EECS 10: Computational Methods in Electrical and Computer Engineering

Lecture 6

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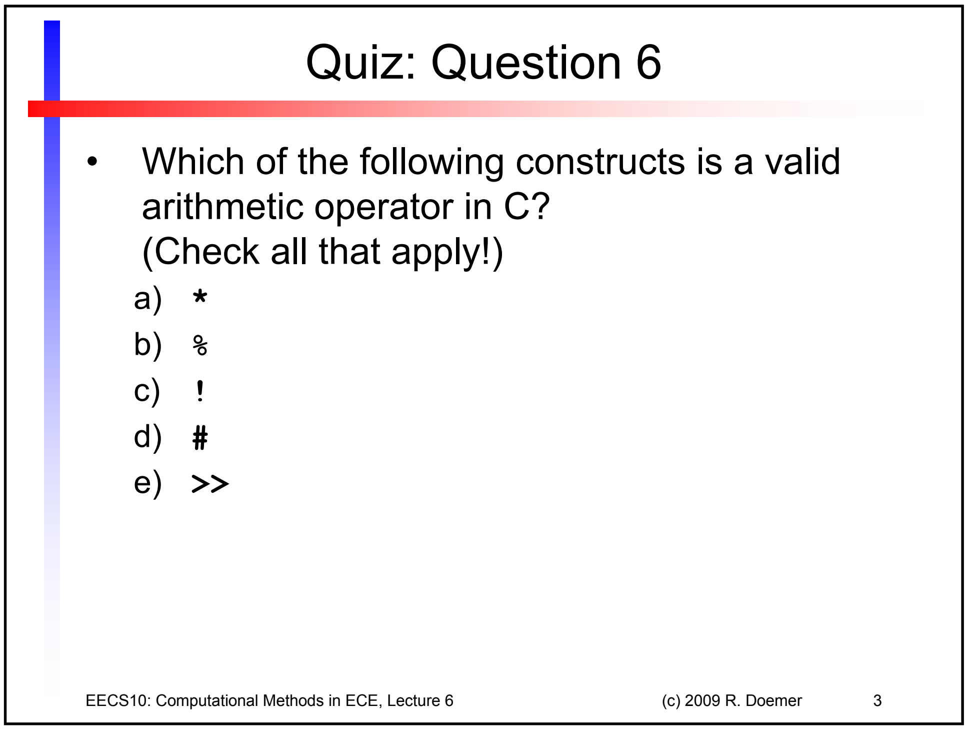
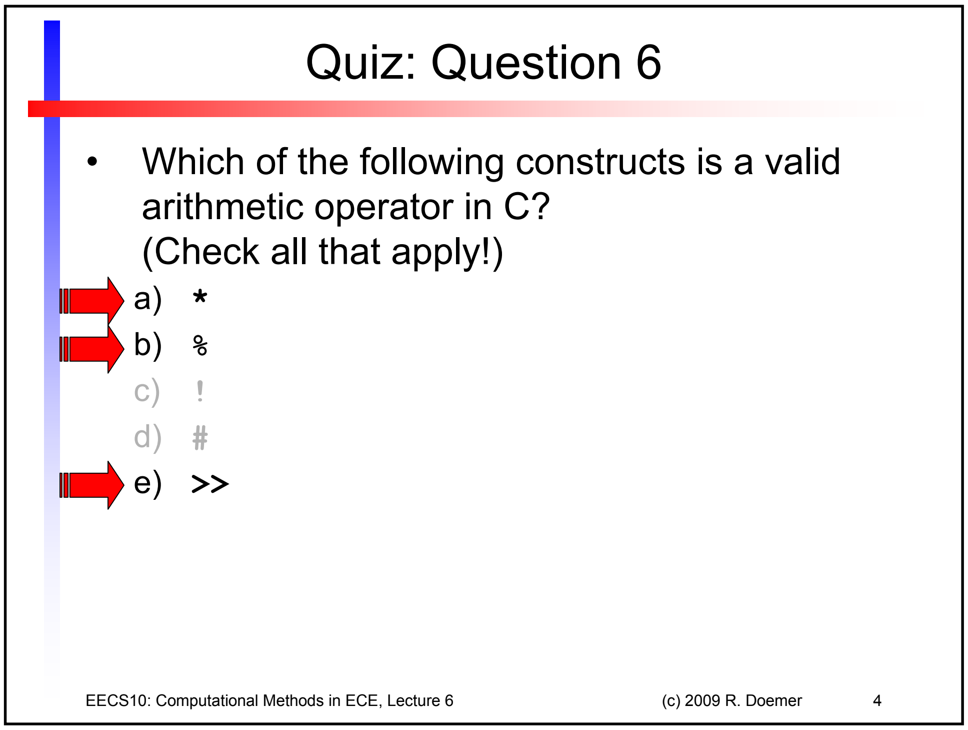
Lecture 6: Overview

