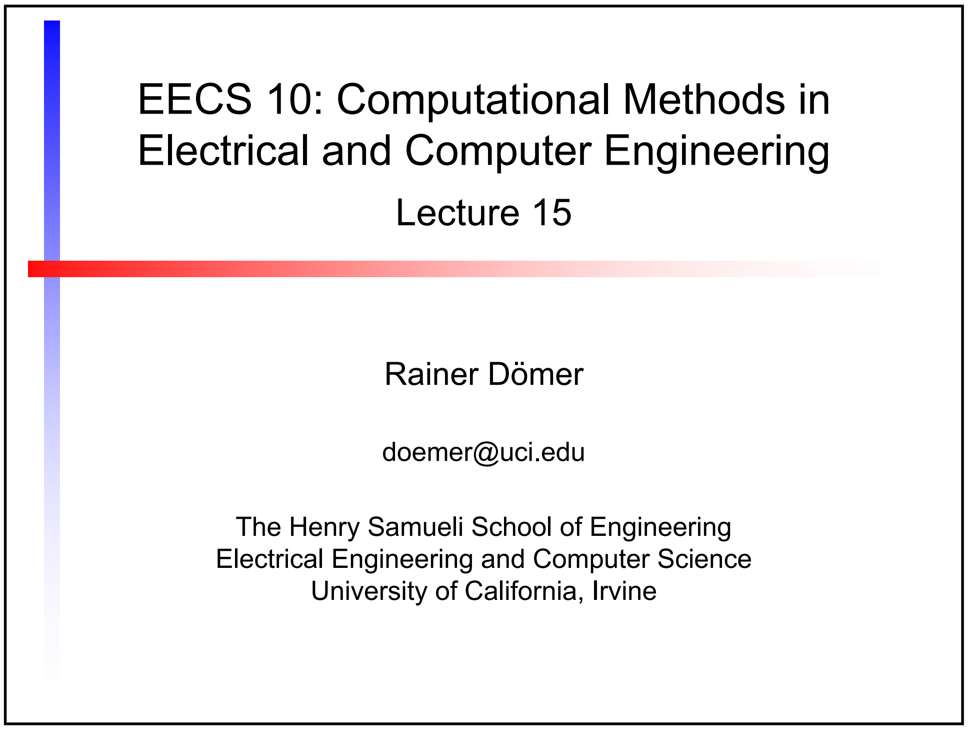

EECS 10: Computational Methods in Electrical and Computer Engineering

Lecture 15

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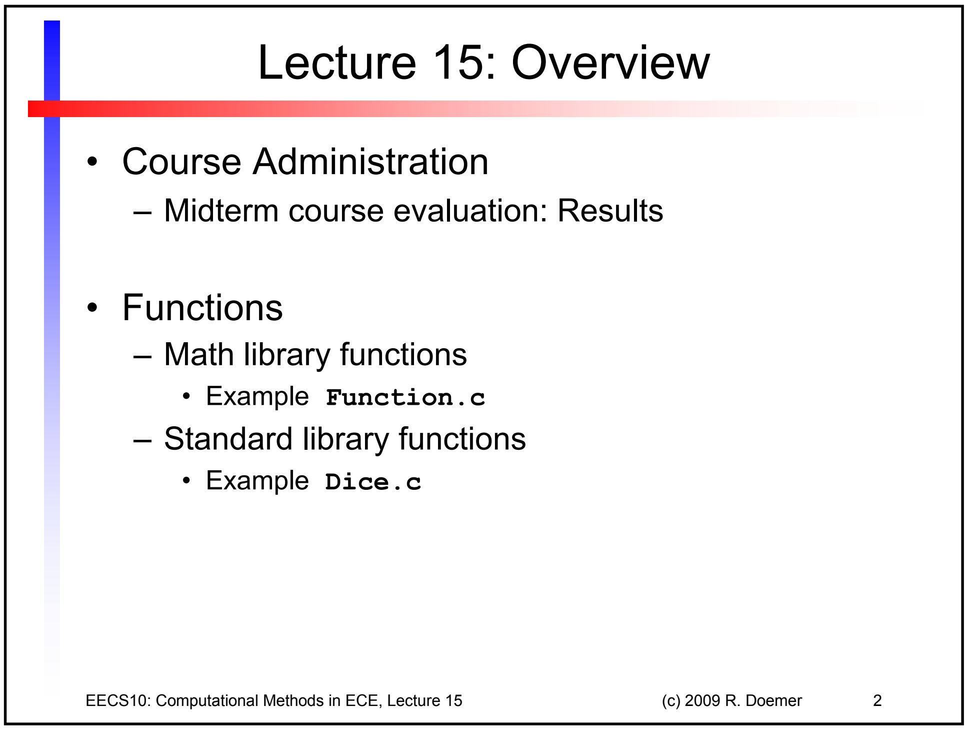
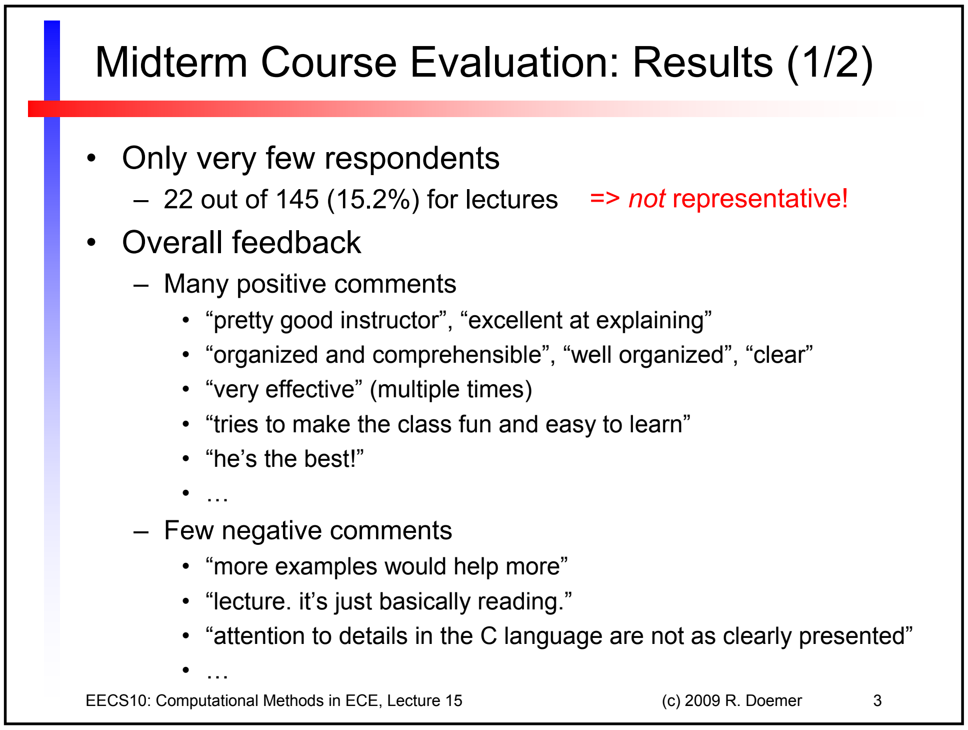


Lecture 15: Overview

- Course Administration
  - Midterm course evaluation: Results
- Functions
  - Math library functions
    - Example `Function.c`
  - Standard library functions
    - Example `Dice.c`



Midterm Course Evaluation: Results (1/2)

- Only very few respondents
  - 22 out of 145 (15.2%) for lectures => *not* representative!
- Overall feedback
  - Many positive comments
    - "pretty good instructor", "excellent at explaining"
    - "organized and comprehensible", "well organized", "clear"
    - "very effective" (multiple times)
    - "tries to make the class fun and easy to learn"
    - "he's the best!"
    - …
  - Few negative comments
    - "more examples would help more"
    - "lecture. it's just basically reading."
    - "attention to details in the C language are not as clearly presented"
    - …

