Programming Fundamental

Week 12 –

Procedure and Function in the C Programming Language

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Weekly Learning Outcomes for Subjects (Sub-CPMK):

Sub-CPMK 0614: Students are able to create simple programs with elements of selection control, repetition control, functions, or procedures, as well as implementing arrays and pointers in the C programming language (C6).

Review

1. For
2. While…
3. Do…While…
4. Break
5. Continue

Outline

1. Introduction
2. Standard Library
3. Programmer-Defined Functions
4. Recursion

Introduction

- The best way to develop and maintain a large program is to construct it from smaller pieces or **modules**
- This technique is called **divide and conquer**
- More manageable

WHY ?

- Modularity
- Readibility
- Code Reusability

Program Modules in C

- Modules in C are called **functions**
  - C Standard Library
    - Prepackaged functions
    - Provides a rich collection of functions for performing common mathematical calculations, string manipulations, character manipulations, input/output, and many other useful operations
  - Programmer-defined functions
    - Programmer can write functions to define specific tasks that may be used at many points in a program

Standard Library Headers

- Each standard library has a corresponding header containing the function prototypes for all the functions in that library and definitions of various data types and constants needed by those functions

Standard Library Header	Explanation
<stdio.h>	Standard input / output library functions
<math.h>	Math library functions
<string.h>	String-processing functions
<time.h>	Time and date manipulation functions
<stdlib.h>	Conversions of numbers to text and text to numbers, memory allocation, random numbers, and other utility functions
<ctype.h>	Functions that test characters for certain properties Functions that can be used to convert lowercase letters to uppercase letters and vice versa

Programmer-defined Functions

- Function Definitions

```
return_value_type function_name(parameter_list)
{
        statement;
}
```

- The **function_name** is any valid identifier
- The **return_value_type** is the data type of the result returned to the caller
- The **parameter_list** is a comma-separated list that specifies the parameters received by the function when it is called
- Together, the **return_value_type**, **function_name,** and **parameter_list** are sometimes referred to as the **function header**
- The statement within braces form the **function body**