- 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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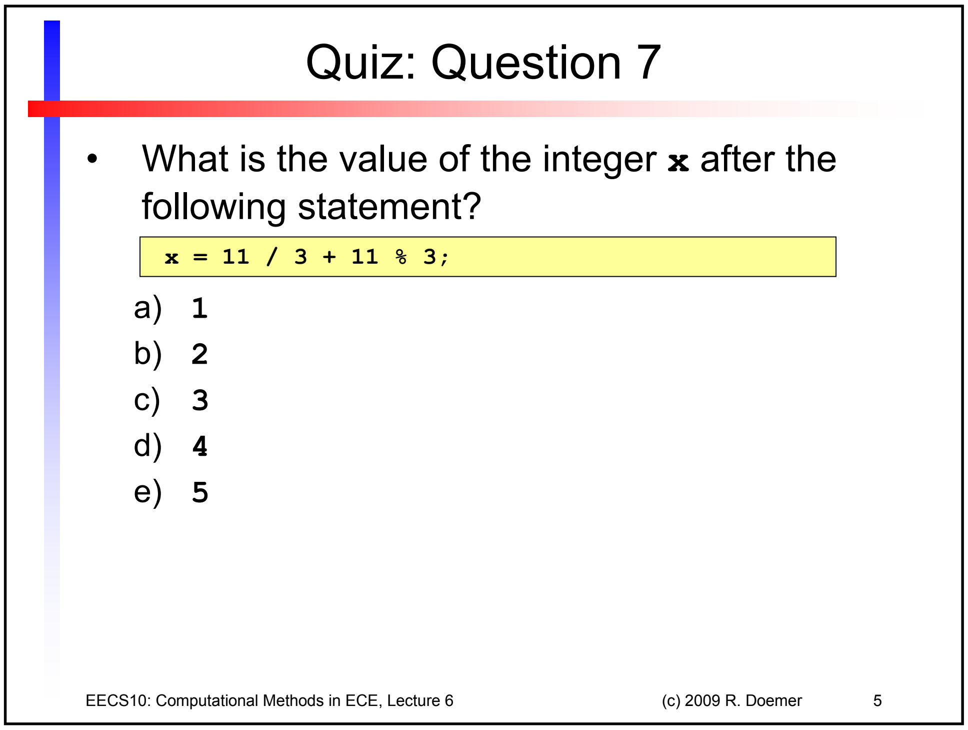
  - [✓ a) `*`]
  - [✓ b) `%`]
  - c) `!`
  - d) `#`
  - [✓ e) `>>`]



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**

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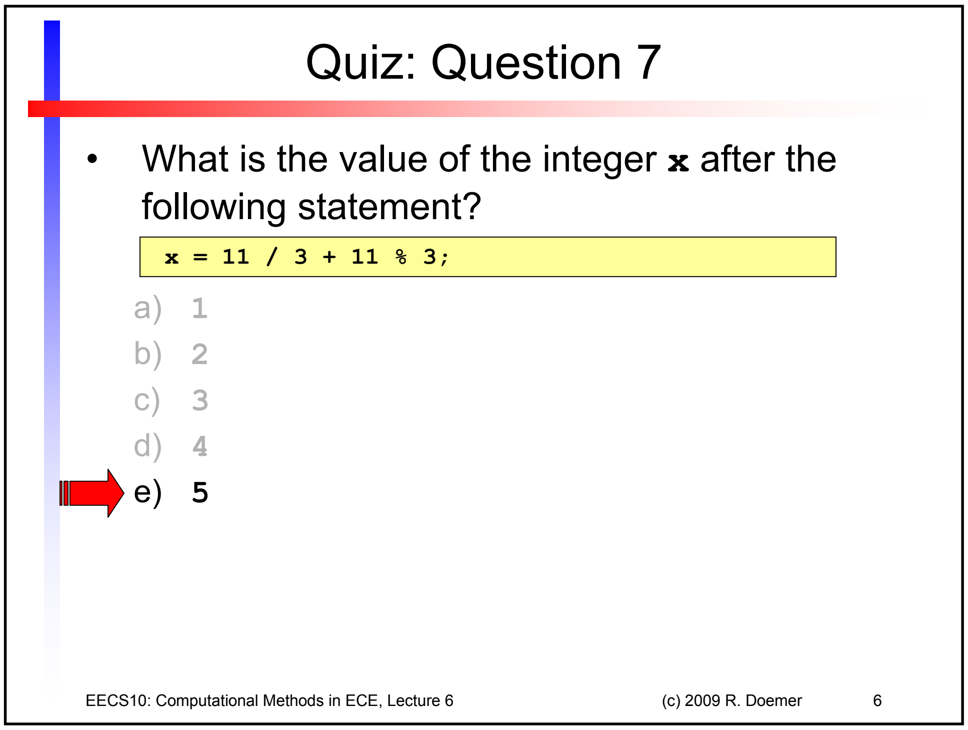