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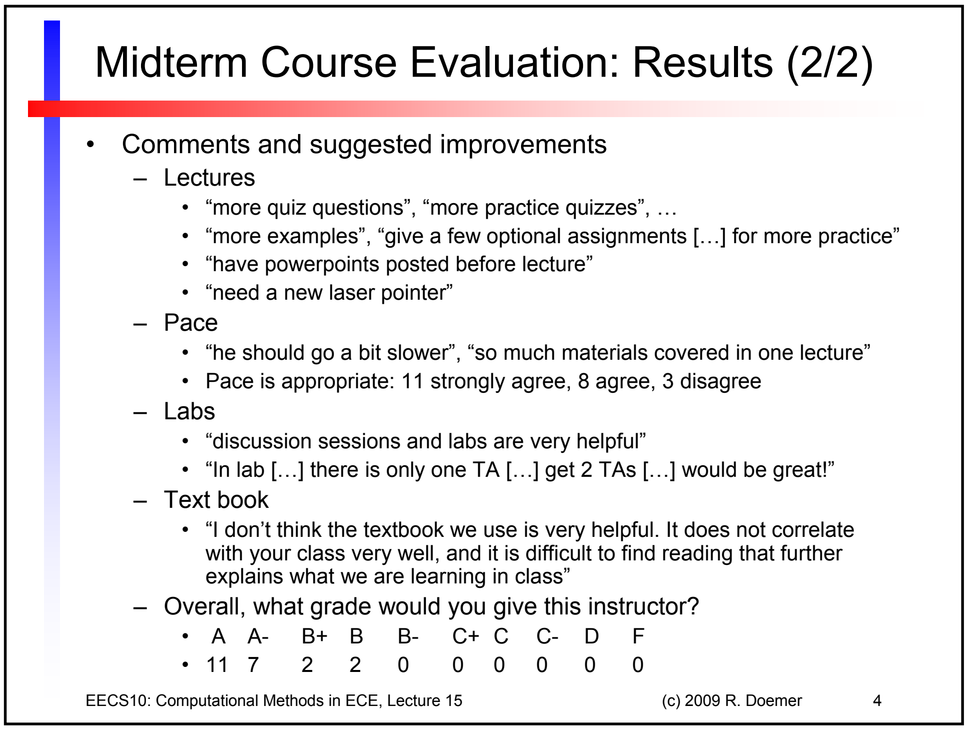

Midterm Course Evaluation: Results (2/2)

- Comments and suggested improvements
  - Lectures
    - "more quiz questions", "more practice quizzes", …
    - "more examples", "give a few optional assignments […] for more practice"
    - "have powerpoints posted before lecture"
    - "need a new laser pointer"
  - Pace
    - "he should go a bit slower", "so much materials covered in one lecture"
    - Pace is appropriate: 11 strongly agree, 8 agree, 3 disagree
  - Labs
    - "discussion sessions and labs are very helpful"
    - "In lab […] there is only one TA […] get 2 TAs […] would be great!"
  - Text book
    - "I don't think the textbook we use is very helpful. It does not correlate with your class very well, and it is difficult to find reading that further explains what we are learning in class"
  - Overall, what grade would you give this instructor?