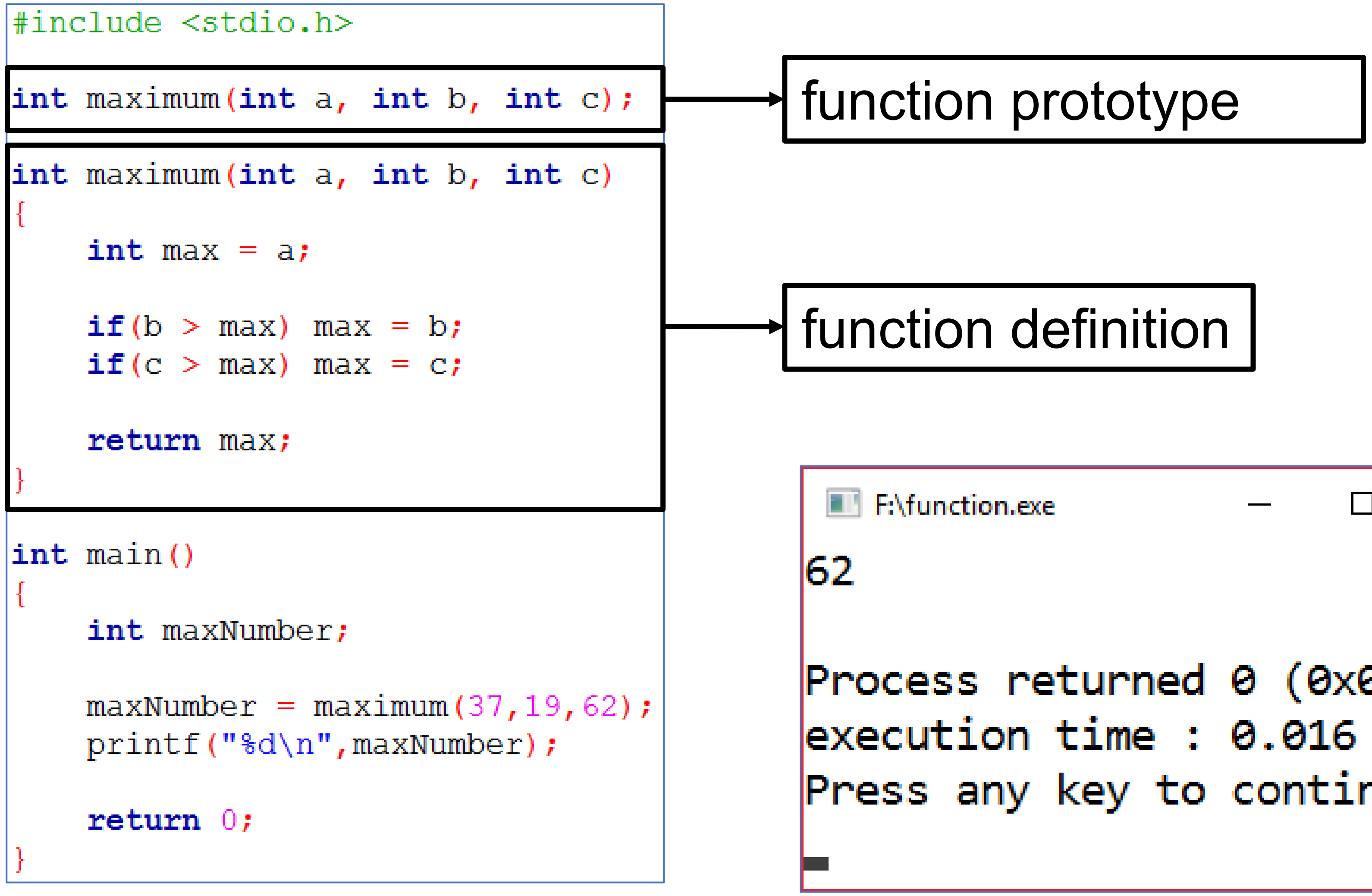
Programmer-defined Functions

- Function Prototypes

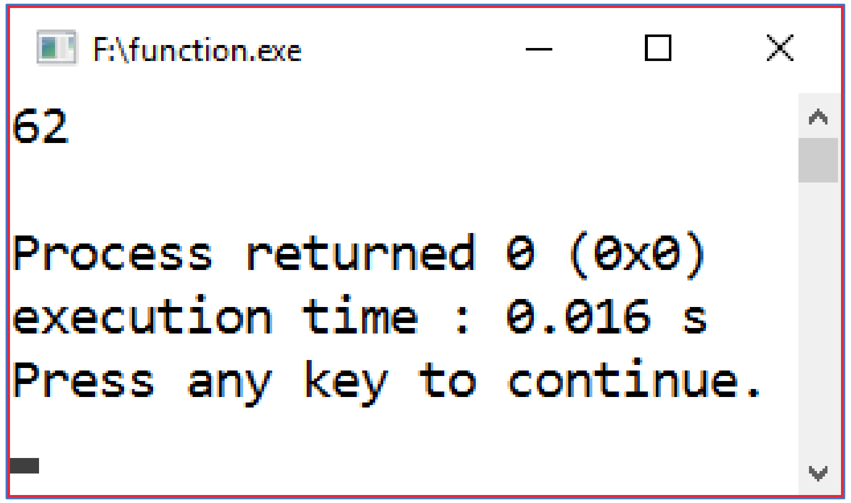
```
return_value_type function_name(parameter_list);
```

- A function prototype tells the compiler
  - The type of data returned by the function
  - The number of parameters the function expects to receive
  - The types of the parameters
  - The order in which these parameters are expected
- The compiler uses function prototypes to validate function calls
- A function call that **does not match** the function prototype is a **syntax error**
- An error is also generated if the function prototype and the function definition disagree

Programmer-defined Functions



```
#include <stdio.h>

int maximum(int a, int b, int c);

int maximum(int a, int b, int c)
{
    int max = a;

    if(b > max) max = b;
    if(c > max) max = c;

    return max;
}

int main()
{
    int maxNumber;

    maxNumber = maximum(37,19,62);
    printf("%d\n",maxNumber);

    return 0;
}
```



F:\function.exe

```
62

Process returned 0 (0x0)
execution time : 0.016 s
Press any key to continue.
```

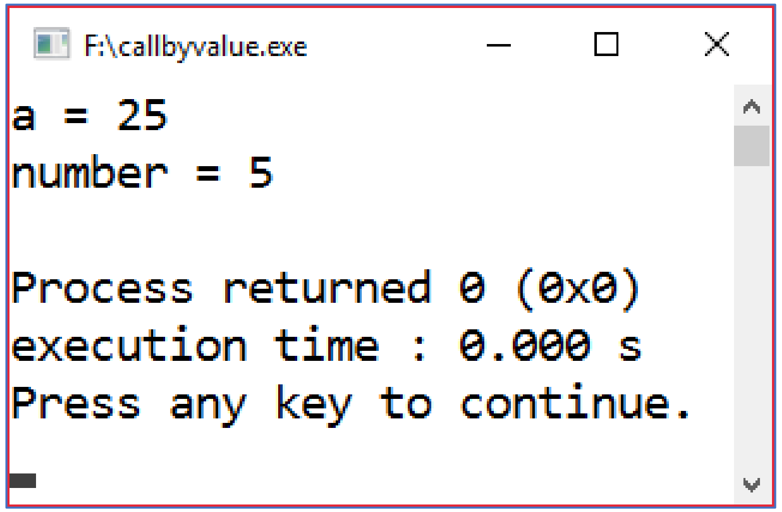
Calling Functions

- Call-by-Value
  - When arguments are passed by value, a copy of the argument’s value is made and passed to the called functions
  - Changes to the copy do not affect an original variable’s value in the caller
  - In C, all calls are by value