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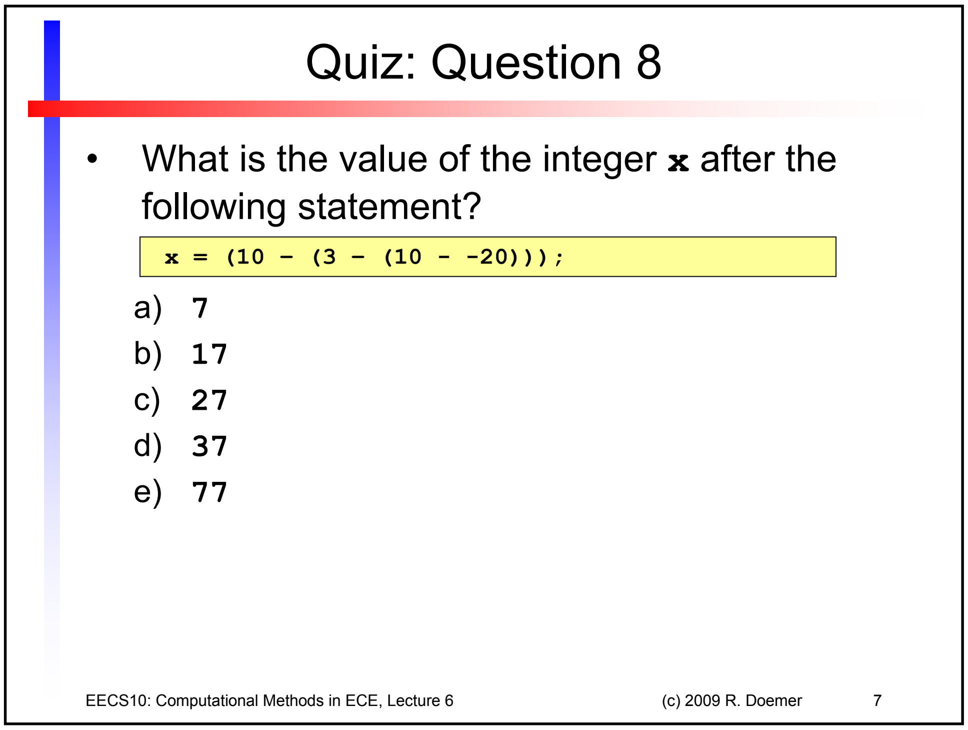
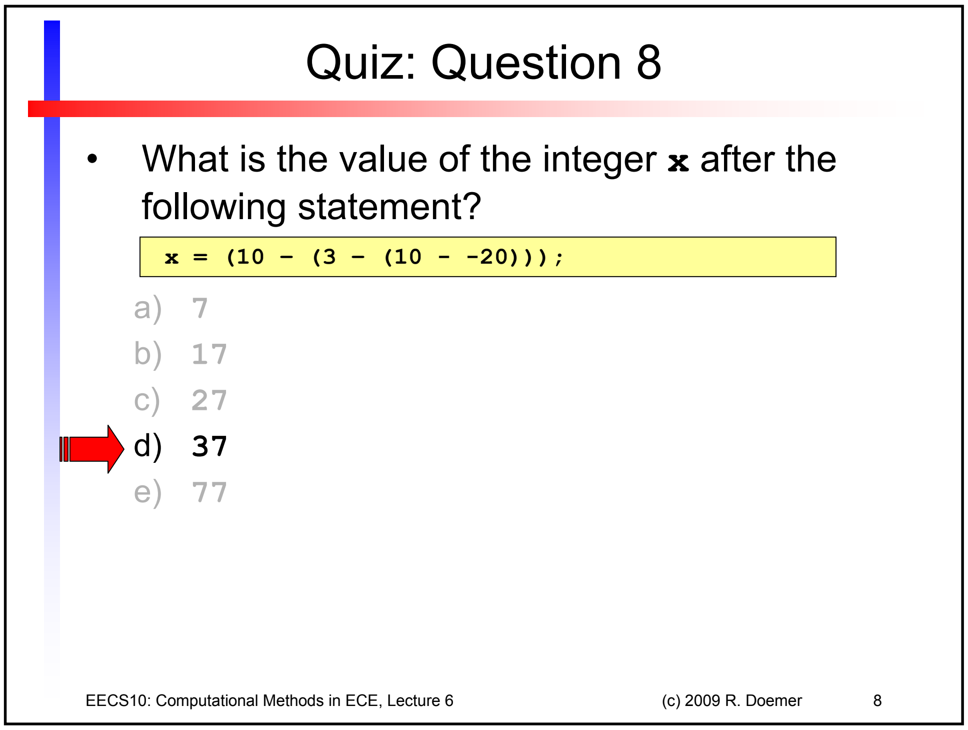