A	A-	B+	B	B-	C+	C	C-	D	F
11	7	2	2	0	0	0	0	0	0

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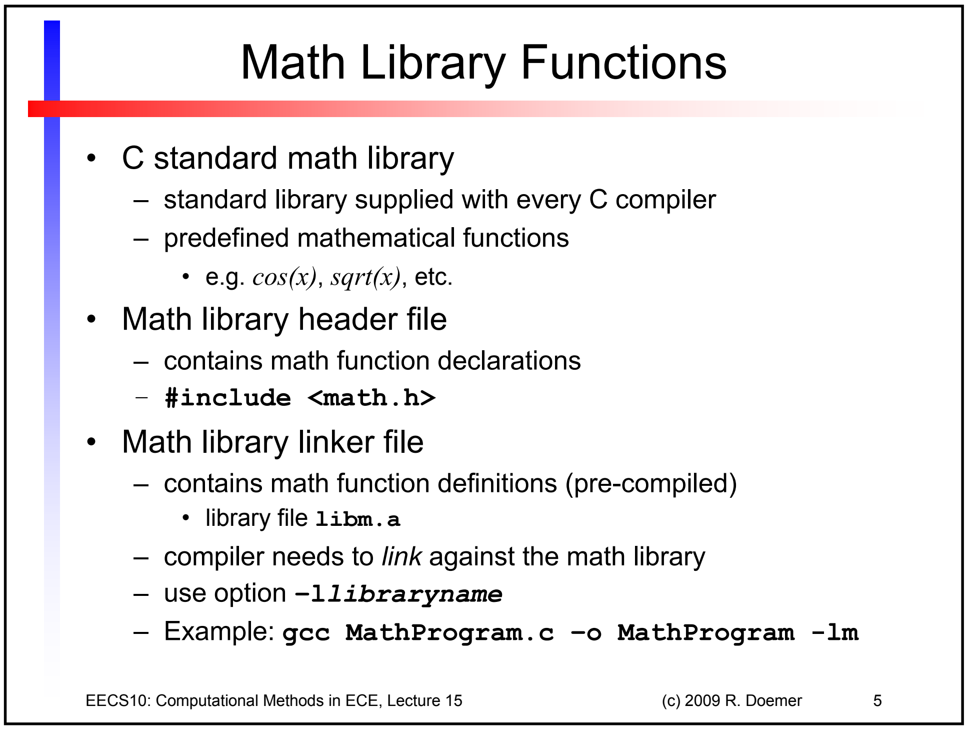
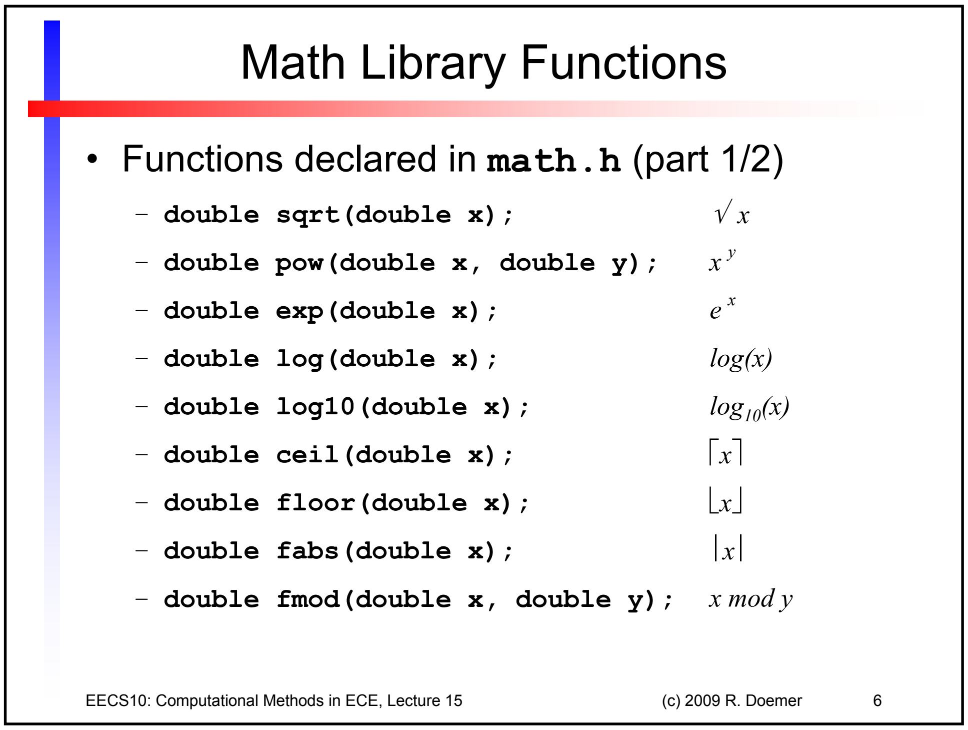


Math Library Functions

- C standard math library
  - standard library supplied with every C compiler
  - predefined mathematical functions
    - e.g. *cos(x)*, *sqrt(x)*, etc.
- Math library header file
  - contains math function declarations
  - **`#include <math.h>`**
- Math library linker file
  - contains math function definitions (pre-compiled)
    - library file **`libm.a`**
  - compiler needs to *link* against the math library
  - use option **`-l`*`libraryname`***
  - Example: **`gcc MathProgram.c -o MathProgram -lm`**



Math Library Functions

- Functions declared in **`math.h`** (part 1/2)

– **`double sqrt(double x);`**	$\sqrt{x}$
– **`double pow(double x, double y);`**	x^y
– **`double exp(double x);`**	e^x
– **`double log(double x);`**	$log(x)$
– **`double log10(double x);`**	$log_{10}(x)$
– **`double ceil(double x);`**	$\lceil x \rceil$
– **`double floor(double x);`**	$\lfloor x \rfloor$
– **`double fabs(double x);`**	$\lvert x \rvert$
– **`double fmod(double x, double y);`**	$x \bmod y$

Math Library Functions

- Functions declared in **`math.h`** (part 2/2)

– `double cos(double x);`	*cos(x)*
– `double sin(double x);`	*sin(x)*
– `double tan(double x);`	*tan(x)*
– `double acos(double x);`	*acos(x)*
– `double asin(double x);`	*asin(x)*
– `double atan(double x);`	*atan(x)*
– `double cosh(double x);`	*cosh(x)*
– `double sinh(double x);`	*sinh(x)*
– `double tanh(double x);`	*tanh(x)*

Math Library Functions

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

```
/* Function.c: compute a math function table    */
/*                                              */
/* author: Rainer Doemer                        */
/*                                              */
/* modifications:                               */
/* 10/28/04 RD  initial version                 */

#include <stdio.h>
#include <math.h>

/* function definition */

double f(double x)
{
    return cos(x);
} /* end of f */

...
```

