EECS 10: Computational Methods in Electrical and Computer Engineering

Lecture 10

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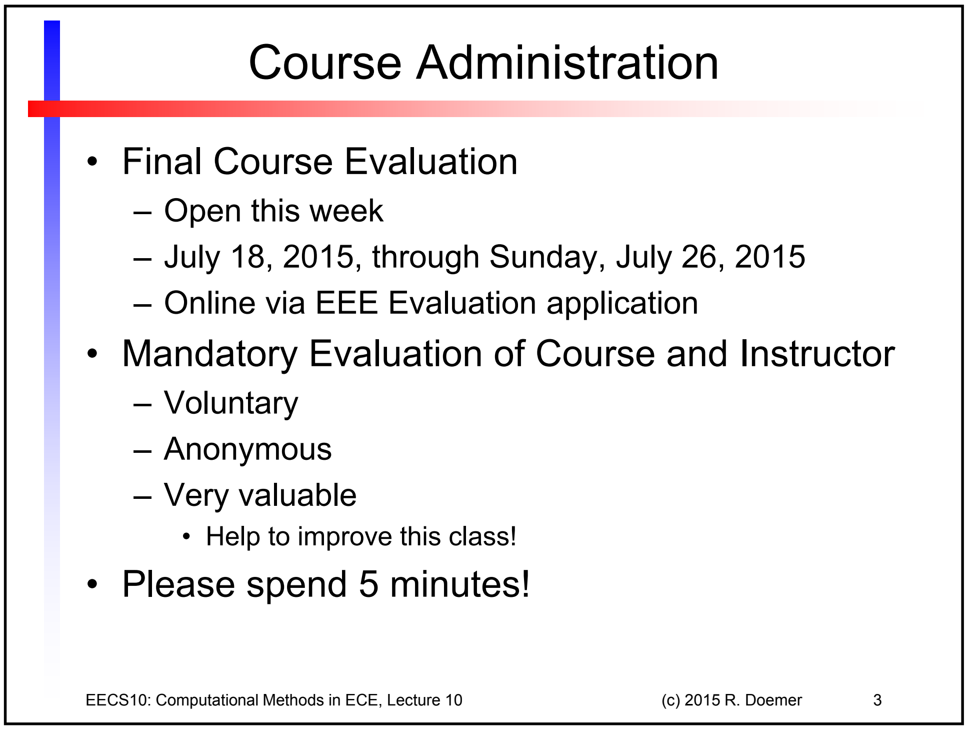
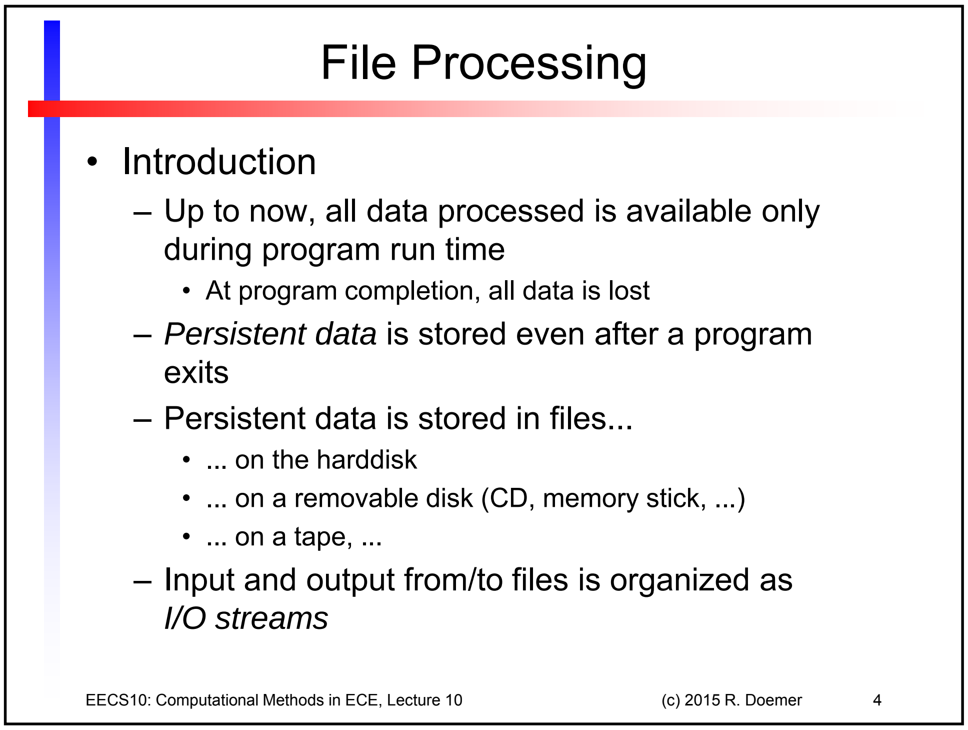
Lecture 10.1: Overview

- Course Administration
  - Final course evaluation
- File Processing
  - Introduction
  - Standard input and output streams
  - File streams, I/O
  - Standard library functions in **`stdio.h`**
  - Program example **`PhotoLab.c`**



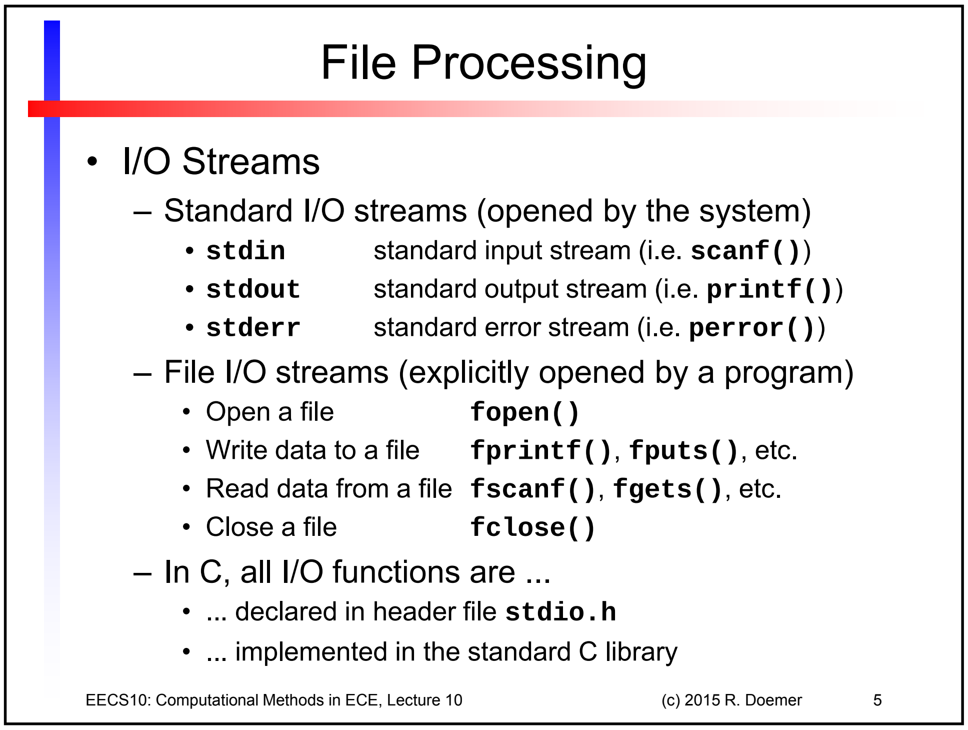
Course Administration

- Final Course Evaluation
  - Open this week
  - July 18, 2015, through Sunday, July 26, 2015
  - Online via EEE Evaluation application
- Mandatory Evaluation of Course and Instructor
  - Voluntary
  - Anonymous
  - Very valuable
    - Help to improve this class!
- Please spend 5 minutes!



