EECS 10: Computational Methods in Electrical and Computer Engineering

Lecture 3

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Lecture 3: Overview

- Review Quiz
- Our second C Program
  - Program structure
    - Input, Computation, Output
  - Example **`Addition.c`**
- Basic Types in C
  - Integer types
  - Floating point types
- Arithmetic Operations in C
  - Arithmetic operators
  - Evaluation order

Quiz: Question 1

- Which Linux command shows you the path to the current directory?
  a) `cd`
  b) `pwd`
  c) `dir`
  d) `ls`
  e) `list`

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Quiz: Question 2

- Which of the following Linux commands renames file “text1” into “homework1”?

a) `ren text1 homework1`
b) `ren homework1 text1`
c) `rm text1 homework1`
d) `mv homework1 text1`
e) `mv text1 homework1`

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Quiz: Question 3

- What is C *not*?
  a) a structured programming language
  b) a object-oriented programming language
  c) a compiled programming language
  d) a high-level programming language
  e) a portable programming language

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Quiz: Question 4

- What is the meaning of the following code fragment?

```
/* printf("C programming is great!\n") */
```

a) it prints “C programming is boring!”
b) it prints “C programming is great!”
c) it is a syntax error because a semicolon is missing after the `printf()` statement
d) it is the main function of the C program
e) it is a comment ignored by the compiler

Quiz: Question 4

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Quiz: Question 5

- What is true about of the following compiler call? (Check all that apply!)

```
% gcc HelloWorld.c -Wall -ansi -o HelloWorld
```

a) the GNU C Compiler is called to generate an executable program called **`HelloWorld`**

b) the compiler will print warning and/or error messages about any non-ANSI compliance in the code

c) the compiler will ignore all warnings

d) the compiler will read the file **`HelloWorld.c`**

e) the compiler will overwrite the **`HelloWorld`** file if it already exists

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Quiz: Question 5

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d) the compiler will read the file **`HelloWorld.c`**

e) the compiler will overwrite the **`HelloWorld`** file if it already exists

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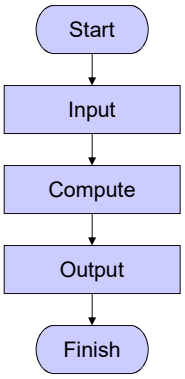
Program Structure

- General Program Structure
  - Input
    - read input data
  - Computation
    - compute output data from input data
  - Output
    - write output data
- Examples
  - Calculator
    - Enter numbers, compute function, output result
  - Word processor
    - Type, format, print text
  - Database application
    - Enter data, process data, present data
  - etc.



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C Program Structure

- Initialization section
  - Definition of variables (storage elements)
    - Name, type, and initial value
- Input section
  - read values from input devices into variables
    - standard input functions
- Computation section
  - perform the necessary computation on variables
    - assignment statements
- Output section
  - write results from variables to output devices
    - standard output functions
- Exit section
  - clean up and exit

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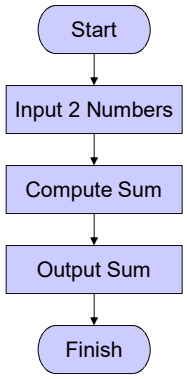
Our second C Program

- Program Example: Addition
  - Input
    - Let the user enter two whole numbers
  - Computation
    - Compute the sum of the two numbers
  - Output
    - Display the sum



Our second C Program

- Program example: **`Addition.c`** (part 1/2)

```
/* Addition.c: adding two integer numbers       */
/*                                              */
/* author: Rainer Doemer                        */
/*                                              */
/* modifications:                               */
/* 09/30/04 RD  initial version                 */

#include <stdio.h>

/* main function */

int main(void)
{
    /* variable definitions */
    int i1 = 0;        /* first integer */
    int i2 = 0;        /* second integer */
    int sum;           /* result */
...
```

Our second C Program

- Program example: **`Addition.c`** (part 2/2)

```
...
    /* input section */
    printf("Please enter an integer:      ");
    scanf("%d", &i1);
    printf("Please enter another integer: ");
    scanf("%d", &i2);

    /* computation section */
    sum = i1 + i2;

    /* output section */
    printf("The sum of %d and %d is %d.\n", i1, i2, sum);

    /* exit */
    return 0;
} /* end of main */

/* EOF */
```

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Our second C Program

- Variable definition and initialization

```
    /* variable definitions */
    int i1 = 0;        /* first integer */
    int i2 = 0;        /* second integer */
    int sum;           /* result */
```

  - Variable type: **`int`**
    - integer type, stores whole numbers (e.g. -5, 0, 42)
    - many other types exist (**`float`**, **`double`**, **`char`**, ...)
  - Variable name: **`i1`**
    - valid identifier, i.e. name composed of letters, digits
    - variable name should be descriptive
  - Initializer: **`= 0`**
    - specifies the initial value of the variable
    - optional (if omitted, initial value is undefined)

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Our second C Program

- Data input using **`scanf()`** function

```
/* input section */
printf("Please enter an integer:      ");
scanf("%d", &i1);
```