Math Library Functions

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

```
...
/* main function */

int main(void)
{
    /* variable definitions */
    double hi, lo, step;
    double x, y;

    /* input section */
    printf("Please enter the lower bound: ");
    scanf("%lf", &lo);
    printf("Please enter the upper bound: ");
    scanf("%lf", &hi);
    printf("Please enter the step size:   ");
    scanf("%lf", &step);

...
```

Math Library Functions

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

```
...

    /* computation and output section */
    for(x = lo; x <= hi; x += step)
    {
        y = f(x);
        printf("f(%10g) = %10g\n", x, y);
    } /* rof */

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

/* EOF */
```

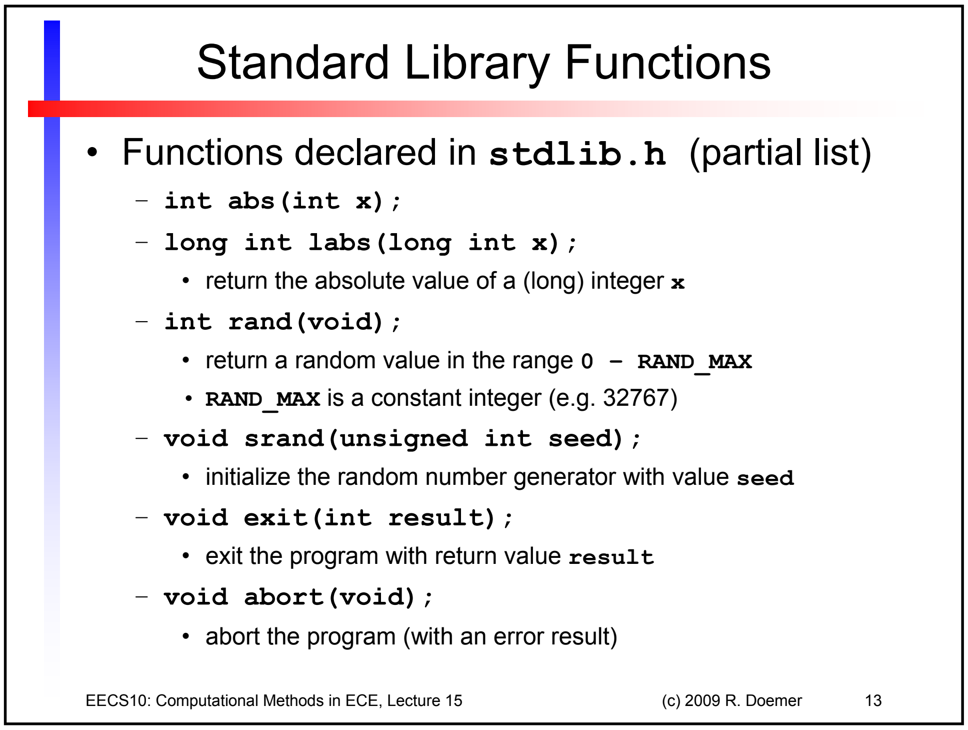
Math Library Functions

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

```
% vi Function.c
% gcc Function.c -o Function -Wall -ansi -lm
% Function
Please enter the lower bound: -0.5
Please enter the upper bound: 1.0
Please enter the step size:   .1
f(      -0.5) =   0.877583
f(      -0.4) =   0.921061
f(      -0.3) =   0.955336
f(      -0.2) =   0.980067
f(      -0.1) =   0.995004
f(-2.77556e-17) =          1
f(       0.1) =   0.995004
f(       0.2) =   0.980067
f(       0.3) =   0.955336
f(       0.4) =   0.921061
f(       0.5) =   0.877583
f(       0.6) =   0.825336
f(       0.7) =   0.764842
f(       0.8) =   0.696707
f(       0.9) =    0.62161
f(         1) =   0.540302
%
```

