

EECS 10: Computational Methods in Electrical and Computer Engineering

Lecture 6

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Lecture 6: Overview

- Warm-up Quiz
- Review
 - Basic Types in C
 - Arithmetic operators
- Type Conversion
 - explicit
 - implicit
- Types in Expressions
- Arithmetic Computation
 - Example `Arithmetic.c`

Quiz: Question 6

- Which of the following constructs is a valid arithmetic operator in C?
(Check all that apply!)
 - a) /
 - b) %
 - c) !
 - d) @
 - e) >>

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Quiz: Question 6

- Which of the following constructs is a valid arithmetic operator in C?
(Check all that apply!)
 - a) /
 - b) %
 - c) !
 - d) @
 - e) >>

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Quiz: Question 7

- What is the value of the integer x after the following statement?

```
x = 11 / 3 + 11 % 3;
```

- a) 1
- b) 2
- c) 3
- d) 4
- e) 5

Quiz: Question 7

- What is the value of the integer x after the following statement?

```
x = 11 / 3 + 11 % 3;
```

- a) 1
- b) 2
- c) 3
- d) 4
-  e) 5

Quiz: Question 8

- What is the value of the integer x after the following statement?


```
x = (10 - (3 - (20 - -10)));
```

- a) 7
- b) 17
- c) 27
- d) 37
- e) 77

Quiz: Question 8

- What is the value of the integer x after the following statement?

```
x = (10 - (3 - (20 - -10)));
```

- a) 7
- b) 17
- c) 27
-  d) 37
- e) 77

Quiz: Question 9


- Which of the following format strings will print an **unsigned int** value in decimal format when used with `printf()`?
 - a) `"%u"`
 - b) `"%ud"`
 - c) `"%d"`
 - d) `"%lu"`
 - e) `"%ui"`

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Quiz: Question 9

- Which of the following format strings will print an **unsigned int** value in decimal format when used with `printf()`?
 -  a) `"%u"`
 - b) `"%ud"`
 - c) `"%d"`
 - d) `"%lu"`
 - e) `"%ui"`

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Quiz: Question 10


- Which of the following statements will correctly read a decimal value from `stdin` into a variable `x` of type `signed int`?
 - a) `stdin("%x", &u);`
 - b) `stdin("%u", x);`
 - c) `scanf("%d", &x);`
 - d) `scanf("&x", %u);`
 - e) `scanf("&x", %d);`

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Quiz: Question 10

- Which of the following statements will correctly read a decimal value from `stdin` into a variable `x` of type `signed int`?
 - a) `stdin("%x", &u);`
 - b) `stdin("%u", x);`
 -  c) `scanf("%d", &x);`
 - d) `scanf("&x", %u);`
 - e) `scanf("&x", %d);`

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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)

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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: $1.0/3.0 = .333333$

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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 %, <<, >>

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Shift Operators

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

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Type Conversion

- Explicit Type Conversion
 - types can be explicitly converted to other types, by use of the type cast operator:
 - `(type) expression`
 - the target type is named explicitly in parentheses before the source expression
 - Examples:
 - `Float = (float) LongInt`
 - converts the `long int` value into a `float` value
 - `Integer = (int) Double`
 - converts the `double` value into an `int` value
 - any fractional part is truncated!
 - `Char = (char) LongLongInt`
 - converts the `long long int` value into a `char` value
 - any out-of-range values are silently cut off!

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Type Conversion

- Implicit Type Conversion
 - Type promotion
 - integral promotion
 - `unsigned` or `signed char` is promoted to `unsigned` or `signed int` before any operation
 - `unsigned` or `signed short` is promoted to `unsigned` or `signed int` before any operation
 - binary arithmetic operators are defined only for same types
 - the smaller type is converted to the larger type (before operation)
 - Examples:
 - » `ShortInt * LongInt` results in a `long int` type
 - » `LongDouble * Float` results in a `long double` type
 - Type coercion
 - most types are automatically converted to expected types
 - Example: `Double = Float`, or `Char = LongInt`

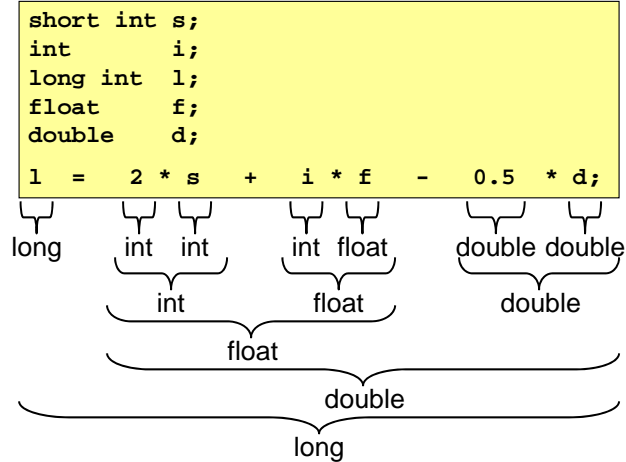
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Types in Expressions

- Expressions are composed of constants, variables and operators, each of which has an associated type
- Example:



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Example Program

- Program example:
 - Task: Write a C program that exercises arithmetic computation by use of different types and operators!
 - The program should compute the following equations:

- Polynomial:

$$p = 2x^2 - 3x + 5$$

- Quotient of sums:

$$q = \frac{a + b}{c + d}$$

- Remainder:

$$r = \text{rem}(2^n / 7)$$

- Assume that a , b , c , d , and n are whole numbers.

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Example Program

- Program example: `Arithmetic.c` (part 1/3)

```

/* Arithmetic.c: arithmetic expresions          */
/*                                              */
/* author: Rainer Doemer                      */
/*                                              */
/* modifications:                             */
/* 10/06/04 RD initial version                */

#include <stdio.h>

/* main function */

int main(void)
{
    /* variable definitions */
    int    a, b, c, d, n;
    double p, q, r, x;

    ...

```

Example Program

- Program example: `Arithmetic.c` (part 2/3)

```

...

/* input section */
printf("Please enter the value for real x:  ");
scanf("%lf", &x);
printf("Please enter the value for integer a: ");
scanf("%d", &a);
printf("Please enter the value for integer b: ");
scanf("%d", &b);
printf("Please enter the value for integer c: ");
scanf("%d", &c);
printf("Please enter the value for integer d: ");
scanf("%d", &d);
printf("Please enter the value for integer n: ");
scanf("%d", &n);

...

```

Example Program

- Program example: `Arithmetic.c` (part 3/3)

```

...

/* computation section */
p = 2.0*x*x - 3.0*x + 5.0;
q = ((double)(a + b)) / ((double)(c + d));
r = (1<n) % 7;

/* output section */
printf("The value for the polynomial p is %f.\n", p);
printf("The value for the quotient q is %f.\n", q);
printf("The value for the remainder r is %f.\n", r);

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

/* EOF */

```

Example Program

- Example session: `Arithmetic.c`

```

% vi Arithmetic.c
% gcc Arithmetic.c -Wall -ansi -o Arithmetic
% ls -l
total 20
-rwx----- 1 doemer  faculty    7344 Oct  6 08:42 Arithmetic*
-rw----- 1 doemer  faculty    1154 Oct  6 08:37 Arithmetic.c
% Arithmetic
Please enter the value for real x:    3.1415927
Please enter the value for integer a: 5
Please enter the value for integer b: 6
Please enter the value for integer c: 7
Please enter the value for integer d: 8
Please enter the value for integer n: 9
The value for the polynomial p is 15.314431.
The value for the quotient q is 0.733333.
The value for the remainder r is 1.000000.
%

```