File Processing

- Introduction
  - Up to now, all data processed is available only during program run time
    - At program completion, all data is lost
  - *Persistent data* is stored even after a program exits
  - Persistent data is stored in files...
    - ... on the harddisk
    - ... on a removable disk (CD, memory stick, ...)
    - ... on a tape, ...
  - Input and output from/to files is organized as *I/O streams*

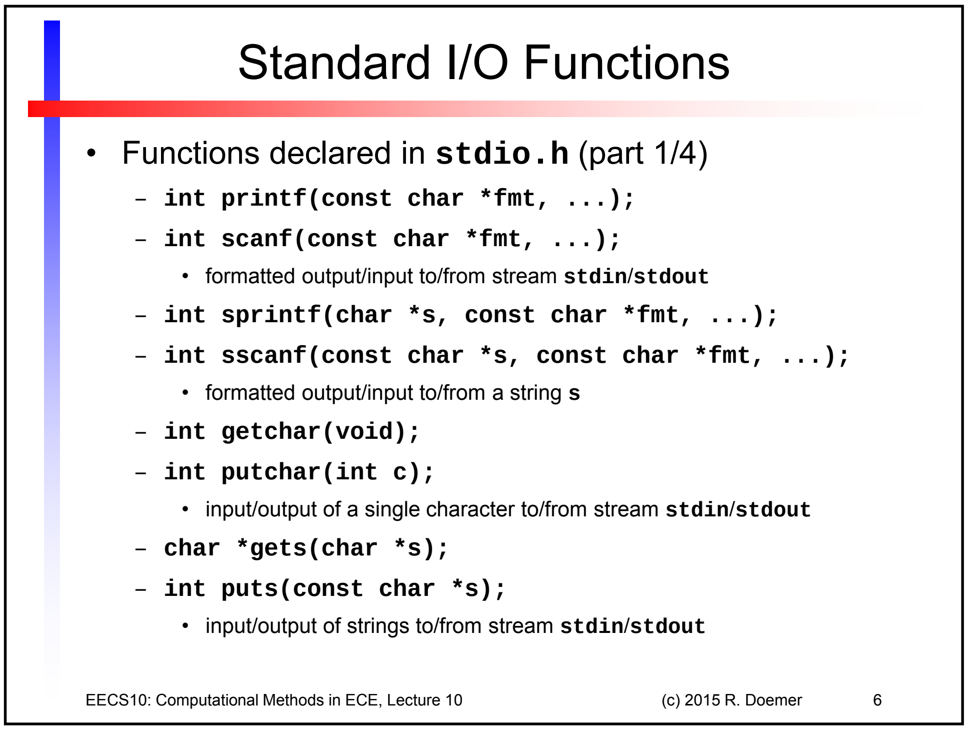


File Processing

- I/O Streams
  - Standard I/O streams (opened by the system)
    - **`stdin`** standard input stream (i.e. **`scanf()`**)
    - **`stdout`** standard output stream (i.e. **`printf()`**)
    - **`stderr`** standard error stream (i.e. **`perror()`**)
  - File I/O streams (explicitly opened by a program)

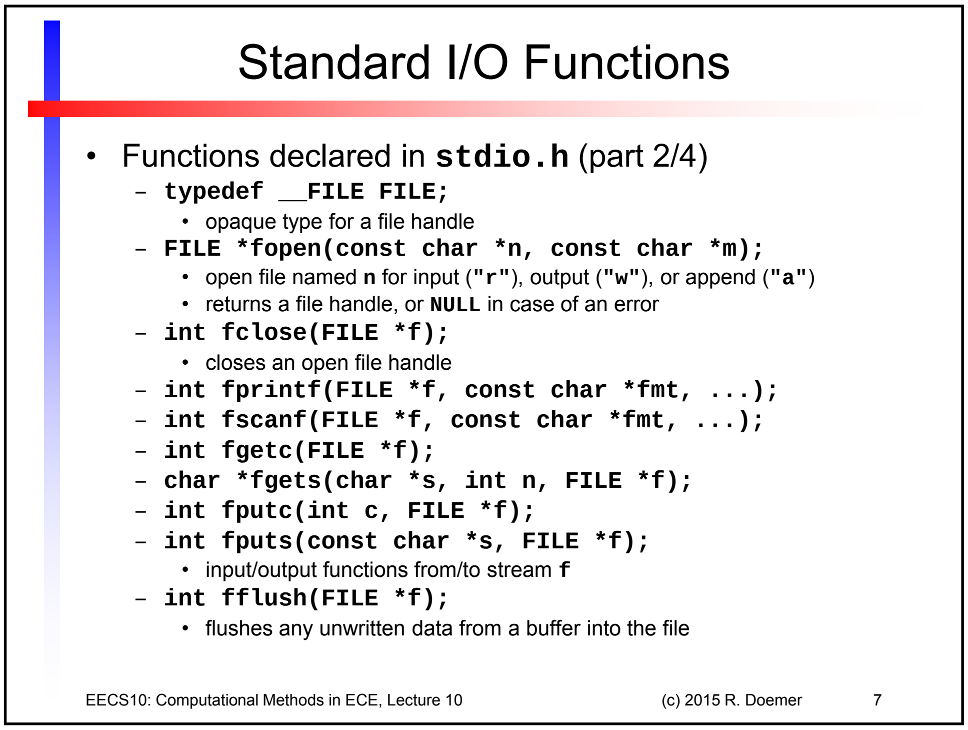
Open a file	**`fopen()`**
Write data to a file	**`fprintf()`**, **`fputs()`**, etc.
Read data from a file	**`fscanf()`**, **`fgets()`**, etc.
Close a file	**`fclose()`**

  - In C, all I/O functions are ...
    - ... declared in header file **`stdio.h`**
    - ... implemented in the standard C library



Standard I/O Functions

- Functions declared in **`stdio.h`** (part 1/4)
  - **`int printf(const char *fmt, ...);`**
  - **`int scanf(const char *fmt, ...);`**
    - formatted output/input to/from stream **`stdin`**/**`stdout`**
  - **`int sprintf(char *s, const char *fmt, ...);`**
  - **`int sscanf(const char *s, const char *fmt, ...);`**
    - formatted output/input to/from a string **`s`**
  - **`int getchar(void);`**
  - **`int putchar(int c);`**
    - input/output of a single character to/from stream **`stdin`**/**`stdout`**
  - **`char *gets(char *s);`**
  - **`int puts(const char *s);`**
    - input/output of strings to/from stream **`stdin`**/**`stdout`**



Standard I/O Functions

- Functions declared in **`stdio.h`** (part 2/4)
  - **`typedef __FILE FILE;`**
    - opaque type for a file handle
  - **`FILE *fopen(const char *n, const char *m);`**
    - open file named **`n`** for input (**`"r"`**), output (**`"w"`**), or append (**`"a"`**)
    - returns a file handle, or **`NULL`** in case of an error
  - **`int fclose(FILE *f);`**
    - closes an open file handle
  - **`int fprintf(FILE *f, const char *fmt, ...);`**
  - **`int fscanf(FILE *f, const char *fmt, ...);`**
  - **`int fgetc(FILE *f);`**
  - **`char *fgets(char *s, int n, FILE *f);`**
  - **`int fputc(int c, FILE *f);`**
  - **`int fputs(const char *s, FILE *f);`**
    - input/output functions from/to stream **`f`**
  - **`int fflush(FILE *f);`**
    - flushes any unwritten data from a buffer into the file

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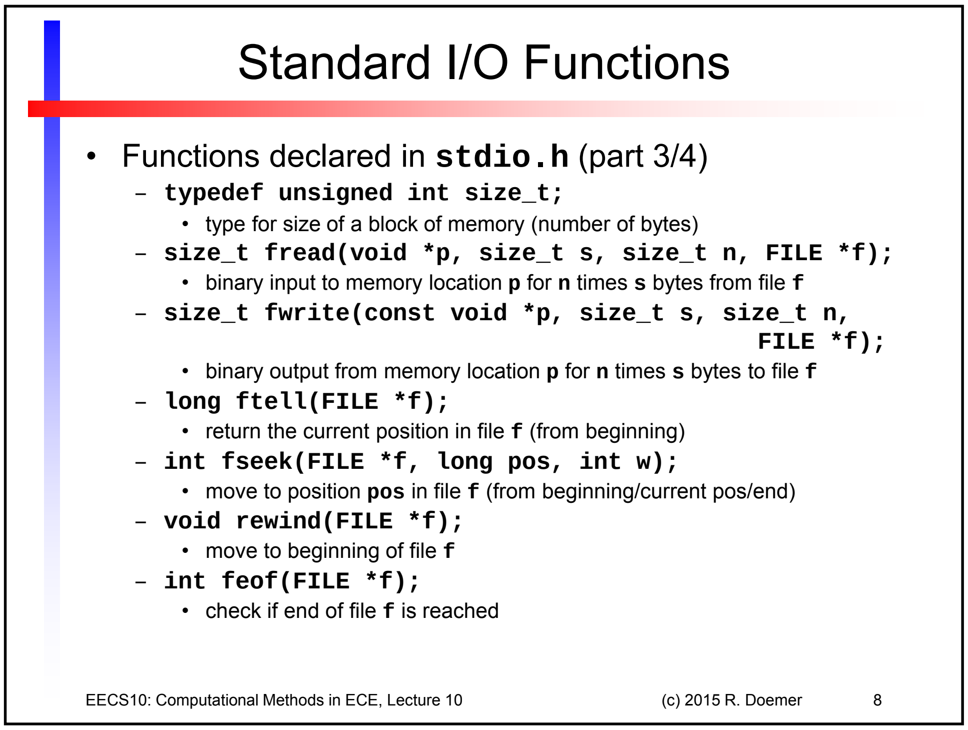

Standard I/O Functions

- Functions declared in **`stdio.h`** (part 3/4)
  - **`typedef unsigned int size_t;`**
    - type for size of a block of memory (number of bytes)
  - **`size_t fread(void *p, size_t s, size_t n, FILE *f);`**
    - binary input to memory location **`p`** for **`n`** times **`s`** bytes from file **`f`**
  - **`size_t fwrite(const void *p, size_t s, size_t n, FILE *f);`**
    - binary output from memory location **`p`** for **`n`** times **`s`** bytes to file **`f`**
  - **`long ftell(FILE *f);`**
    - return the current position in file **`f`** (from beginning)
  - **`int fseek(FILE *f, long pos, int w);`**
    - move to position **`pos`** in file **`f`** (from beginning/current pos/end)
  - **`void rewind(FILE *f);`**
    - move to beginning of file **`f`**
  - **`int feof(FILE *f);`**
    - check if end of file **`f`** is reached