Calling Functions

- Call-by-Value

```
#include <stdio.h>

void square(int a)
{
    a *= a;
    printf("a = %d\n",a);
}

int main()
{
    int number = 5;

    square(number);
    printf("number = %d\n",number);

    return 0;
}
```



F:\callbyvalue.exe

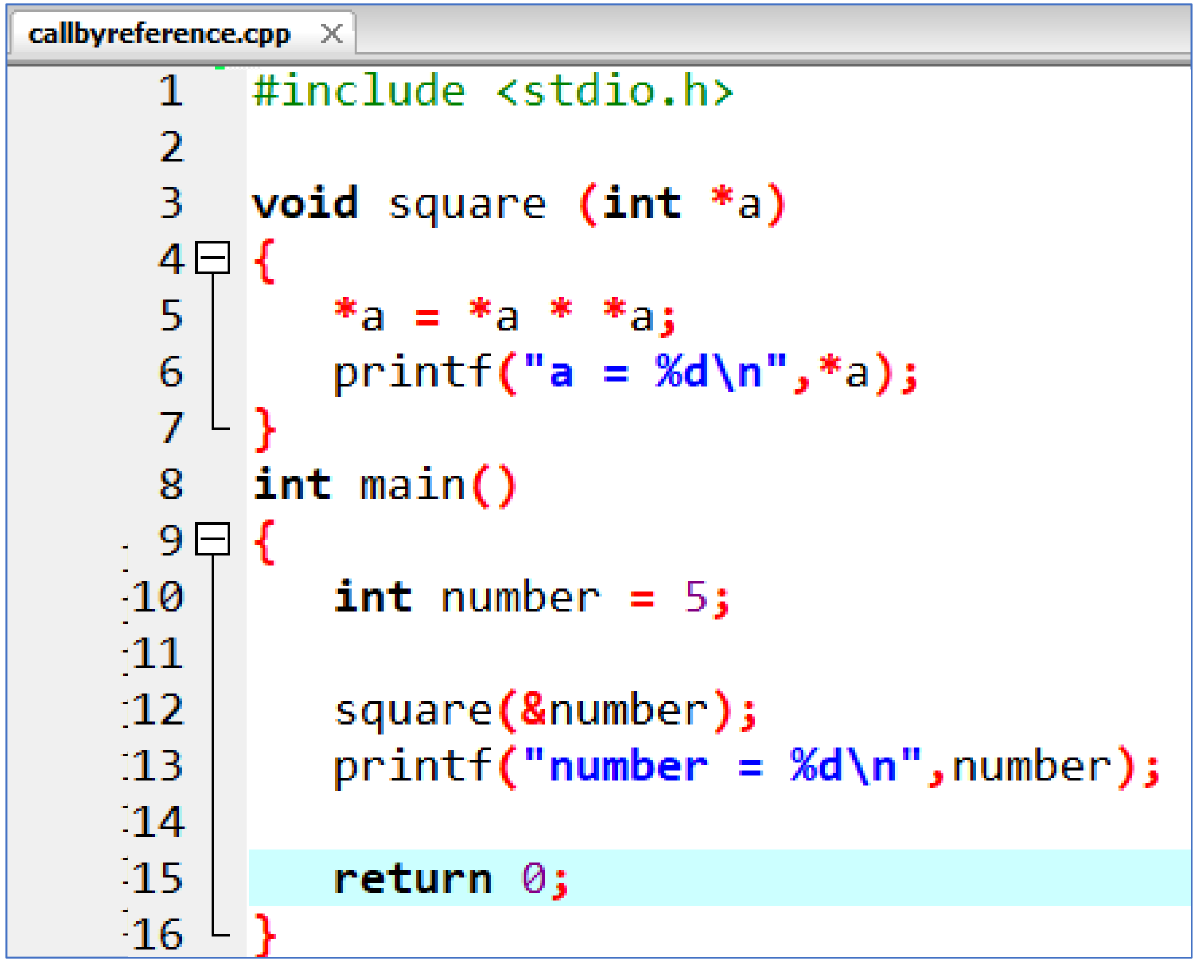
```
a = 25
number = 5

Process returned 0 (0x0)
execution time : 0.000 s
Press any key to continue.
```