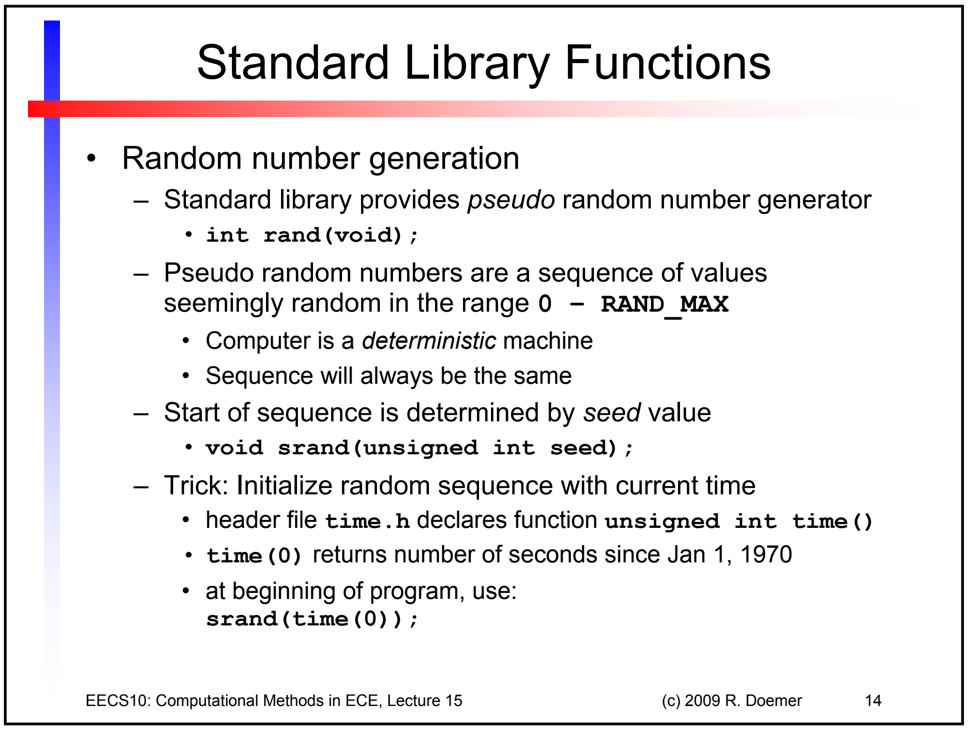
Standard Library Functions

- Standard C library
  - standard library supplied with every C compiler
  - predefined standard functions
    - e.g. **`printf()`**, **`scanf()`**, etc.
- C library header files
  - input/output function declarations **`#include <stdio.h>`**
  - standard function declarations **`#include <stdlib.h>`**
  - time function declarations **`#include <time.h>`**
  - etc.
- C library linker file
  - contains standard function definitions (pre-compiled)
    - library file **`libc.a`**
  - compiler *automatically links* against the standard library (no need to supply extra options)