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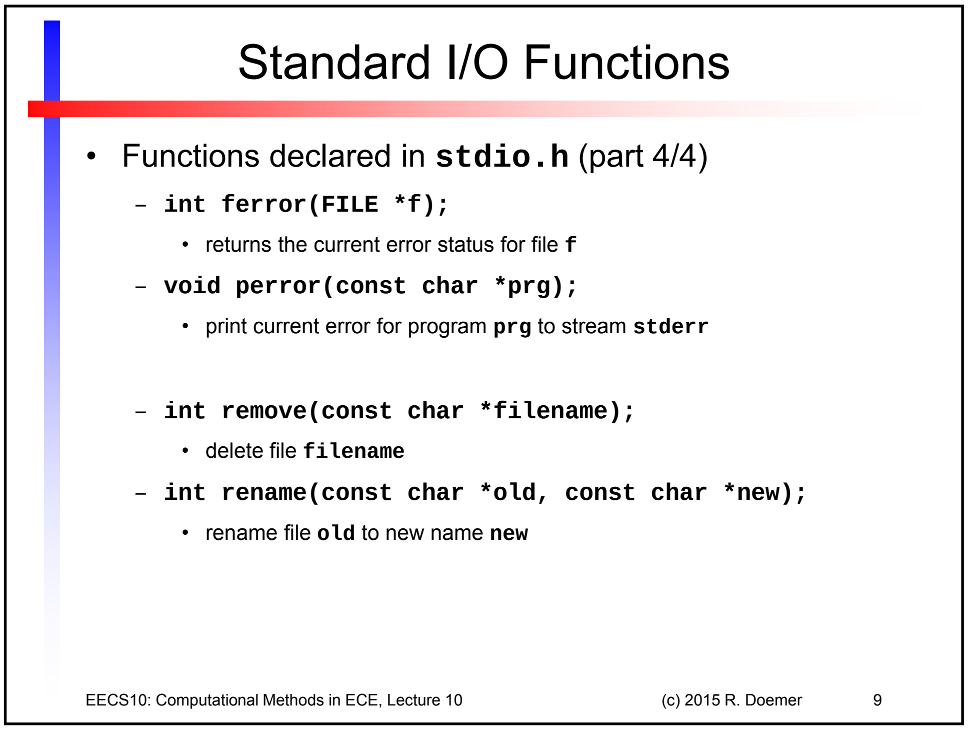
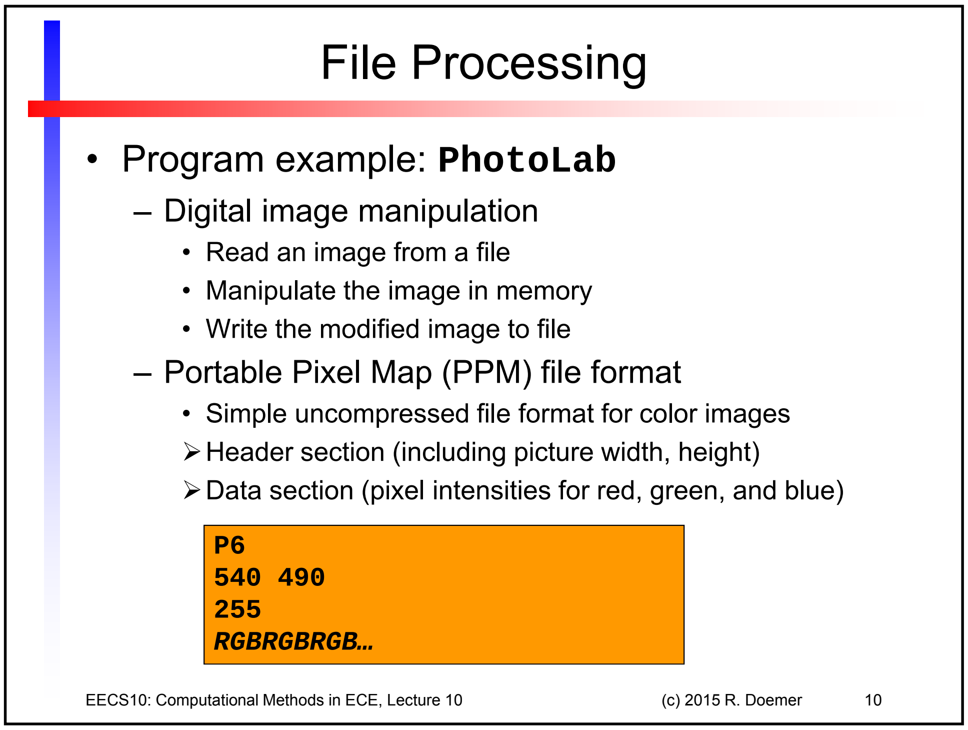


Standard I/O Functions

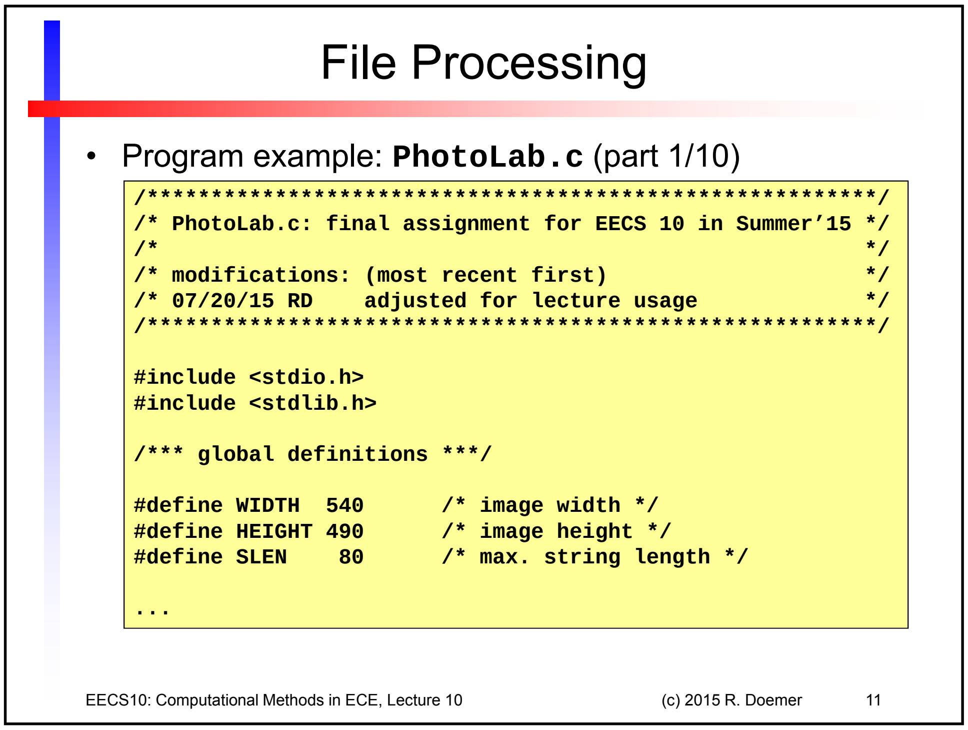
- Functions declared in **`stdio.h`** (part 4/4)
  - **`int ferror(FILE *f);`**
    - returns the current error status for file **`f`**
  - **`void perror(const char *prg);`**
    - print current error for program **`prg`** to stream **`stderr`**
  - **`int remove(const char *filename);`**
    - delete file **`filename`**
  - **`int rename(const char *old, const char *new);`**
    - rename file **`old`** to new name **`new`**



File Processing

- Program example: **`PhotoLab`**
  - Digital image manipulation
    - Read an image from a file
    - Manipulate the image in memory
    - Write the modified image to file
  - Portable Pixel Map (PPM) file format
    - Simple uncompressed file format for color images
    - ➢ Header section (including picture width, height)
    - ➢ Data section (pixel intensities for red, green, and blue)

```
P6
540 490
255
RGBRGBRGB…
```



File Processing

- Program example: **`PhotoLab.c`** (part 1/10)