Calling Functions

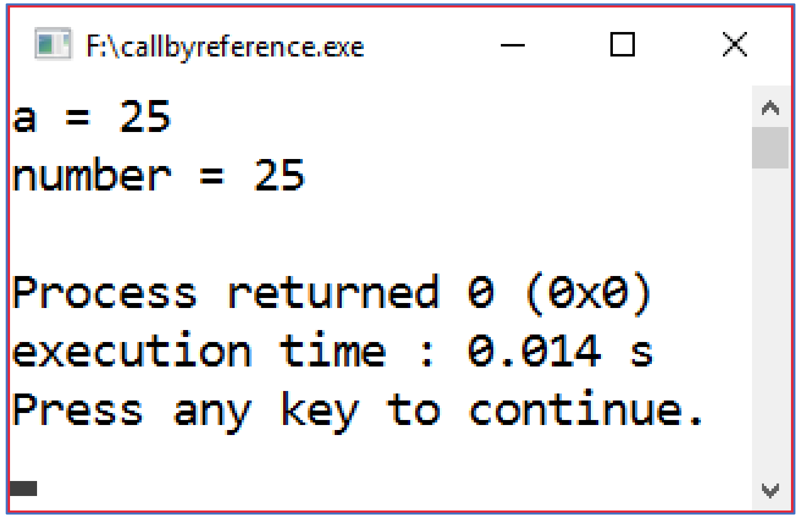
- Call-by-Reference
  - When an argument is passed by reference, the caller allows the called function to modify the original variable’s value

Calling Functions

- Call-by-Reference


callbyreference.cpp

```c
#include <stdio.h>

void square (int *a)
{
    *a = *a * *a;
    printf("a = %d\n",*a);
}
int main()
{
    int number = 5;

    square(&number);
    printf("number = %d\n",number);

    return 0;
}
```


F:\callbyreference.exe

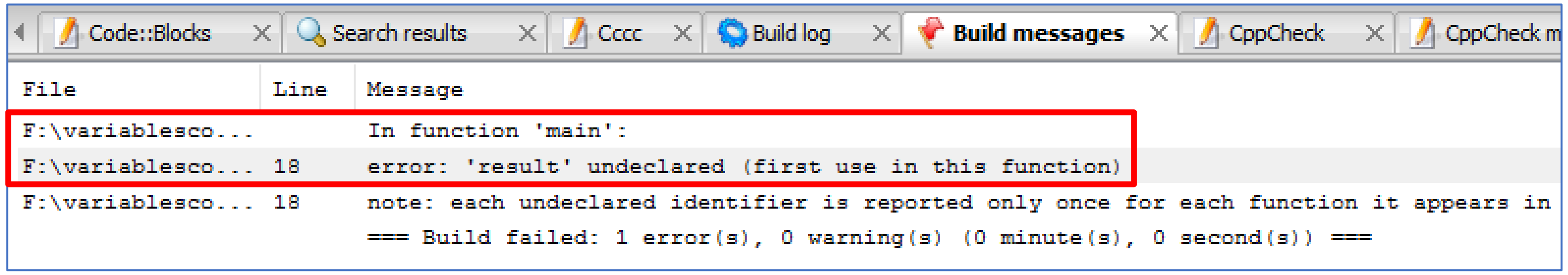
```
a = 25
number = 25

Process returned 0 (0x0)
execution time : 0.014 s
Press any key to continue.
```

