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# IT1010 – Introduction to Programming

## Lecture 6 - Functions

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# Objectives

- At the end of the Lecture students should be able to
  - Construct programs using functions.
  - Use math functions in C standard library.
  - Use assertions to test whether the values of expressions are correct.

# Introduction

- Most computer programs that solve real-world problems are much larger than the programs that we discuss in the class.
- The best way to develop and maintain large program is to construct it from smaller pieces or modules.
- This technique is called divide and conquer.
- In C language these modules are called functions.
- Another motivation to use functions is software reusability.

# C standard library

- C standard library provides a rich collection of functions for performing common mathematical calculations, string manipulations, input/output.
- e.g: printf

  scanf

  pow

# Math Library Functions

- Allows the user to perform certain common mathematical calculations.

| Function | Description | Example |
|---|---|---|
| sqrt( x ) | square root of x | sqrt (900.0) is 30.0 |
| pow( x, y ) | x raised to power y ($x^y$) | pow ( 2, 7) is 128.0 |
| exp( x ) | exponential function $e^x$ | exp (1.0) is 2.718282 |
| log ( x ) | natural logarithm of x | log(2.718282) is 1.0 |
| ceil ( x ) | rounds x to the smallest integer not less than x | ceil (9.2) is 10.0<br>ceil ( - 9.8 ) is – 9.0 |
| floor ( x ) | rounds x to the smallest integer not greater than x | floor (9.2) is 9.0<br>floor ( - 9.8 ) is – 10.0 |

# Using math functions in C programs

```
# include <stdio.h>
# include <math.h>
int  main (void)
{
        printf("%.2f", sqrt(900.0));
        return 0;
}
```

output

30.00

```
# include <stdio.h>
# include <math.h>
int  main (void)
{
        float c1 = 13;
        float d = 3.0;
        float f = 4.0;
        printf("%.2f", sqrt(c1 + d * f);
        return 0;
}
```

output

5.00

# Quiz

- Write the value of x after each of the following statements is performed:
  a) x = floor (7.5)
  b) x = floor (0.0)
  c) x = ceil (-6.4)
  d) x = pow (5, 2)

# Programmer – defined functions

```
# include <stdio.h>
int square ( int y ) ;
int main ( void )
{
        int x;

        for (x =1; x <= 10; ++x)
        {
            printf("%d  ", square( x ));
        }

}
int square (int y)
{
        return y * y;
}
```

1 4 9 16 25 36 49 64 81 100

# Calling and Called Functions

```
# include <stdio.h>
int square ( int y ) ;
int main ( void )
{
    int x;

    for (x =1; x <= 10; ++x)
            printf("%d ", square( x ));
    puts("");
}

int square (int y)
{
    return y * y;
}
```

Function prototype

Calling Function / Caller

Called Function

- Functions are invoked by a function call.
- The function which invokes a function is called the calling function or caller.
- The function being activated is referred to as the called function.
- A function prototype gives all of the information needed by the calling function to invoke the called function.
- The function prototype is the declaration of the function and must appear before the function is invoked.

# Local variables

- All variables defined in function definitions are local variables.
- They can be accessed only in the function in which they are  defined.
- Example : int y in the square function

# Parameter List

- The parameter list is a comma-separated list that specifies the parameters received by the function when it's called.
- If a function does not receive any values, parameter list is void.
- A type must be listed explicitly for each parameter.
- Example : int y in the square function is a parameter

# Function prototype

- The compiler uses function prototypes to validate function calls.

  e.g:

```
int square (int y)
```

- The *int* in parenthesis informs the compiler that square expects to receive an integer.
- The int to the left of the function name informs the compiler that square returns an integer result to the caller.

# return statement

- return statement helps the called function to return a value to the calling function.
- If a function does not return a value, the statement

```
return;
```

- If a function does return a result, the statement

```
return expression;
```

# The format of a function

```
return-value-type function-name( parameter-list)
{
        definitions
        statements
}
```

- Function name is any valid identifier
- The return-value-type is the data type of the result returned to caller.
- Definitions and statements within the braces form the function body.
- If a function does not return a value, the return-value-type should be indicated as void.