Quiz: Question 8

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

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

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



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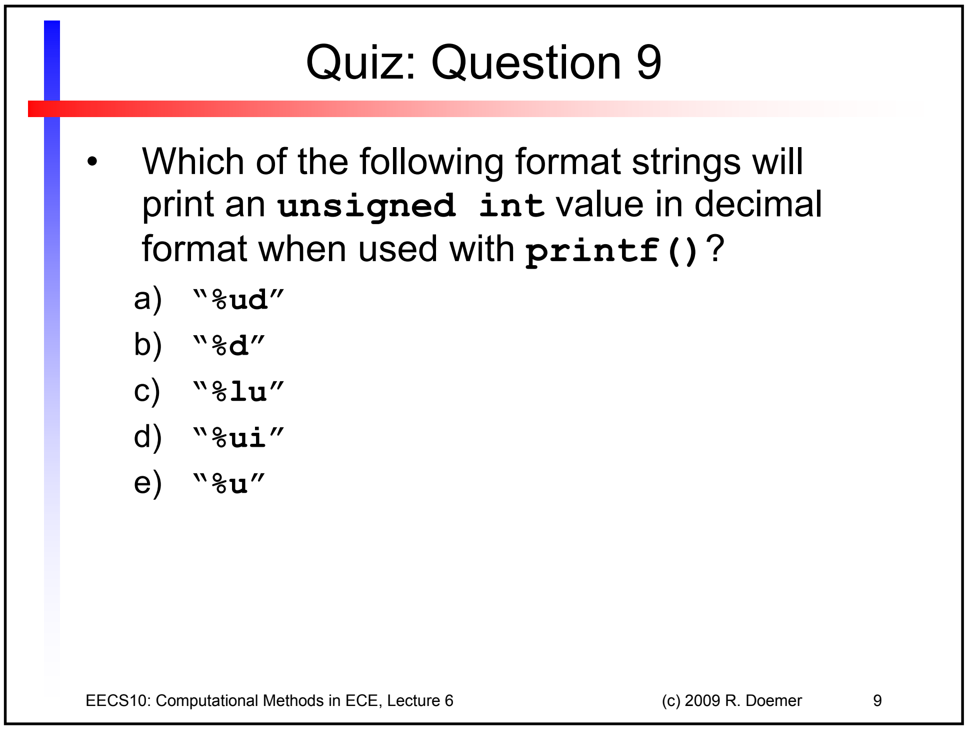
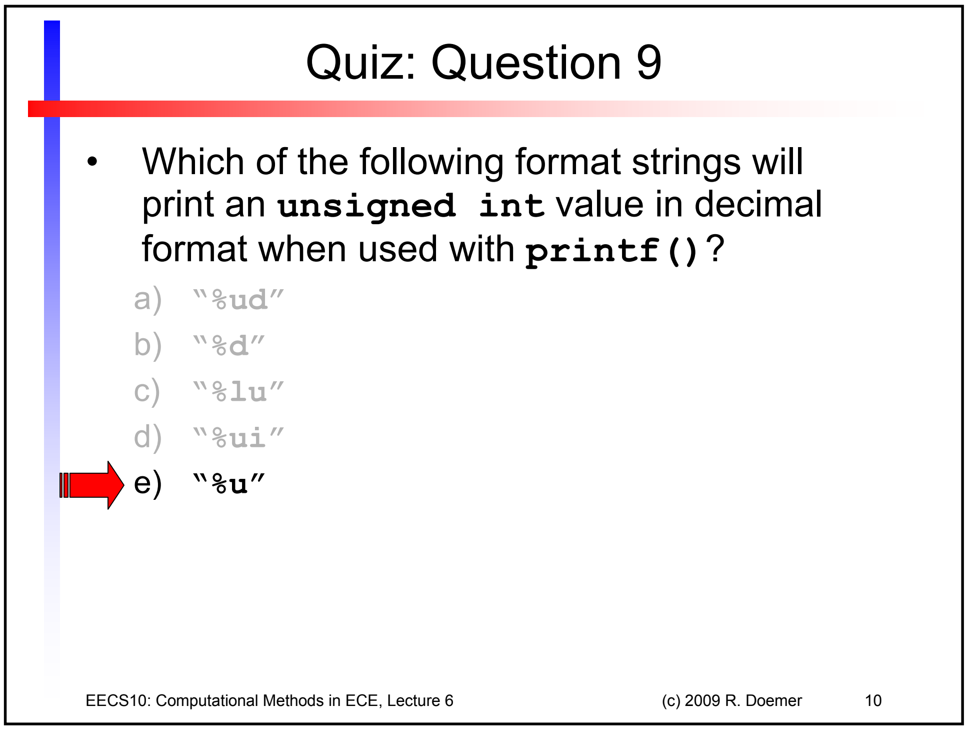


Quiz: Question 9

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



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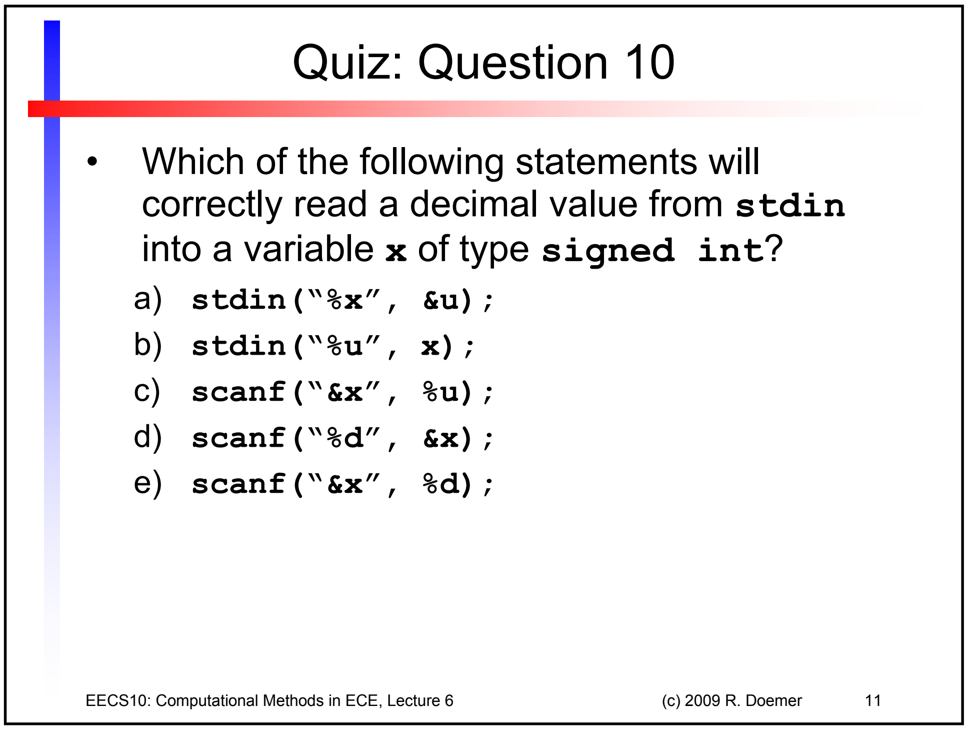
  d) **`“%ui”`**
  [✓ e) **`“%u”`**]



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(“&x”, %u);`**
  d) **`scanf(“%d”, &x);`**
  e) **`scanf(“&x”, %d);`**