Variable Scope

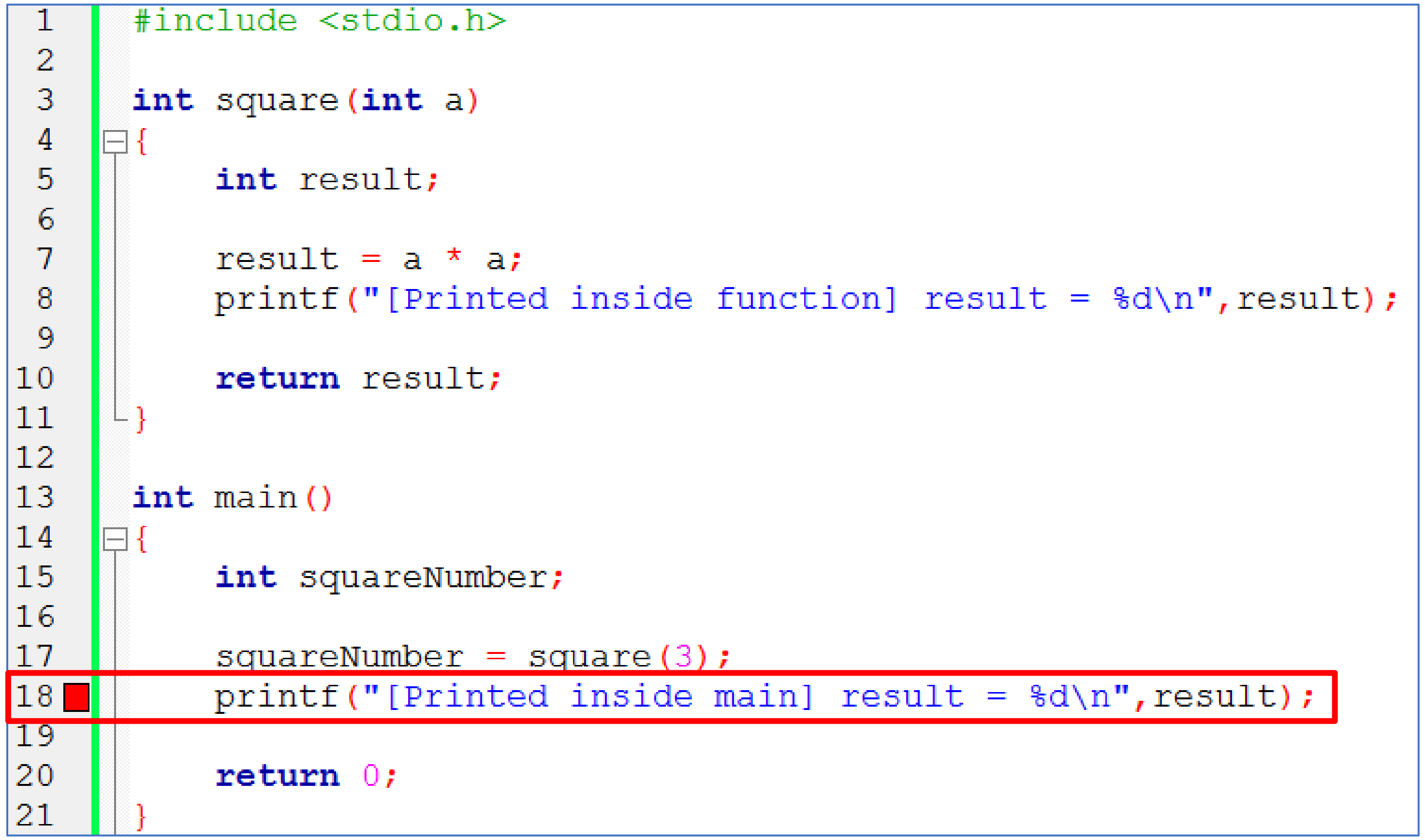
- Local Variables
  - All variables defined in function definitions are local variables
  - Known only in the function in which they are defined
  - A function’s parameters are also local variables of that function

Variable Scope

- Local Variables



```
File               Line   Message
F:\variablesco...         In function 'main':
F:\variablesco...  18     error: 'result' undeclared (first use in this function)
F:\variablesco...  18     note: each undeclared identifier is reported only once for each function it appears in
                          === Build failed: 1 error(s), 0 warning(s) (0 minute(s), 0 second(s)) ===
```