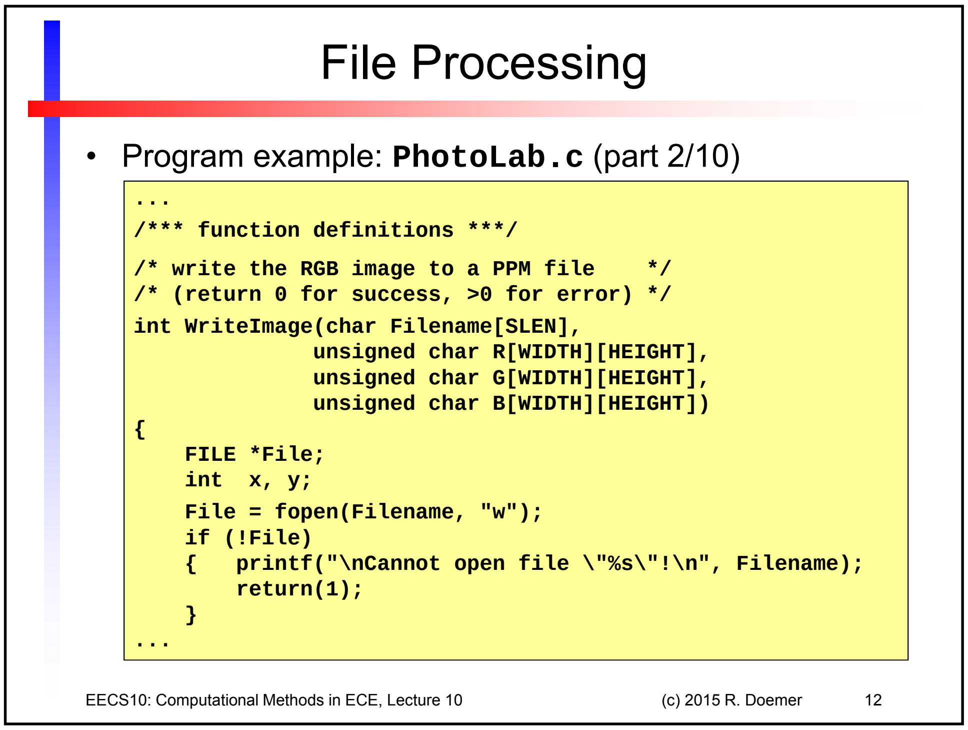
```
/**************************************************************/
/* PhotoLab.c: final assignment for EECS 10 in Summer'15 */
/*                                                          */
/* modifications: (most recent first)                       */
/* 07/20/15 RD    adjusted for lecture usage                */
/**************************************************************/

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

/*** global definitions ***/

#define WIDTH  540      /* image width */
#define HEIGHT 490      /* image height */
#define SLEN    80      /* max. string length */

...
```



File Processing

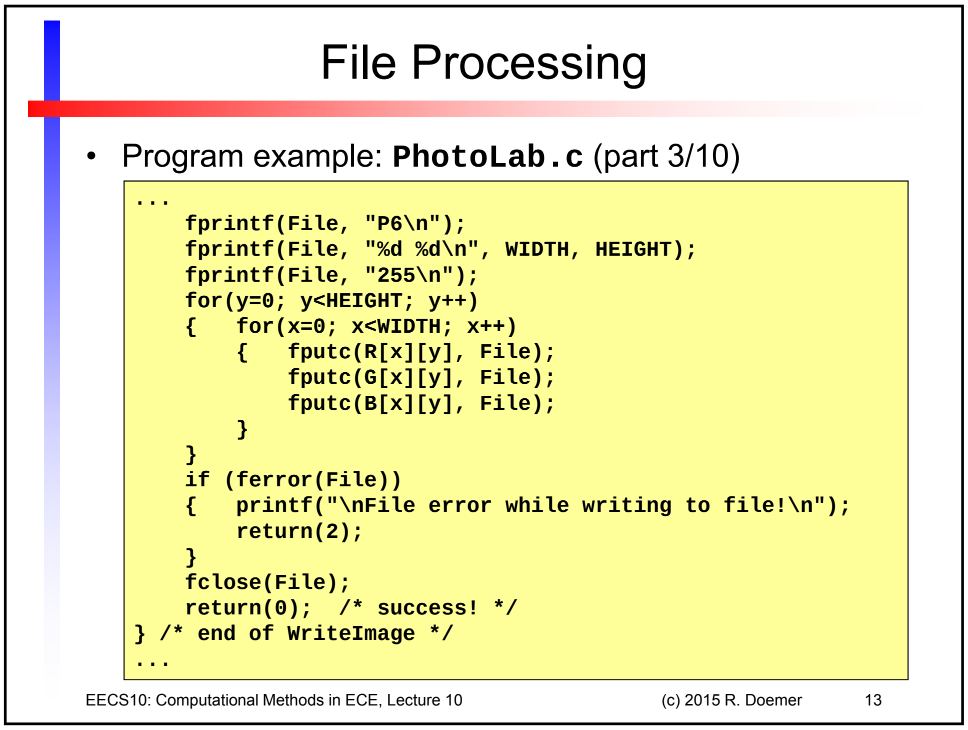
- Program example: **`PhotoLab.c`** (part 2/10)

```
...
/*** function definitions ***/

/* write the RGB image to a PPM file    */
/* (return 0 for success, >0 for error) */

int WriteImage(char Filename[SLEN],
              unsigned char R[WIDTH][HEIGHT],
              unsigned char G[WIDTH][HEIGHT],
              unsigned char B[WIDTH][HEIGHT])
{
    FILE *File;
    int  x, y;

    File = fopen(Filename, "w");
    if (!File)
    {   printf("\nCannot open file \"%s\"!\n", Filename);
        return(1);
    }
...
```



File Processing

- Program example: **`PhotoLab.c`** (part 3/10)

```
...
    fprintf(File, "P6\n");
    fprintf(File, "%d %d\n", WIDTH, HEIGHT);
    fprintf(File, "255\n");
    for(y=0; y<HEIGHT; y++)
    {   for(x=0; x<WIDTH; x++)
        {   fputc(R[x][y], File);
            fputc(G[x][y], File);
            fputc(B[x][y], File);
        }
    }
    if (ferror(File))
    {   printf("\nFile error while writing to file!\n");
        return(2);
    }
    fclose(File);
    return(0);  /* success! */
} /* end of WriteImage */
...
```

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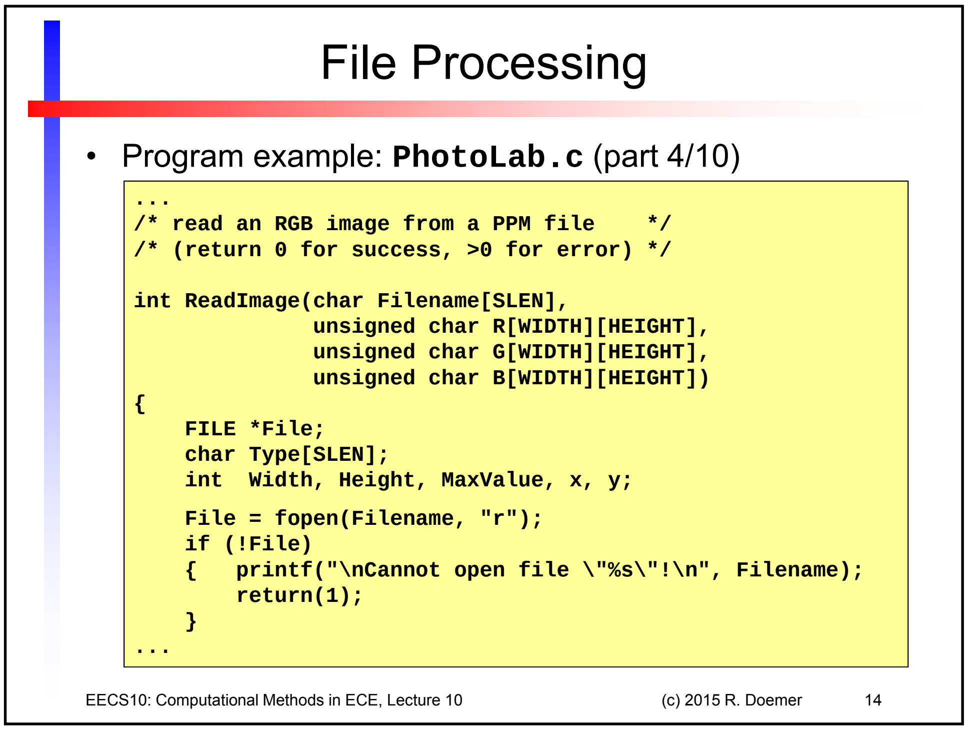

File Processing

- Program example: **`PhotoLab.c`** (part 4/10)

```
...
/* read an RGB image from a PPM file    */
/* (return 0 for success, >0 for error) */

int ReadImage(char Filename[SLEN],
              unsigned char R[WIDTH][HEIGHT],
              unsigned char G[WIDTH][HEIGHT],
              unsigned char B[WIDTH][HEIGHT])
{
    FILE *File;
    char Type[SLEN];
    int  Width, Height, MaxValue, x, y;

    File = fopen(Filename, "r");
    if (!File)
    {   printf("\nCannot open file \"%s\"!\n", Filename);
        return(1);
    }
...
```