# Exercise 1

- Write a function that displays a solid square of asterisks whose side is specified in integer parameter side. For example,  if side is 4, the function displays:

```
****
****
****
****
```

# Exercise 2

- Write a function called *max* to determine and return the largest of two integers. The integers should be input from the key board in the main program and pass to *max* function.

# Passing Arguments By Value

- When arguments are passed by value, a copy of the argument's value is made and passed to the called function.
- Changes to the copy do not affect an original variable's value in the caller.

# Passing Arguments By Value - Example

```
# include <stdio.h>
int cubeByValue ( int n ) ;

int main ( void )
{
  int  number = 5;

   number  = cubeByValue (number);

}
```

number

5

```
int cubeByValue (int n)
{
   return n * n * n;
}
```

n

undefined

# Passing Arguments By Value - Example

```
# include <stdio.h>
int cubeByValue ( int n ) ;

int main ( void )
{
   int  number = 5;

   number  = cubeByValue (number);

}
```

number

5

```
int cubeByValue (  int n  )
{
   return n * n * n;
}
```

n

5

# Passing Arguments By Value - Example

```
# include <stdio.h>
int cubeByValue ( int n ) ;

int main ( void )
{
   int  number = 5;

   number  = cubeByValue (number);

}
```

number

5

```
int cubeByValue (  int n  )
{
   return n * n * n;
}
```

125

n

5

# Passing Arguments By Value - Example

```
# include <stdio.h>
int cubeByValue ( int n ) ;

int main ( void )
{
   int  number = 5;

   number  = cubeByValue (number);

}
```

number

5

125

```
int cubeByValue (  int n  )
{
   return n * n * n;
}
```

n

undefined

# Passing Arguments By Value - Example

```
# include <stdio.h>
int cubeByValue ( int n ) ;

int main ( void )
{
   int  number = 5;

   number  = cubeByValue (number);

}
```

number

125

125

125

```
int cubeByValue (  int n  )
{
   return n * n * n;
}
```

n

undefined

# Block Scope

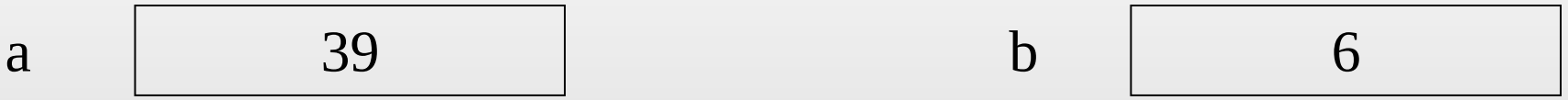
- The scope of an identifier is the portion of the program in which the identifier can be referenced.
- Identifiers defined inside a block have a block scope.
- Block scope ends at the terminating right brace.
- Local variables defined at the beginning of a function have block scope.
- when blocks are nested and inner and outer blocks both have the same identifier name, identifier in the outer block is hidden until the inner block terminates.

# Block scope example

```
{  //start of outer block
   int a = 39;
   int b = 6;
   printf( “a=   %d  and b= %d \n”, a, b);
   {  // start of inner block
          float a = 26.25;
          int c = 30;
          printf(“Now a= %.2f and b= % d  and c= %d\n”, a, b, c);
    }  //end inner block
   printf( “Finally a= %d  and b = %d \n”, a, b);
} // end of outer block
```

# Block scope example

```
{  //start of outer block
   int a = 39;
   int b = 6;
   printf( “a=   %d  and b= %d \n”, a, b);
```




a = 39 and b = 6

# Block scope example

```
{  //start of outer block
   int a = 39;
   int b = 6;
   printf( “a=   %d  and b= %d \n”, a, b);
   {  // start of inner block
          float a = 26.25;
          int c = 30;
          printf(“Now a= %.2f and b= % d  and c= %d\n”, a, b, c);
    }  //end inner block
```