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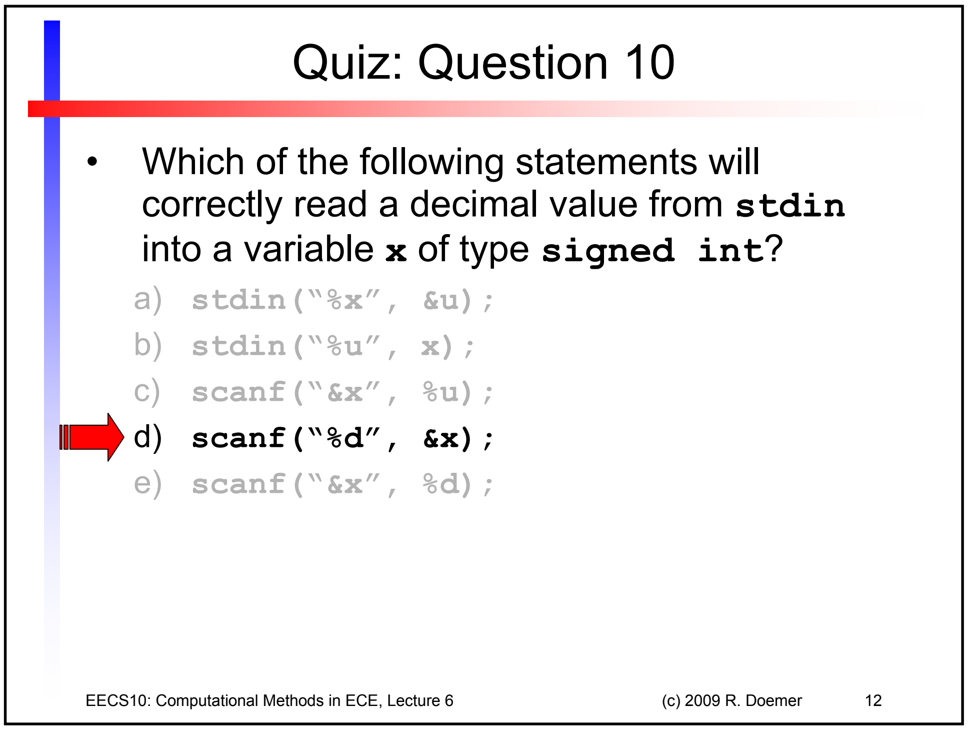

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  b) `stdin(“%u”, x);`
  c) `scanf(“&x”, %u);`
  [✓ d) **`scanf(“%d”, &x);`**]
  e) `scanf(“&x”, %d);`

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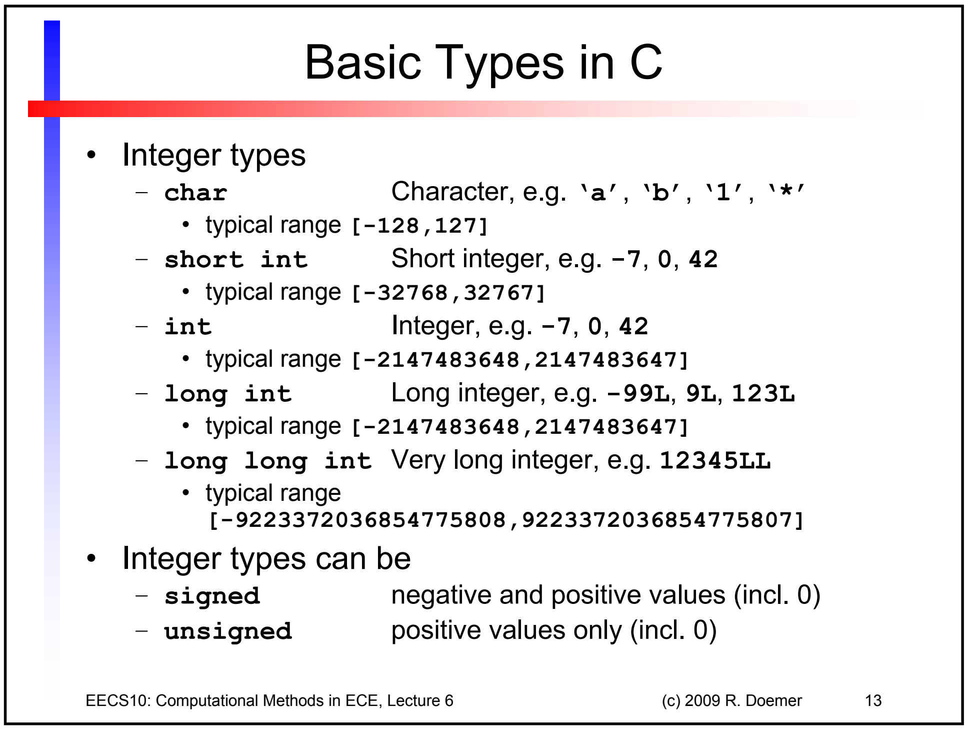

Basic Types in C

- 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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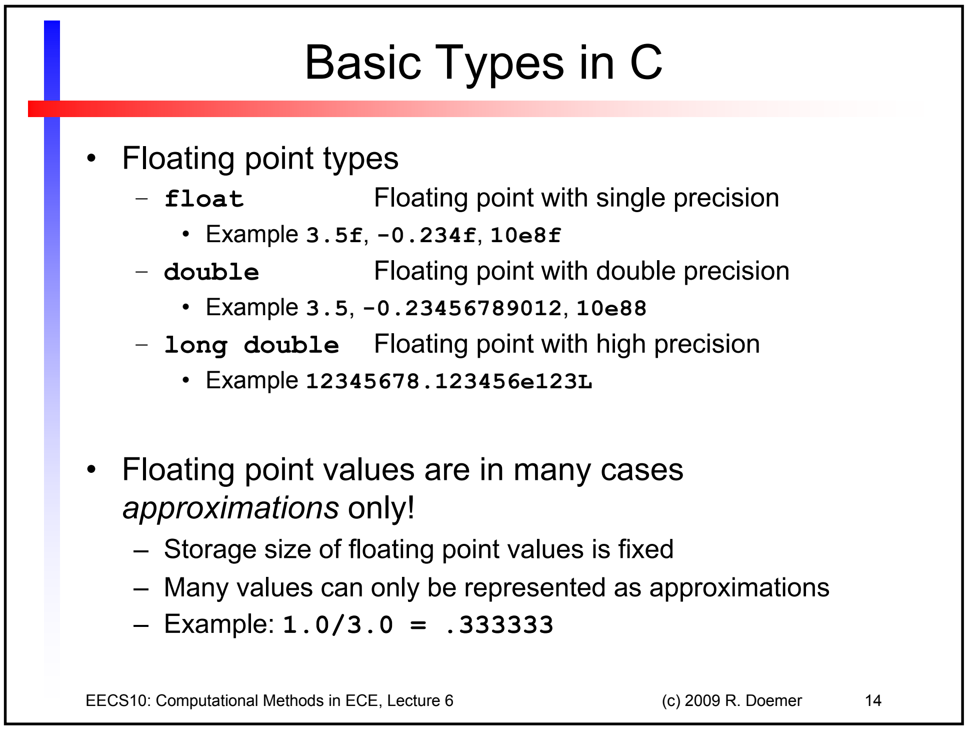