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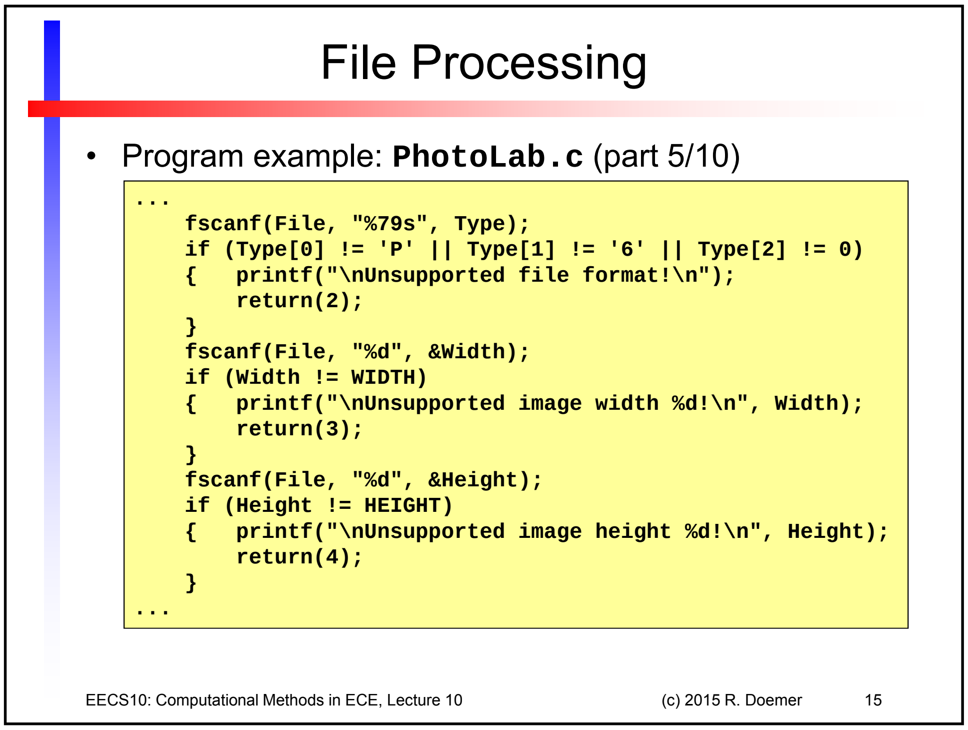
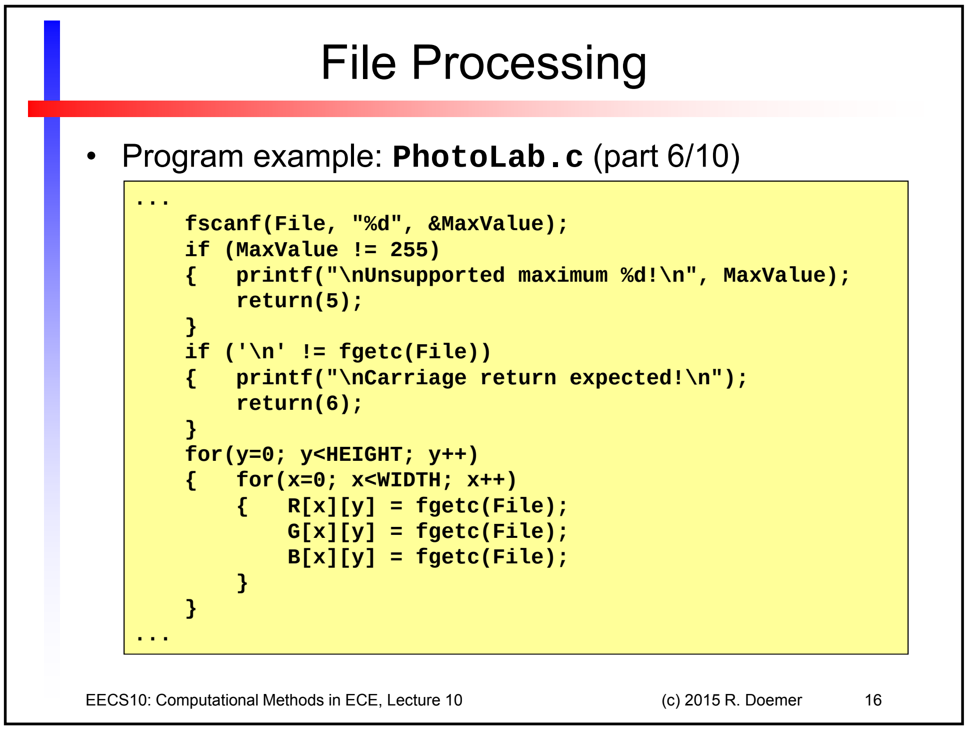


File Processing

- Program example: **`PhotoLab.c`** (part 5/10)

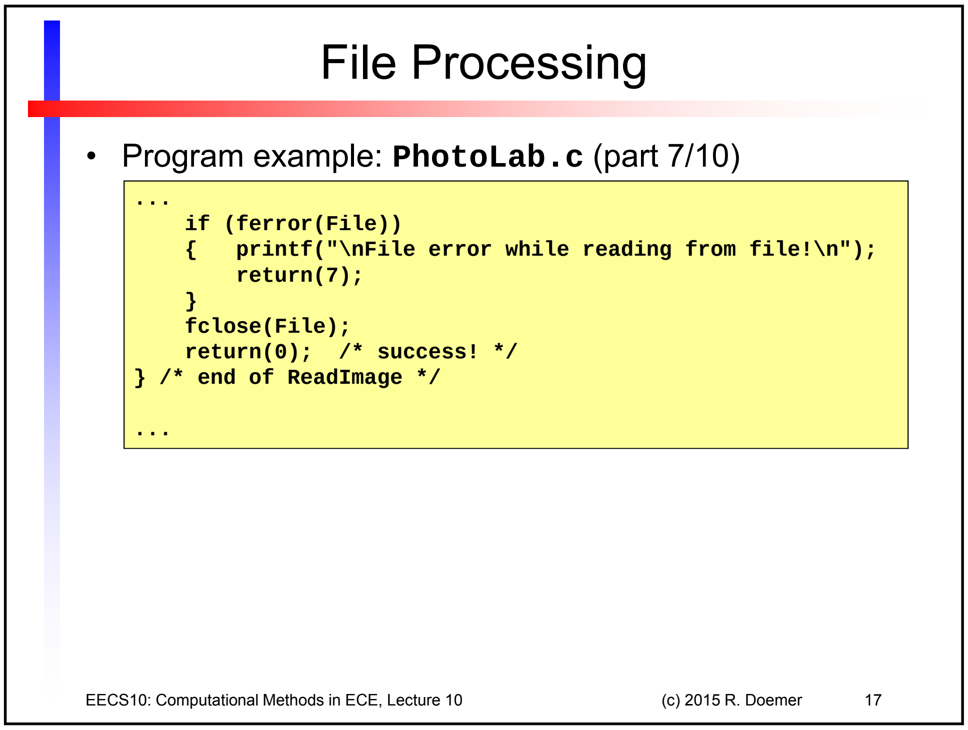
```
...
    fscanf(File, "%79s", Type);
    if (Type[0] != 'P' || Type[1] != '6' || Type[2] != 0)
    {   printf("\nUnsupported file format!\n");
        return(2);
    }
    fscanf(File, "%d", &Width);
    if (Width != WIDTH)
    {   printf("\nUnsupported image width %d!\n", Width);
        return(3);
    }
    fscanf(File, "%d", &Height);
    if (Height != HEIGHT)
    {   printf("\nUnsupported image height %d!\n", Height);
        return(4);
    }
...
```



File Processing

- Program example: **`PhotoLab.c`** (part 6/10)

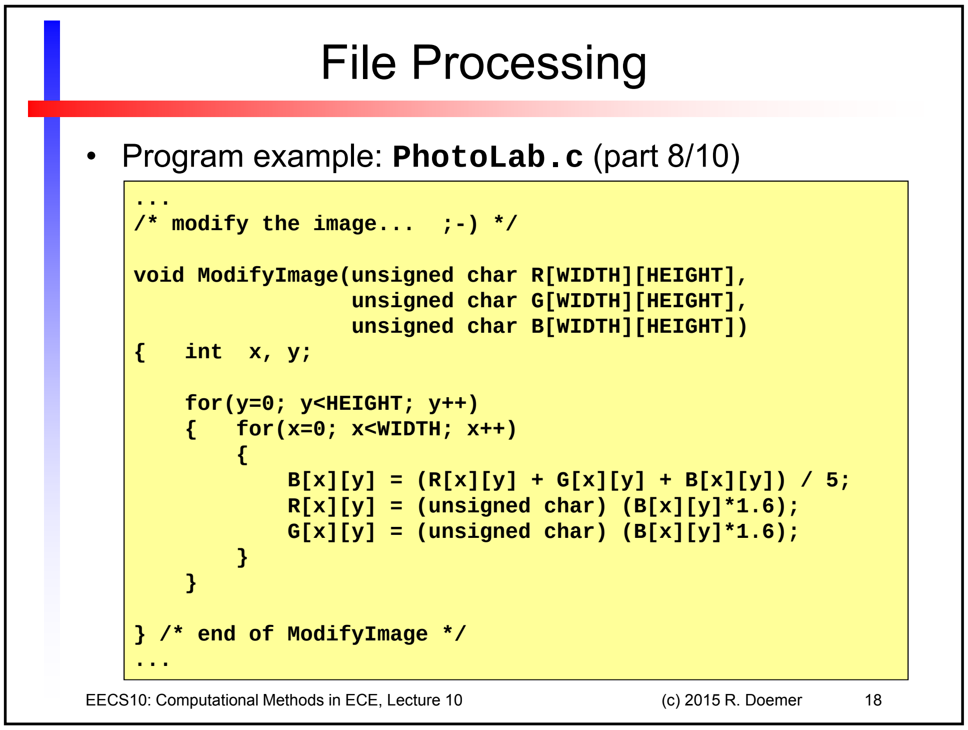
```
...
    fscanf(File, "%d", &MaxValue);
    if (MaxValue != 255)
    {   printf("\nUnsupported maximum %d!\n", MaxValue);
        return(5);
    }
    if ('\n' != fgetc(File))
    {   printf("\nCarriage return expected!\n");
        return(6);
    }
    for(y=0; y<HEIGHT; y++)
    {   for(x=0; x<WIDTH; x++)
        {   R[x][y] = fgetc(File);
            G[x][y] = fgetc(File);
            B[x][y] = fgetc(File);
        }
    }
...
```