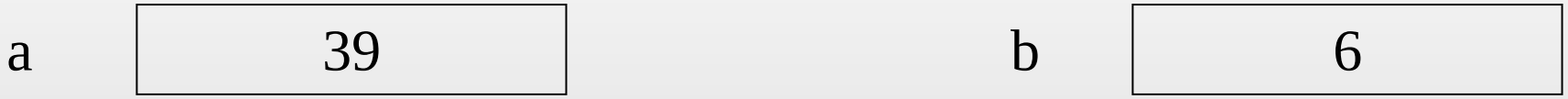
| a | 26.25 | b | 6 | c | 30 |
|---|---|---|---|---|---|

a = 39 and b = 6

Now a = 26.25 and b =6 and c = 30

# Block scope example

```
{    //start of outer block
     int a = 39;
     int b = 6;
     printf( “a=   %d  and b= %d \n“, a, b);
     {  // start of inner block
                    float a = 26.25;
                    int c = 30;
                    printf(“Now a= %.2f and b= % d  and c= %d\n”, a, b, c);
    }  //end inner block
     printf( “Finally a= %d  and b = %d \n”, a, b);
} // end of outer block
```




a = 39 and b = 6

Now a = 26.25 and b =6 and c = 30

Finally a = 39 and b = 6

# File scope

- An identifier declared outside  any function has file scope.
- Such identifiers are  known to all the function in the program
- Global variables, function definitions and function prototypes

has file scope.

```
# include <stdio.h>

int x = 1; // global variable

int main(void )
{
        printf("%d", x);
        return 0;
}
```

output

```
1
```

# Assert

- assert.h contains information for adding diagnostics that aid program debugging.
- Assert test the value of an expression at execution time.
- If the value is false (0) , assert print an error message and terminate the program.

# Assert – Example 1

- Write a program which print numbers greater than 10.

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


int main(void )
{
        int x;
        printf("Pls input a number");
        scanf("%d", &x);
        assert(x >= 10);
        printf("The value of x is  %d", x);
        return 0;
}
```

Output

Pls input a number : 12
The value of x is 12

Pls input a number : 8
Assertion 'x>=10' failed

# Assert – Example 2

- Write a function called grade( ) which takes a mark as a argument and return the grade according to the following table. Write another function called test_grade( ) which contain test cases to debug the grade( ) function.

| Marks Range | Grade |
|---|---|
| 0 to 39 | F |
| 40 to 59 | C |
| 60 to 74 | B |
| 75 to 100 | A |
| Mark< 0 and Mark >100 | X |

# Assert – Example 2 – grade( ) function

```
char grade(int marks) {
  char result;
  if (marks < 0)
    result = 'X';
  if (marks < 40)
    result = 'F';
  else if (marks < 60)
    result = 'C';
  else if (marks < 75)
    result = 'B';
  else if (marks <= 100)
    result = 'A';
  else
    result = 'X'; // Error (invalid mark)
    return result;
}
```

# Assert – Example 2 – test_grade( ) function

```
void test_grade() {
  assert(grade(20) == 'F');
  assert(grade(50) == 'C');
  assert(grade(70) == 'B');
  assert(grade(78) == 'A');
  assert(grade(-10) == 'X');
  assert(grade(110) == 'X');
  // boundary conditions
  assert(grade(0) == 'F');
  assert(grade(40) == 'C');
  assert(grade(60) == 'B');
  assert(grade(75) == 'A');
  assert(grade(100) == 'A');
  printf("grade() unit tests passed\n");
}
```

# Assert – Example 2 – main function

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

char grade(int marks);
void test_grade();

int main( void ) {

   test_grade();
   return 0;
}
```

Output

Assertion ‘grade(-10) ==‘X’ failed.

Modify the grade( ) function as follows and run the program

```
if (marks < 0)
      result = 'X';
 else  if (marks < 40)
      result = 'F';
……..
……..
```

# Summary

- C math library functions
- User-defined functions
- Scope of a variable
- Parameter passing by value
- Assert statement