Basic Types in C

- 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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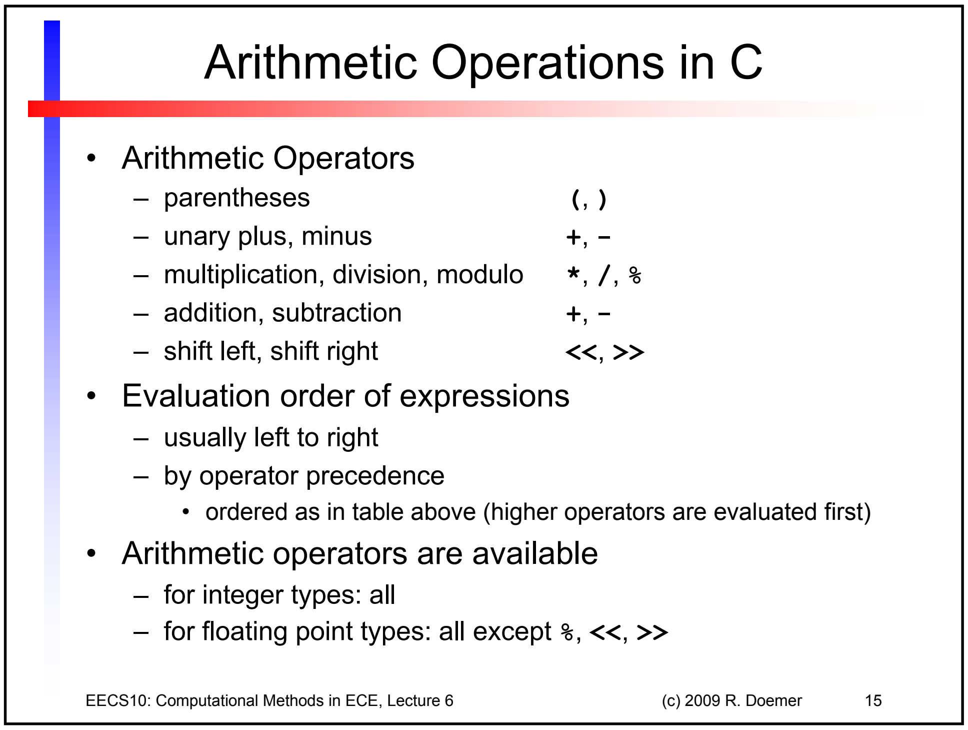
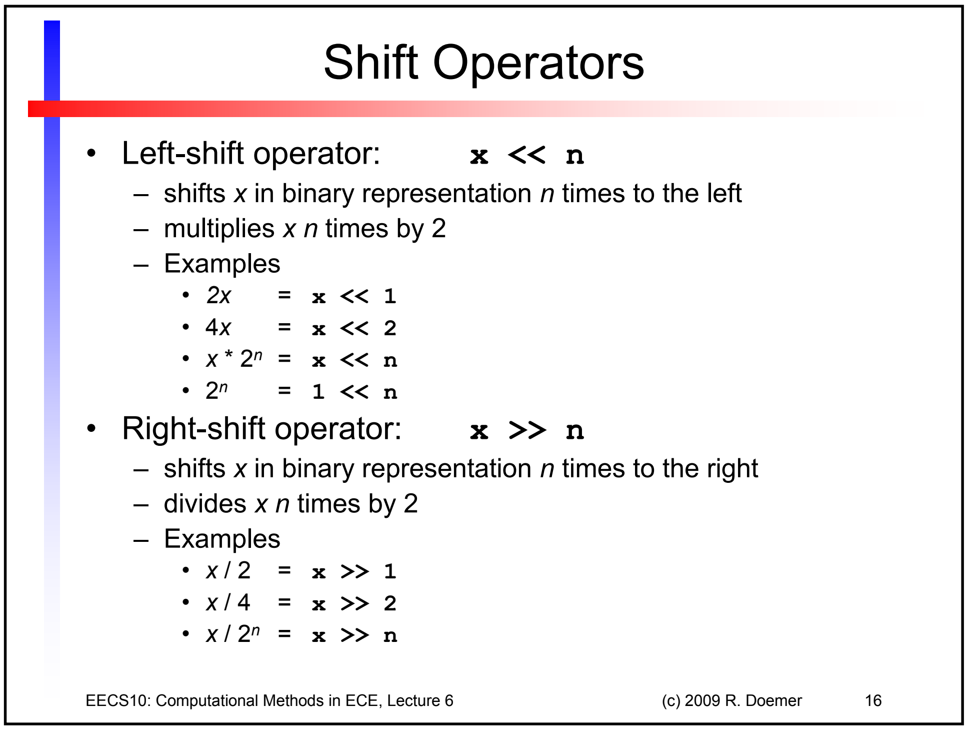


