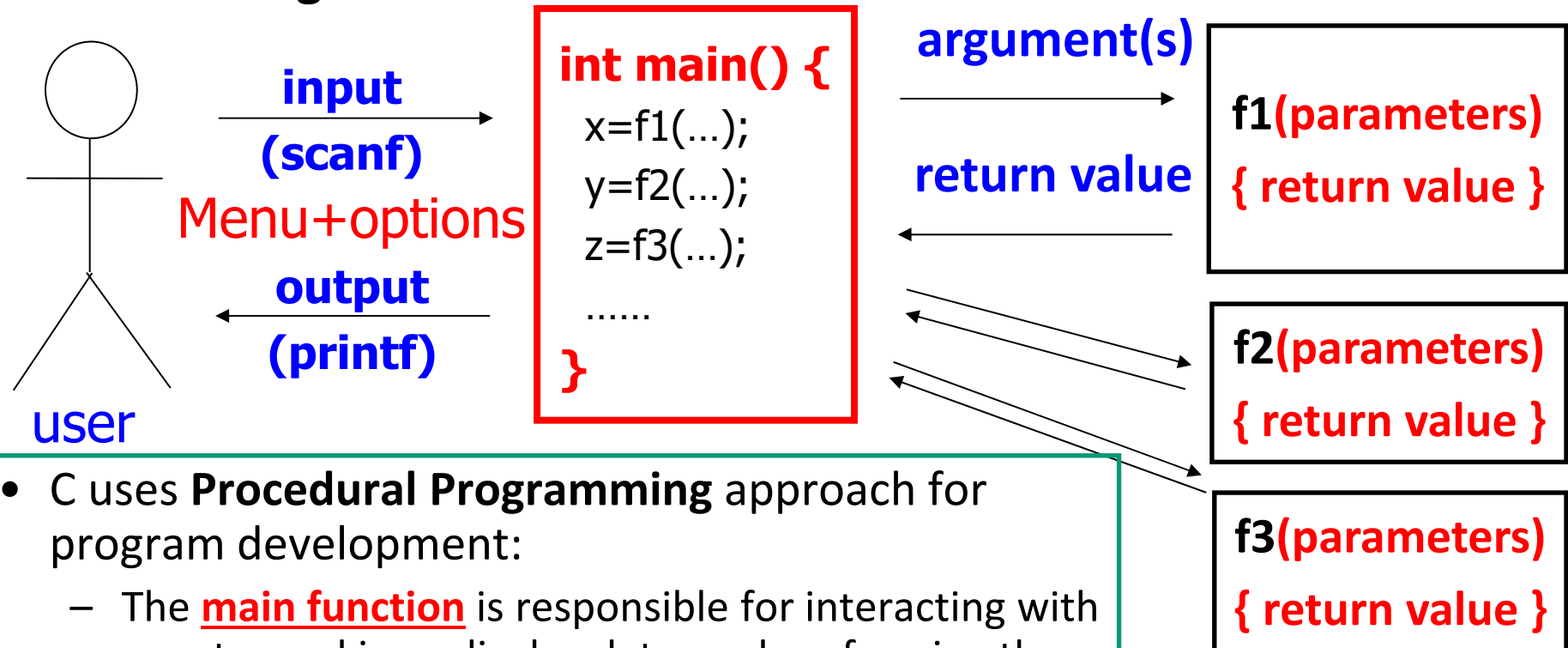
# Functional Decomposition

<pre>#include &lt;stdio.h&gt; #define ...  int main() { ..... ..... ..... ..... ..... ..... ..... ..... ..... ..... } /* end. line 2000 */</pre>	<pre>#include &lt;stdio.h&gt; #define ...  int main() { ..... } /* line 20 */  float f1(float h) { ..... } /* line 55*/  .....  void f18() { ..... } /* line 1560 */</pre>
--	--

- The **main()** function contains about 2000 lines of code which is difficult to read and debug.
- Functional decomposition refers to the top-down stepwise refinement technique that uses the divide-and-conquer strategy to produce smaller functions that are easier to understand. Smaller functions promote software reusability.

# Functional Decomposition: Modular Design

The approach of designing programs as functional modules is called **modular design**.



- C uses **Procedural Programming** approach for program development:
  - The **main function** is responsible for interacting with user to read in or display data, and performing the actions by calling the other functions.
  - The **other functions'** input and output are passed using the arguments and return type via the main function.
- Easier to write and debug programs.

**Thank You!**