File Processing

- Program example: **`PhotoLab.c`** (part 7/10)

```
...
    if (ferror(File))
    {   printf("\nFile error while reading from file!\n");
        return(7);
    }
    fclose(File);
    return(0);  /* success! */
} /* end of ReadImage */

...
```



File Processing

- Program example: **`PhotoLab.c`** (part 8/10)

```
...
/* modify the image...  ;-) */

void ModifyImage(unsigned char R[WIDTH][HEIGHT],
                 unsigned char G[WIDTH][HEIGHT],
                 unsigned char B[WIDTH][HEIGHT])
{   int  x, y;

    for(y=0; y<HEIGHT; y++)
    {   for(x=0; x<WIDTH; x++)
        {
            B[x][y] = (R[x][y] + G[x][y] + B[x][y]) / 5;
            R[x][y] = (unsigned char) (B[x][y]*1.6);
            G[x][y] = (unsigned char) (B[x][y]*1.6);
        }
    }

} /* end of ModifyImage */
...
```

File Processing

- Program example: **`PhotoLab.c`** (part 9/10)

```
...
/*** main program ***/

int main(void)
{
    /* image data */
    unsigned char R[WIDTH][HEIGHT];
    unsigned char G[WIDTH][HEIGHT];
    unsigned char B[WIDTH][HEIGHT];
    /* file name */
    char Filename[SLEN];

...
```

File Processing

- Program example: **`PhotoLab.c`** (part 10/10)

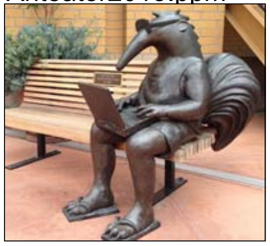
```
...
    printf("Enter input file name:  ");
    scanf("%79s", Filename);
    if (ReadImage(Filename, R,G,B) != 0)
    { exit(10); }

    /* modify the image */
    ModifyImage(R, G, B);

    printf("Enter output file name: ");
    scanf("%79s", Filename);
    if (WriteImage(Filename, R,G,B) != 0)
    { exit(10); }

    return 0;
} /* end of main */

/* EOF */
```

File Processing

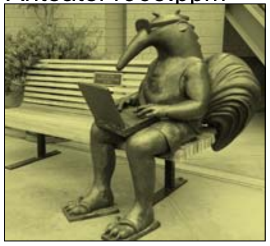
- Example session: **`PhotoLab.c`**

```
% vi PhotoLab.c
% gcc PhotoLab.c -o PhotoLab -Wall -ansi
% PhotoLab
Enter input file name:  Anteater2015.ppm
Enter output file name: Anteater1965.ppm
%
```

Anteater2015.ppm



Anteater1965.ppm



Lecture 10.2: Overview

- Translation Units
  - Introduction
  - Compiler components
    - Preprocessor
    - Compiler
    - Linker
  - Modules
  - Program example **`PhotoLab2`**
    - Module **`FileIO`**
    - Module **`Age`**
    - Module **`Main`**

Translation Units

- Introduction
  - C compilation process is a sequence of phases

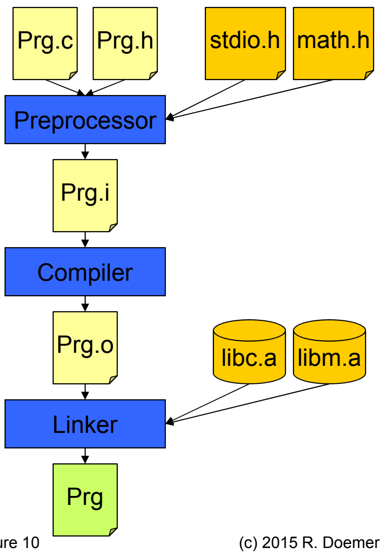
1. Preprocessing	(handle # directives)
2. Scanning and parsing	(generate internal data structure)
3. Instruction generation	(emit stream of CPU instructions)
4. Assembly	(generate binary object file)
5. Linking	(combine objects into executable file)

  - C compiler consists of separate components

• Preprocessor	(processes # directives)
• Compiler	(compiles and assembles code)
• Linker	(processes object files and libraries)

Translation Units

- Compilation Phases
  - Source code
    - Program files
    - Header files
  - Preprocessed file
  - Object files
  - Library files
  - Executable file



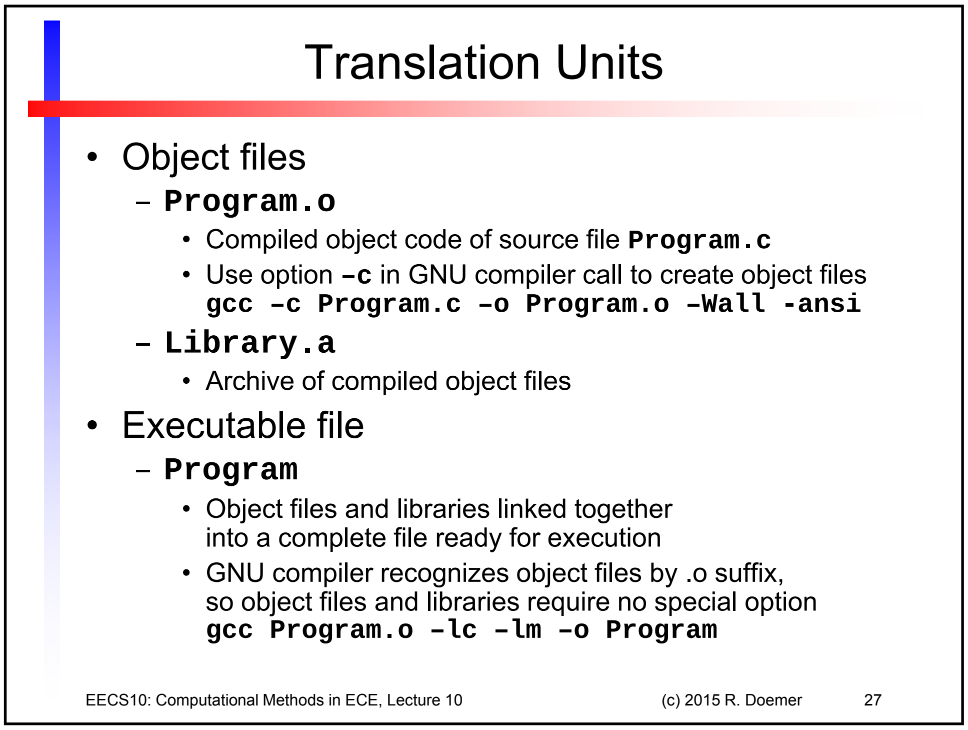
Translation Units

- Source files
  - Header files: **`Program.h`**
    - Inclusion of required header files
    - Definitions of exported constants
    - Declarations of exported global variables
    - Declarations of exported functions
  - Program files: **`Program.c`**
    - Inclusion of required header files
    - Declaration and definition of local variables
    - Declaration and definition of local functions
    - Definitions of exported global variables
    - Definitions of exported functions

Translation Units

- C Preprocessor
  - preprocesses source files
  - handles # directives
- Preprocessing Directives
  - Constant definition `#define WIDTH  540`
  - Macro definition `#define ABS(x) (x>0 ? x : -x)`
  - Header file inclusion `#include <stdio.h>`
  - Conditional compilation

```
#define DEBUG  /* comment out to turn debugging off */
...
#ifdef DEBUG
printf("value of x is now %d\n", x);
#endif
```



Translation Units

- Object files
  - **`Program.o`**
    - Compiled object code of source file **`Program.c`**
    - Use option **`-c`** in GNU compiler call to create object files
      `gcc -c Program.c -o Program.o -Wall -ansi`
  - **`Library.a`**
    - Archive of compiled object files
- Executable file
  - **`Program`**
    - Object files and libraries linked together into a complete file ready for execution
    - GNU compiler recognizes object files by .o suffix, so object files and libraries require no special option
      `gcc Program.o -lc -lm -o Program`