Arithmetic Operations in C

- Arithmetic Operators

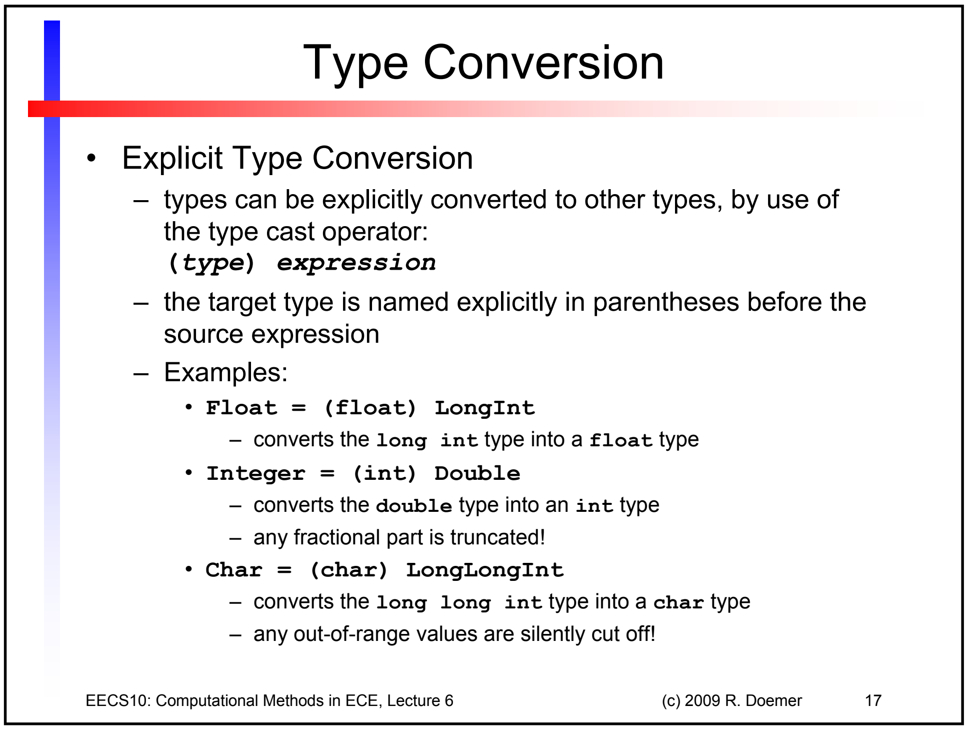
– parentheses	`(, )`
– unary plus, minus	`+, -`
– multiplication, division, modulo	`*, /, %`
– addition, subtraction	`+, -`
– shift left, shift right	`<<, >>`

- 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 `%`, `<<`, `>>`



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`



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`** type into a **`float`** type
    - **`Integer = (int) Double`**
      - converts the **`double`** type into an **`int`** type
      - any fractional part is truncated!
    - **`Char = (char) LongLongInt`**
      - converts the **`long long int`** type into a **`char`** type
      - any out-of-range values are silently cut off!

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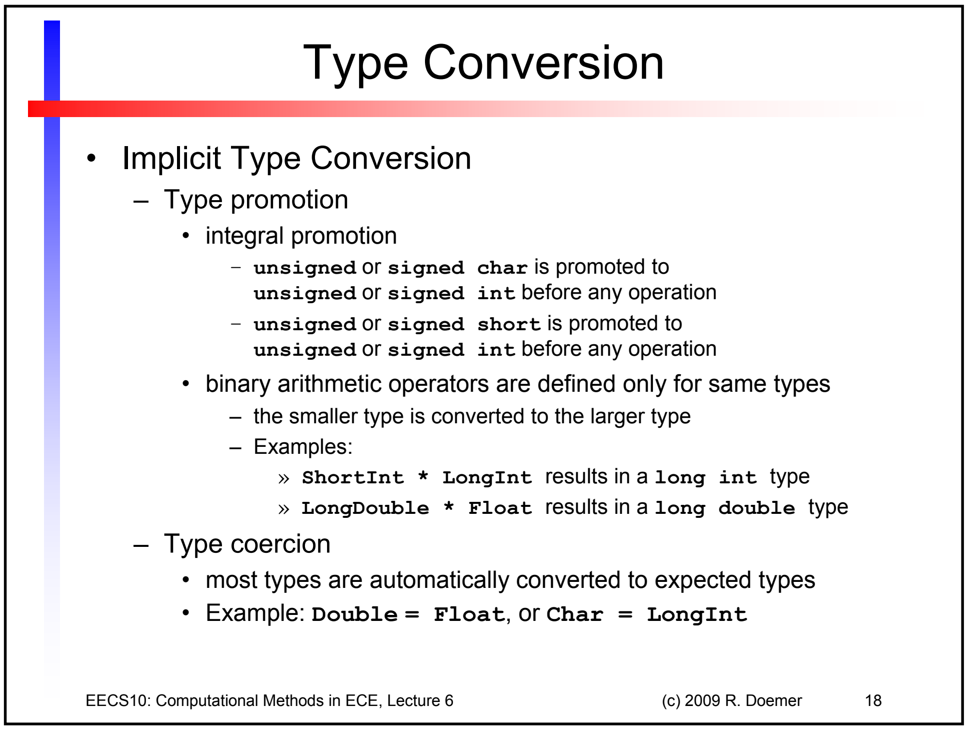