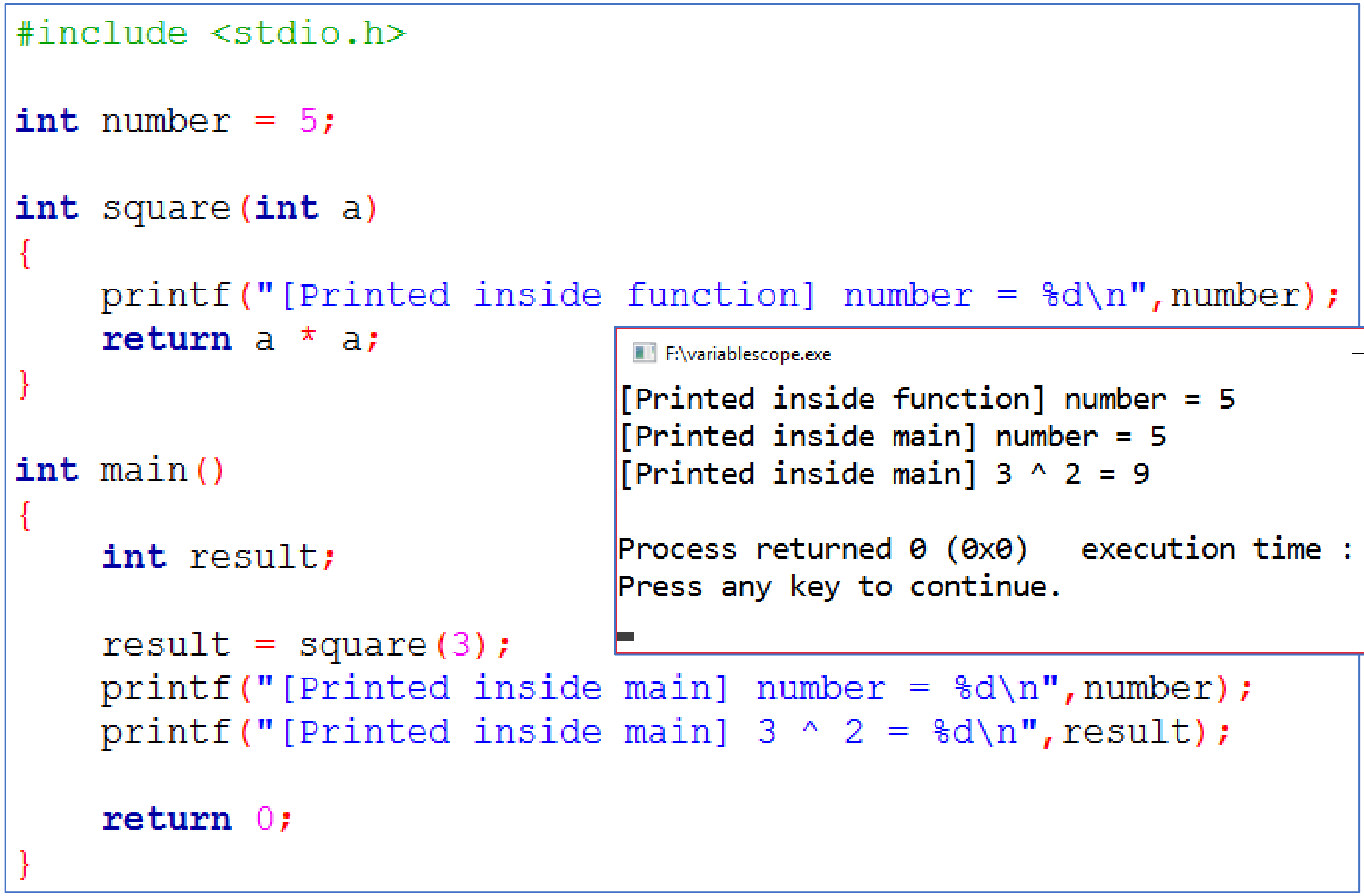
```c
#include <stdio.h>

int square(int a)
{
    int result;

    result = a * a;
    printf("[Printed inside function] result = %d\n",result);

    return result;
}

int main()
{
    int squareNumber;

    squareNumber = square(3);
    printf("[Printed inside main] result = %d\n",result);

    return 0;
}
```

Variable Scope

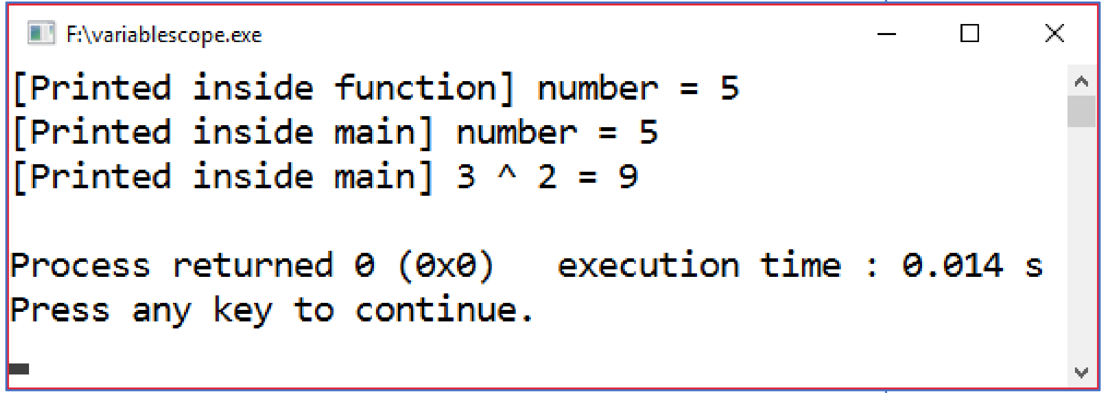
- Global Variables
  - Created by placing variable declarations **outside** any function definition
  - Retain their values throughout the execution of the program
  - Can be referenced by any function that follows their declarations or definitions in the file