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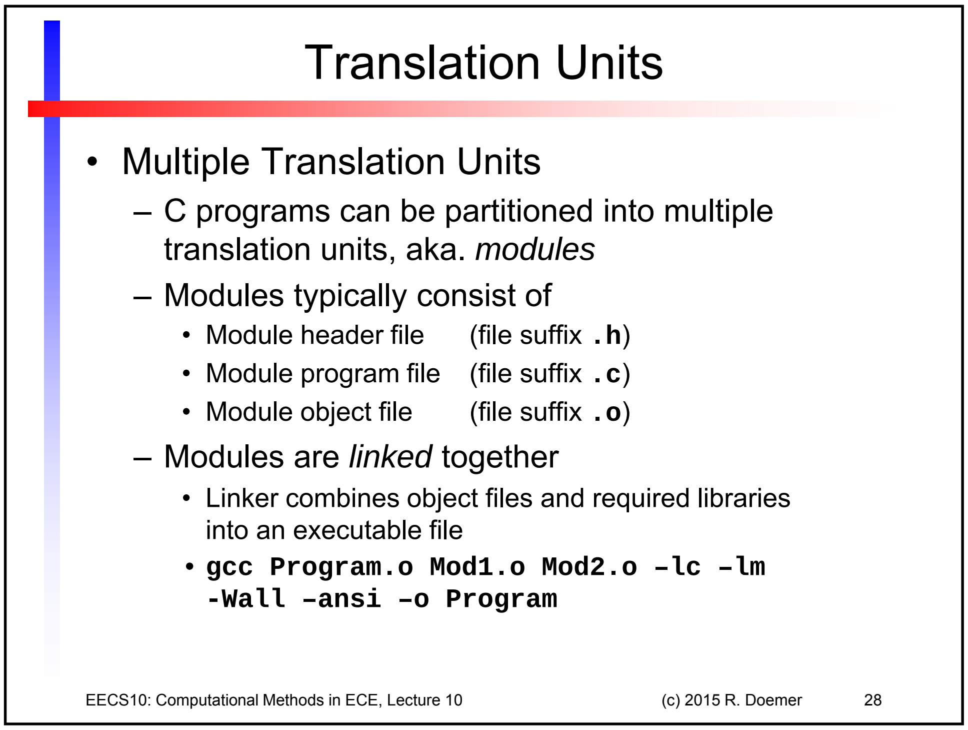

Translation Units

- Multiple Translation Units
  - C programs can be partitioned into multiple translation units, aka. *modules*
  - Modules typically consist of
    - Module header file (file suffix **`.h`**)
    - Module program file (file suffix **`.c`**)
    - Module object file (file suffix **`.o`**)
  - Modules are *linked* together
    - Linker combines object files and required libraries into an executable file
    - **`gcc Program.o Mod1.o Mod2.o -lc -lm -Wall -ansi -o Program`**

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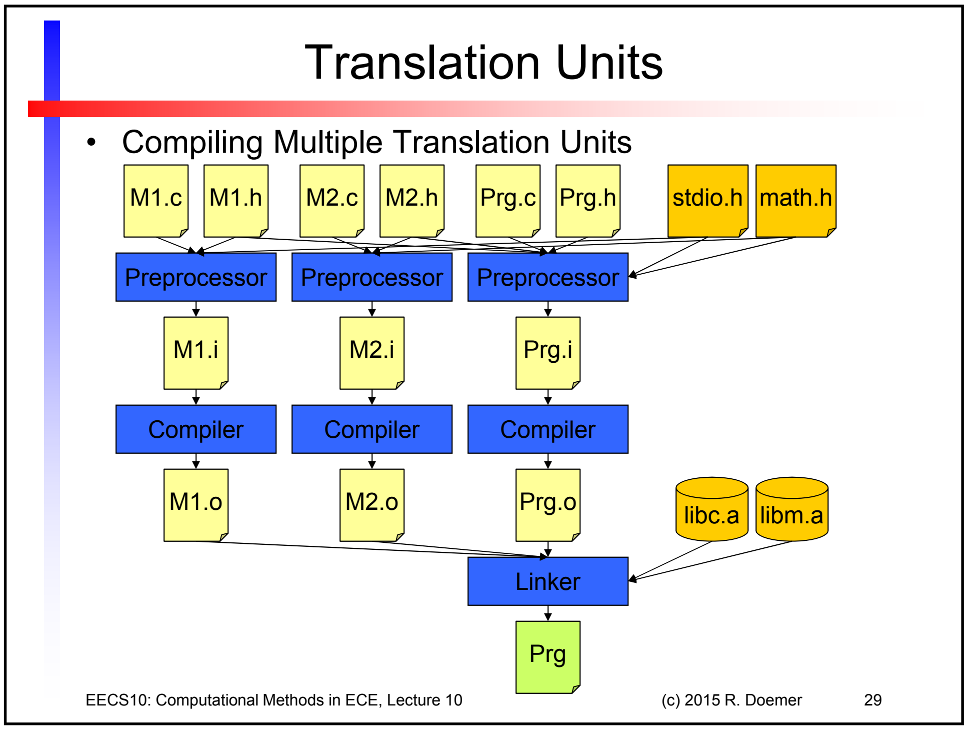
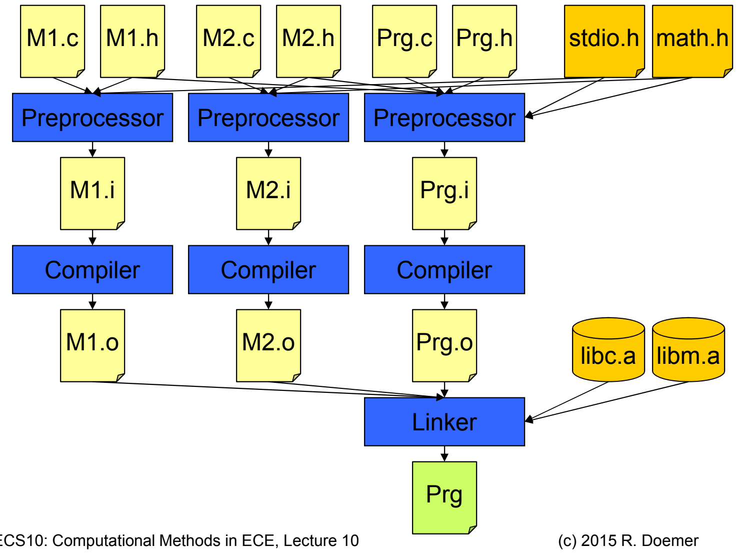


Translation Units

- Compiling Multiple Translation Units



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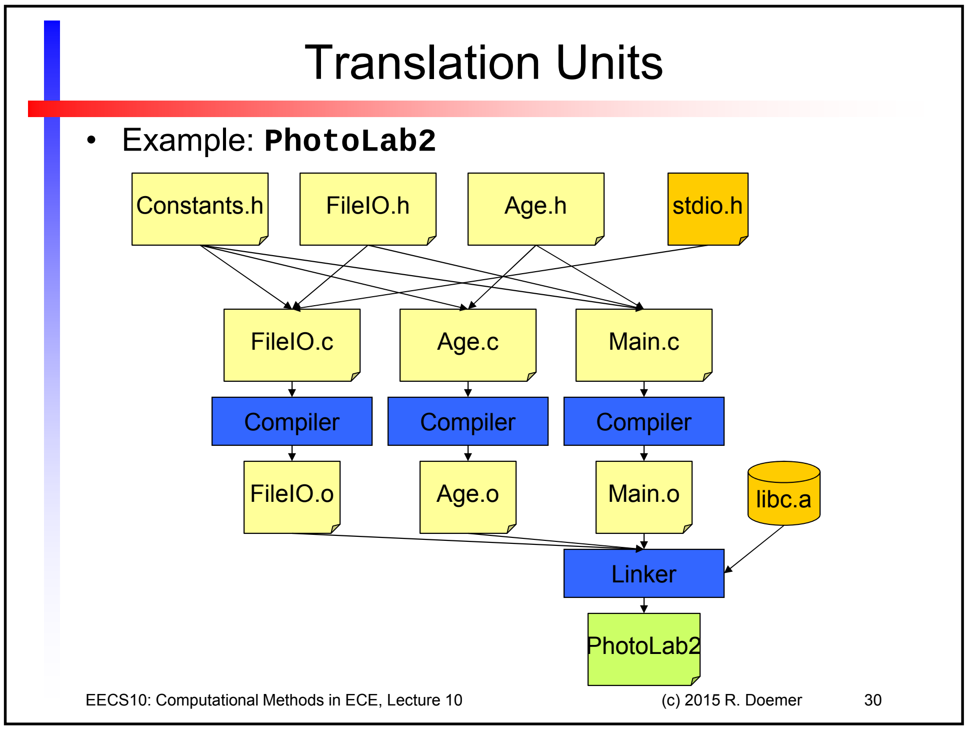
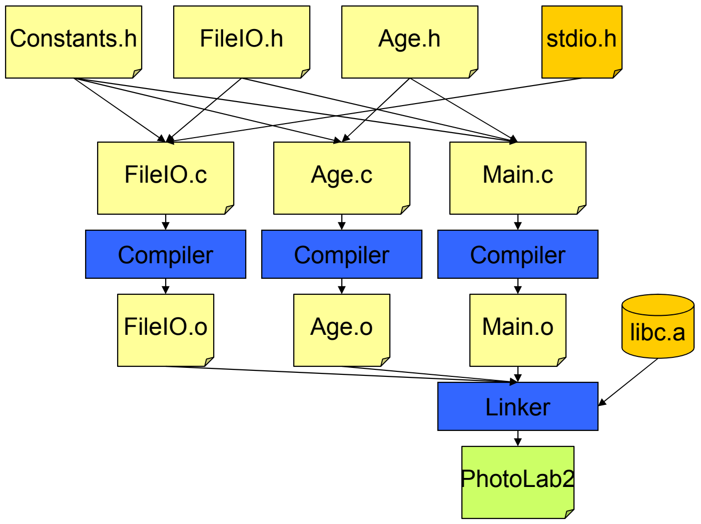