Type Conversion

- 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
      - 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:

```
short int s;
int       i;
long int  l;
float     f;
double    d;

l  =   2 * s   +   i * f   -   0.5   * d;
```

$$\underbrace{\underbrace{l}_{\text{long}} = \underbrace{\underbrace{\underbrace{\underbrace{2}_{\text{int}} * \underbrace{s}_{\text{int}}}_{\text{int}} + \underbrace{\underbrace{i}_{\text{int}} * \underbrace{f}_{\text{float}}}_{\text{float}}}_{\text{float}} - \underbrace{\underbrace{0.5}_{\text{double}} * \underbrace{d}_{\text{double}}}_{\text{double}}}_{\text{double}}}_{\text{long}}$$

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:

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

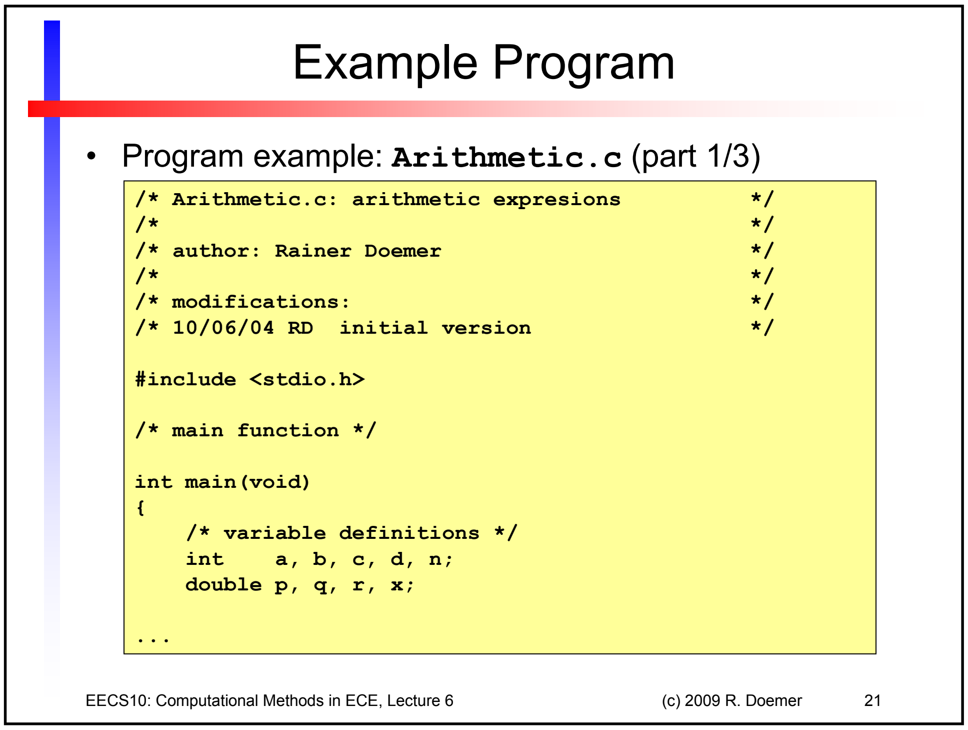
    - Quotient of sums:

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

    - Remainder:

$$r = rem(2^n / 7)$$

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



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;

...
```

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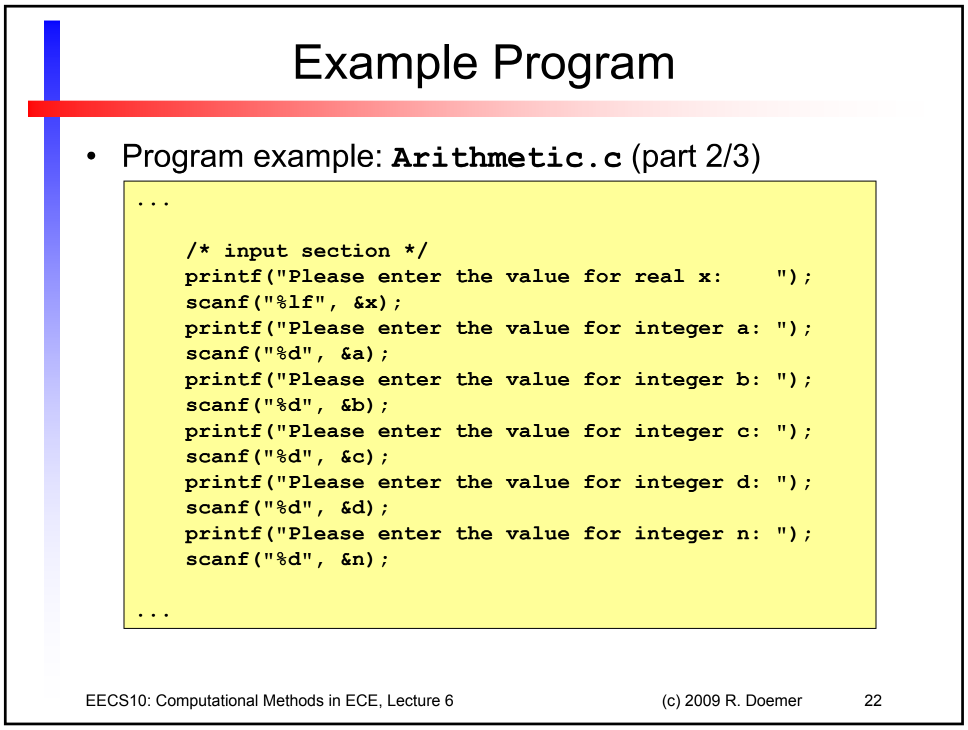

Example Program

- 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);

...
```

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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.
%
```