Variable Scope

- Global Variables



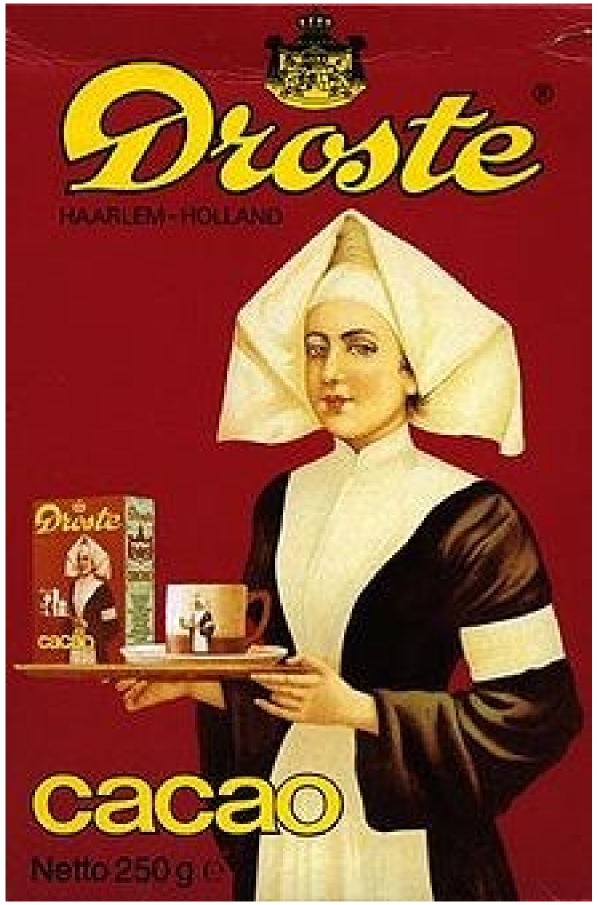
```c
#include <stdio.h>

int number = 5;

int square(int a)
{
    printf("[Printed inside function] number = %d\n",number);
    return a * a;
}

int main()
{
    int result;

    result = square(3);
    printf("[Printed inside main] number = %d\n",number);
    printf("[Printed inside main] 3 ^ 2 = %d\n",result);

    return 0;
}
```



F:\variablescope.exe

```
[Printed inside function] number = 5
[Printed inside main] number = 5
[Printed inside main] 3 ^ 2 = 9

Process returned 0 (0x0)   execution time : 0.014 s
Press any key to continue.
```

Recursion



- A **recursive function** is a function that calls itself

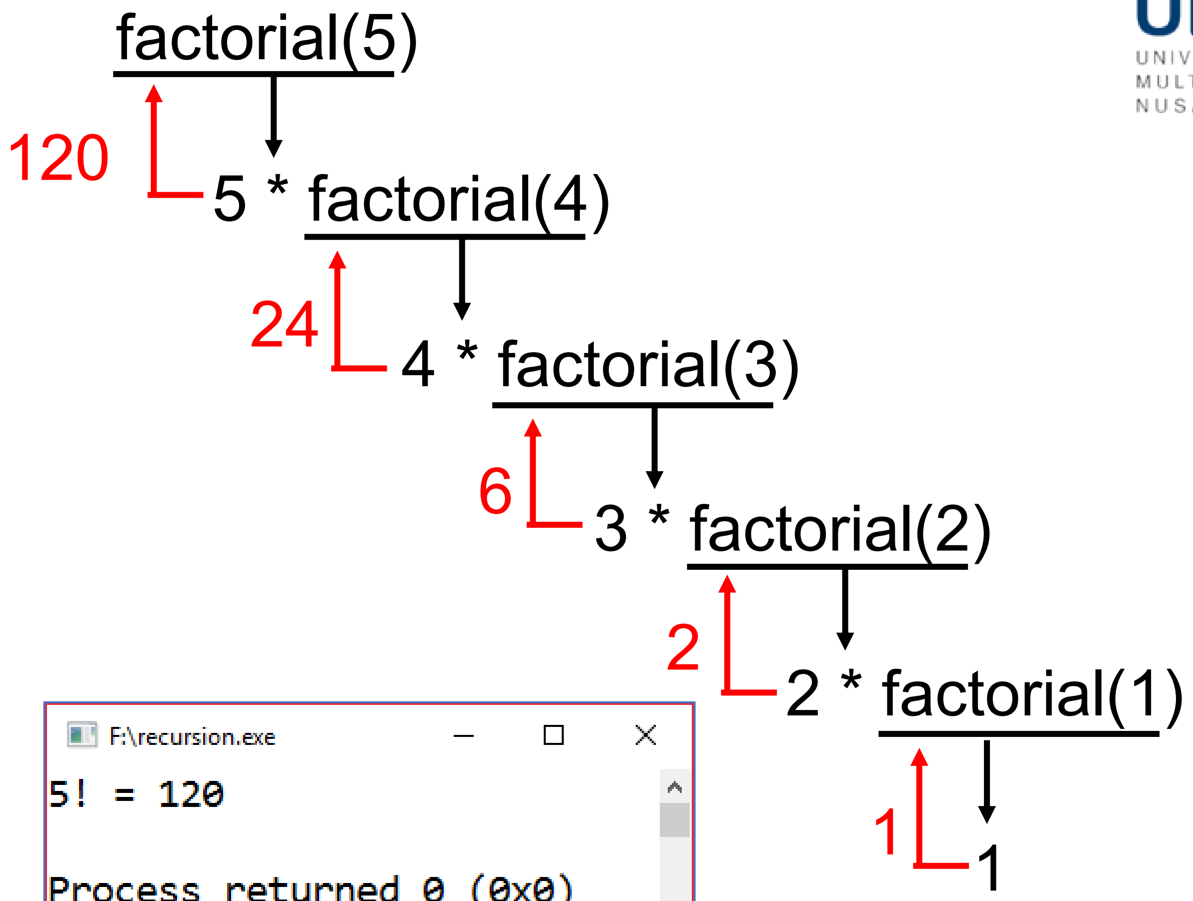
$$\begin{tikzcd}
\boxed{\text{A recursive function}} \arrow[d] \arrow[dr] & \\
& \boxed{\text{base case}} \\
& \boxed{\text{recursion step}}
\end{tikzcd}$$