  - Function **`scanf()`** is defined in standard I/O library
    - declared in header file **`stdio.h`**
  - … reads data from the standard input stream **`stdin`**
    - **`stdin`** usually means the keyboard
  - … converts input data according to format string
    - "**`%d`**" indicates that a decimal integer value is expected
  - … stores result in specified location
    - **`&i1`** indicates to store at the *address of* variable **`i1`**

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Our second C Program

- Computation using assignment statements

```
/* computation section */
sum = i1 + i2;
```

  - Operator **=** specifies an assignment
    - value of the right-hand side (**`i1 + i2`**) is assigned to the left-hand side (**`sum`**)
    - left-hand side is usually a variable
    - right-hand side is a simple or complex expression
  - Operator **+** specifies addition
    - left and right arguments are added
    - result is the sum of the two arguments
  - Many other operators exist
    - For example, **-**, *****, **/**, **%**, **<**, **>**, **==**, **^**, **&**, **|**, ...

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Our second C Program

- Data output using **`printf()`** function

```
/* output section */
printf("The sum of %d and %d is %d.\n", i1, i2, sum);
```

  - Function **`printf()`** is defined in standard I/O library
    - declared in header file **`stdio.h`**
  - … writes data to the standard output stream **`stdout`**
    - **`stdout`** usually means the monitor
  - … converts output data according to format string
    - text ("**`The sum…`**") is copied verbatim to the output
    - "**`%d`**" is replaced with a decimal integer value
  - … takes values from specified arguments (in order)
    - **`i1`** indicates to use the value of the variable **`i1`**

Our second C Program

- Example session: **`Addition.c`**

```
% vi Addition.c
% ls -l
-rw-------   1 doemer   faculty      702 Sep 30 14:17 Addition.c
% gcc -Wall -ansi Addition.c -o Addition
% ls -l
-rwx------   1 doemer   faculty     6628 Sep 30 16:44 Addition*
-rw-------   1 doemer   faculty      702 Sep 30 14:17 Addition.c
% Addition
Please enter an integer:      27
Please enter another integer: 15
The sum of 27 and 15 is 42.
% Addition
Please enter an integer:      123
Please enter another integer: -456
The sum of 123 and -456 is -333.
%
```

Basic Types in C

- Integer types
  - `char` Character, e.g. `'a'`, `'b'`, `'1'`, `'*'`
    - typical range `[-128,127]`
  - `short int` Short integer, e.g. `-7`, `0`, `42`
    - typical range `[-32768,32767]`
  - `int` Integer, e.g. `-7`, `0`, `42`
    - typical range `[-2147483648,2147483647]`
  - `long int` Long integer, e.g. `-99L`, `9L`, `123L`
    - typical range `[-2147483648,2147483647]`
  - `long long int` Very long integer, e.g. `12345LL`
    - typical range `[-9223372036854775808,9223372036854775807]`
- Integer types can be
  - `signed` negative and positive values (incl. 0)
  - `unsigned` positive values only (incl. 0)

Basic Types in C

- Floating point types
  - `float` Floating point with single precision
    - Example `3.5f`, `-0.234f`, `10e8f`
  - `double` Floating point with double precision
    - Example `3.5`, `-0.23456789012`, `10e88`
  - `long double` Floating point with high precision
    - Example `12345678.123456e123L`
- Floating point values are in many cases *approximations* only!
  - Storage size of floating point values is fixed
  - Many values can only be represented as approximations
  - Example: `1.0/3.0 = .333333`

Conversion Specifiers for Basic Types

Type	printf()	scanf()
long double	%Lf	%Lf
double	%f	%lf
float	%f	%f
unsigned long long	%llu	%llu
long long	%lld	%lld
unsigned long	%lu	%lu
long	%ld	%ld
unsigned int	%u	%u
int	%d	%d
short	%hd	%hd
char	%c	%c

Arithmetic Operations in C

- Arithmetic Operators
  - parentheses `(`, `)`
  - unary plus, minus `+`, `-`
  - multiplication, division, modulo `*`, `/`, `%`
  - addition, subtraction `+`, `-`
  - shift left, shift right `<<`, `>>`
- Evaluation order of expressions
  - usually left to right
  - by operator precedence
    - ordered as in table above (higher operators are evaluated first)
- Arithmetic operators are available
  - for integer types: all
  - for floating point types: all except `%`, `<<`, `>>`

Shift Operators

- Left-shift operator: `x << n`
  - shifts *x* in binary representation *n* times to the left
  - multiplies *x* *n* times by 2
  - Examples
    - $2x$ = `x << 1`
    - $4x$ = `x << 2`
    - $x * 2^n$ = `x << n`
    - 2^n = `1 << n`
- Right-shift operator: `x >> n`
  - shifts *x* in binary representation *n* times to the right
  - divides *x* *n* times by 2
  - Examples
    - $x / 2$ = `x >> 1`
    - $x / 4$ = `x >> 2`
    - $x / 2^n$ = `x >> n`

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