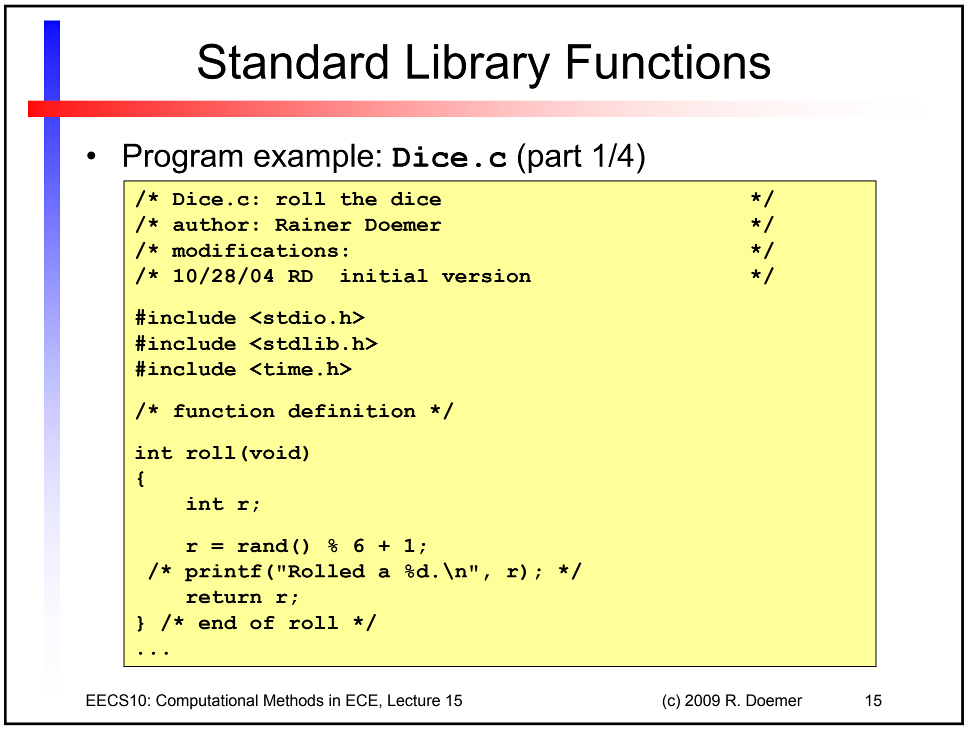
Standard Library Functions

- Functions declared in **`stdlib.h`** (partial list)
  - **`int abs(int x);`**
  - **`long int labs(long int x);`**
    - return the absolute value of a (long) integer **`x`**
  - **`int rand(void);`**
    - return a random value in the range `0 – RAND_MAX`
    - **`RAND_MAX`** is a constant integer (e.g. 32767)
  - **`void srand(unsigned int seed);`**
    - initialize the random number generator with value **`seed`**
  - **`void exit(int result);`**
    - exit the program with return value **`result`**
  - **`void abort(void);`**
    - abort the program (with an error result)



Standard Library Functions

- Random number generation
  - Standard library provides *pseudo* random number generator
    - **`int rand(void);`**
  - Pseudo random numbers are a sequence of values seemingly random in the range `0 – RAND_MAX`
    - Computer is a *deterministic* machine
    - Sequence will always be the same
  - Start of sequence is determined by *seed* value
    - **`void srand(unsigned int seed);`**
  - Trick: Initialize random sequence with current time
    - header file **`time.h`** declares function **`unsigned int time()`**
    - **`time(0)`** returns number of seconds since Jan 1, 1970
    - at beginning of program, use:
      `srand(time(0));`



Standard Library Functions

- Program example: `Dice.c` (part 1/4)

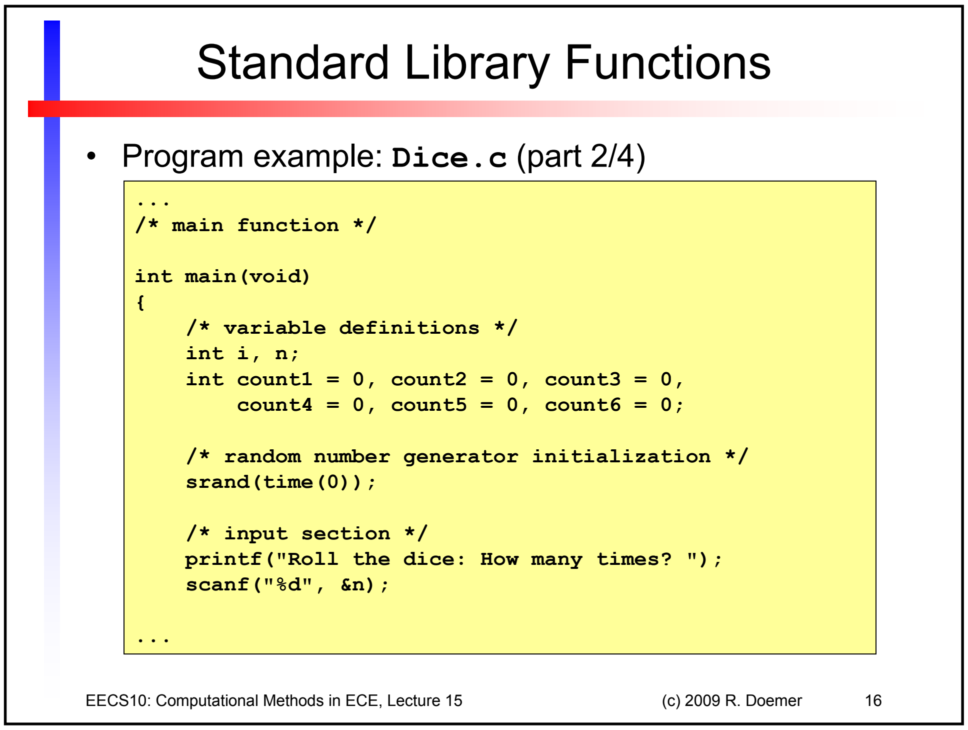
```
/* Dice.c: roll the dice                            */
/* author: Rainer Doemer                            */
/* modifications:                                   */
/* 10/28/04 RD  initial version                     */

#include <stdio.h>
#include <stdlib.h>
#include <time.h>

/* function definition */

int roll(void)
{
    int r;

    r = rand() % 6 + 1;
 /* printf("Rolled a %d.\n", r); */
    return r;
} /* end of roll */
...
```