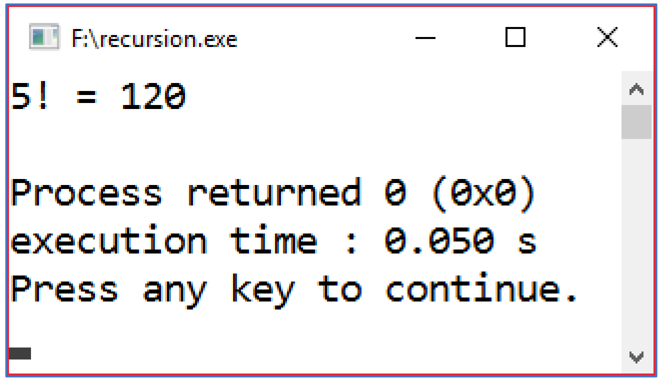
Recursion

```c
#include <stdio.h>

int factorial(int n)
{
    if(n == 1)
        return 1;
    else
        return n * factorial(n-1);
}

int main()
{
    printf("5! = %d\n",factorial(5));

    return 0;
}
```

base case

recursion step





```
5! = 120

Process returned 0 (0x0)
execution time : 0.050 s
Press any key to continue.
```

Practice 0

- Find the error in the following program segment and explain how the error can be corrected.

```
void f(int a)
{
     int a;
     printf("%d",a);
}
```

Practice 1

- Find the error in the following program segment and explain how the error can be corrected.

```
float sum(float x, float y)
{
    float result;
    result = x + y;
}
```

Practice 2

- Find the error in the following program segment and explain how the error can be corrected.

```
int sum(int n)
{
    if(n == 0)
    {
        return 0;
    }
    else
    {
        n + sum(n-1);
    }
}
```

Practice 3

- Find the error in the following program segment and explain how the error can be corrected.

```
void product()
{
    int p, q, r, result;
    printf("Enter 3 integers: ");
    scanf("%d %d %d",&p,&q,&r);
    result = p * q * r;
    printf("Result = %d\n",result);
    return result;
}
```

Practice 4

- Write a function **convertCase** that converts a lowercase alphabetic character to an uppercase letter and vice versa.

Statement printf(“%c”,convertCase(‘A’)); should print ‘a’

Statement printf(“%c”,convertCase(‘a’)); should print ‘A’

Practice 5

- Write a function **power(base, exponent)** that returns the value of $base^{exponent}$. For example, power(2, 5) = 2^5 = 32. Assume that exponent is a positive, nonzero integer, and base is an integer. Do not use any math library functions.

Practice 6

- Write a recursive function **fibonacci(n)** that calculates the nth Fibonacci number.

  fibonacci(n) = fibonacci(n-2) + Fibonacci(n-1)

  fibonacci(0) = 0

  Fibonacci(1) = 1

NEXT WEEK’S OUTLINE

1. Pointer
2. Pointer Operators
3. Array Declaration
4. Array Access

REFERENCES

- Hanly, Jeri R. and Koffman, Elliot B., 2013, Problem Solving and Program Design in C, Seventh Edition, Pearson Education, Inc.
- Deitel, Paul and Deitel, Harvey, 2016, C How to Program, Eighth Edition, Pearson Education, Inc.

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