Standard Library Functions

- Program example: `Dice.c` (part 2/4)

```
...
/* main function */

int main(void)
{
    /* variable definitions */
    int i, n;
    int count1 = 0, count2 = 0, count3 = 0,
        count4 = 0, count5 = 0, count6 = 0;

    /* random number generator initialization */
    srand(time(0));

    /* input section */
    printf("Roll the dice: How many times? ");
    scanf("%d", &n);

...
```

Standard Library Functions

- Program example: **`Dice.c`** (part 3/4)

```
... /* computation section */
    for(i = 0; i < n; i++)
       { switch(roll())
            { case 1:
                { count1++; break; }
              case 2:
                { count2++; break; }
              case 3:
                { count3++; break; }
              case 4:
                { count4++; break; }
              case 5:
                { count5++; break; }
              case 6:
                { count6++; break; }
              default:
                { printf("INVALID ROLL!");
                  exit(10); }
             } /* hctiws */
        } /* rof */
...
```

Standard Library Functions

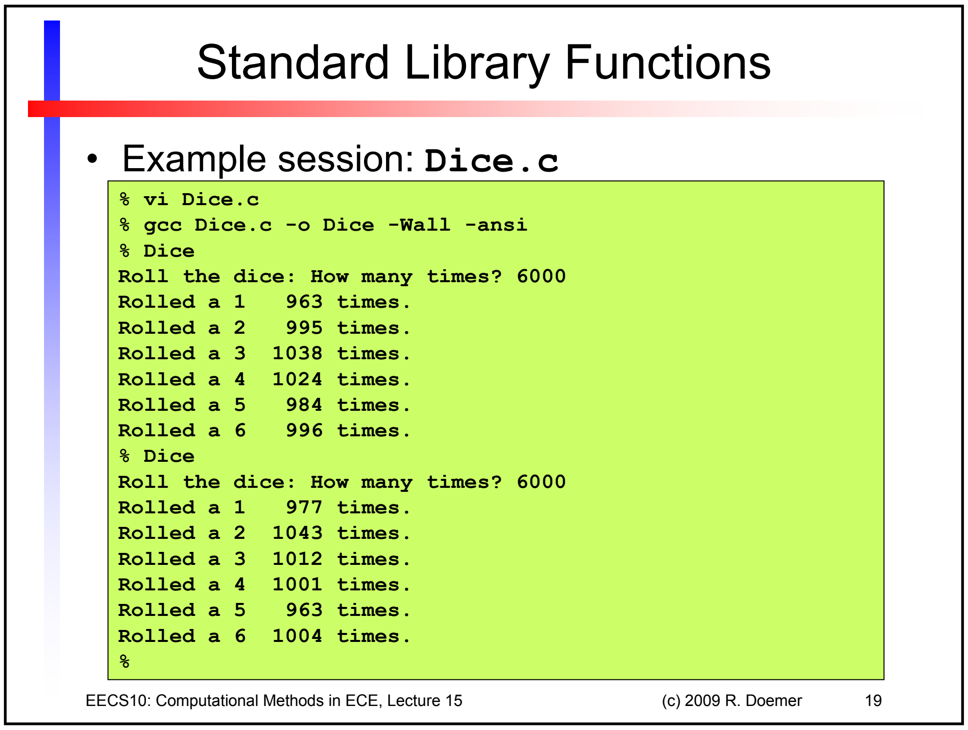
- Program example: **`Dice.c`** (part 4/4)

```
...

    /* output section */
    printf("Rolled a 1 %5d times.\n", count1);
    printf("Rolled a 2 %5d times.\n", count2);
    printf("Rolled a 3 %5d times.\n", count3);
    printf("Rolled a 4 %5d times.\n", count4);
    printf("Rolled a 5 %5d times.\n", count5);
    printf("Rolled a 6 %5d times.\n", count6);

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

/* EOF */
```



Standard Library Functions

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

```
% vi Dice.c
% gcc Dice.c -o Dice -Wall -ansi
% Dice
Roll the dice: How many times? 6000
Rolled a 1   963 times.
Rolled a 2   995 times.
Rolled a 3  1038 times.
Rolled a 4  1024 times.
Rolled a 5   984 times.
Rolled a 6   996 times.
% Dice
Roll the dice: How many times? 6000
Rolled a 1   977 times.
Rolled a 2  1043 times.
Rolled a 3  1012 times.
Rolled a 4  1001 times.
Rolled a 5   963 times.
Rolled a 6  1004 times.
%
```