Translation Units

- Example: **`PhotoLab2`**



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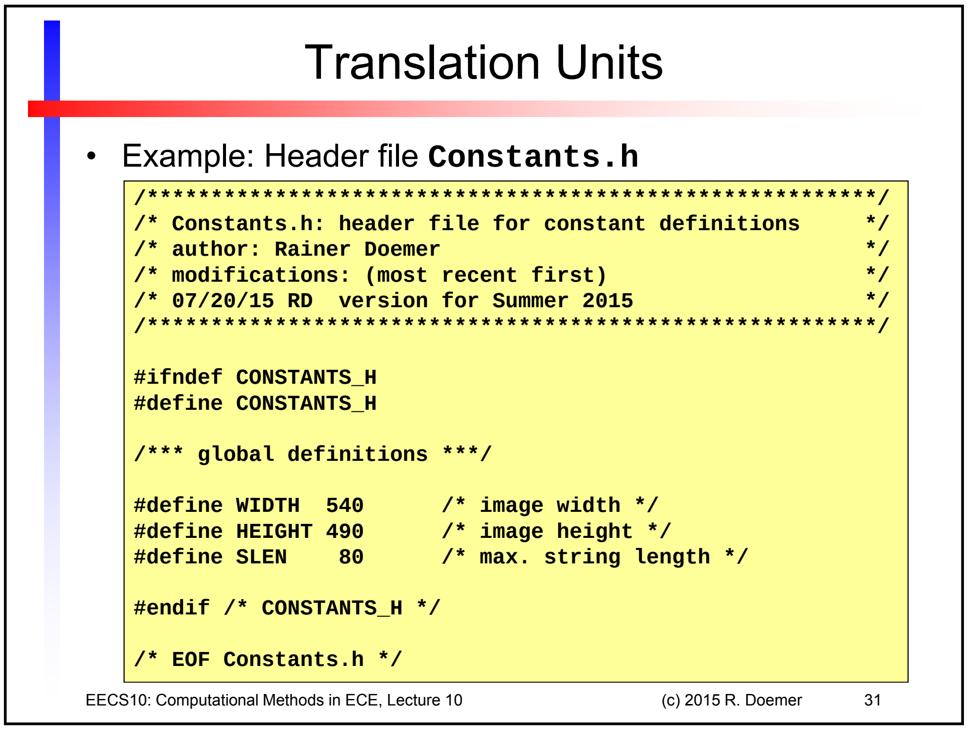
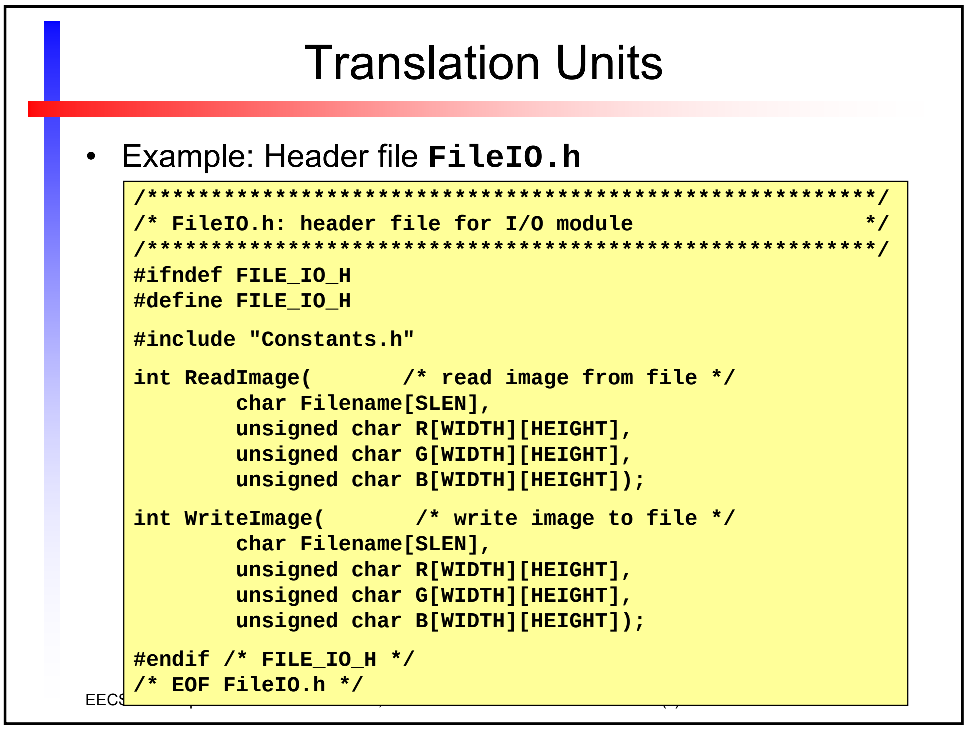


Translation Units

- Example: Header file **`Constants.h`**

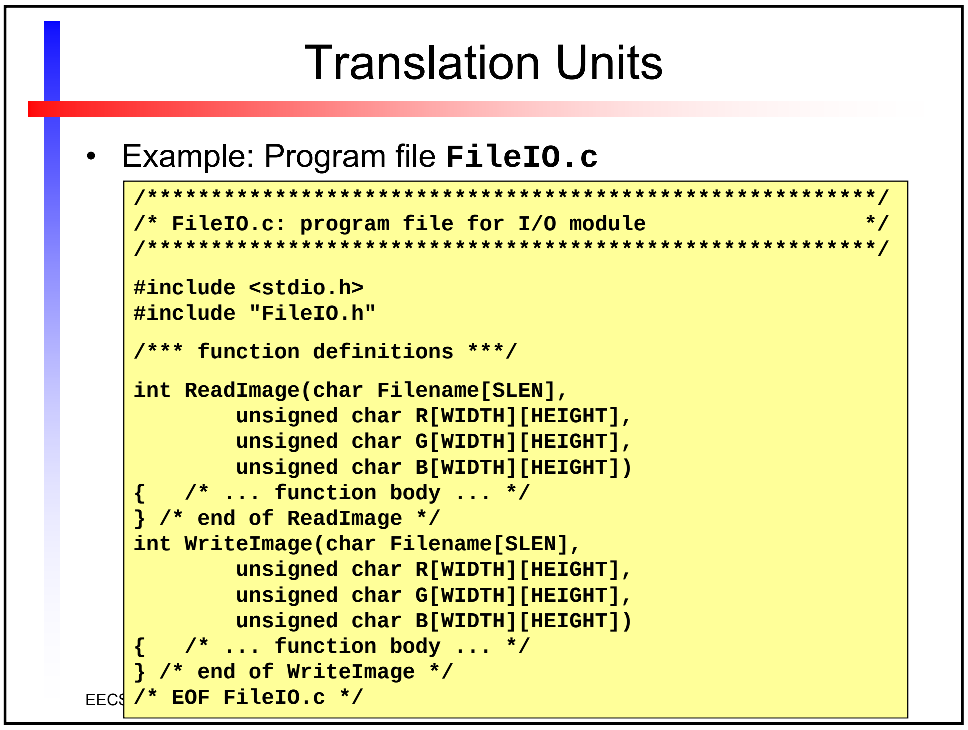
```
/*********************************************************/
/* Constants.h: header file for constant definitions     */
/* author: Rainer Doemer                                 */
/* modifications: (most recent first)                    */
/* 07/20/15 RD  version for Summer 2015                  */
/*********************************************************/

#ifndef CONSTANTS_H
#define CONSTANTS_H

/*** global definitions ***/

#define WIDTH  540      /* image width */
#define HEIGHT 490      /* image height */
#define SLEN    80      /* max. string length */

#endif /* CONSTANTS_H */

/* EOF Constants.h */
```



Translation Units

- Example: Header file **`FileIO.h`**

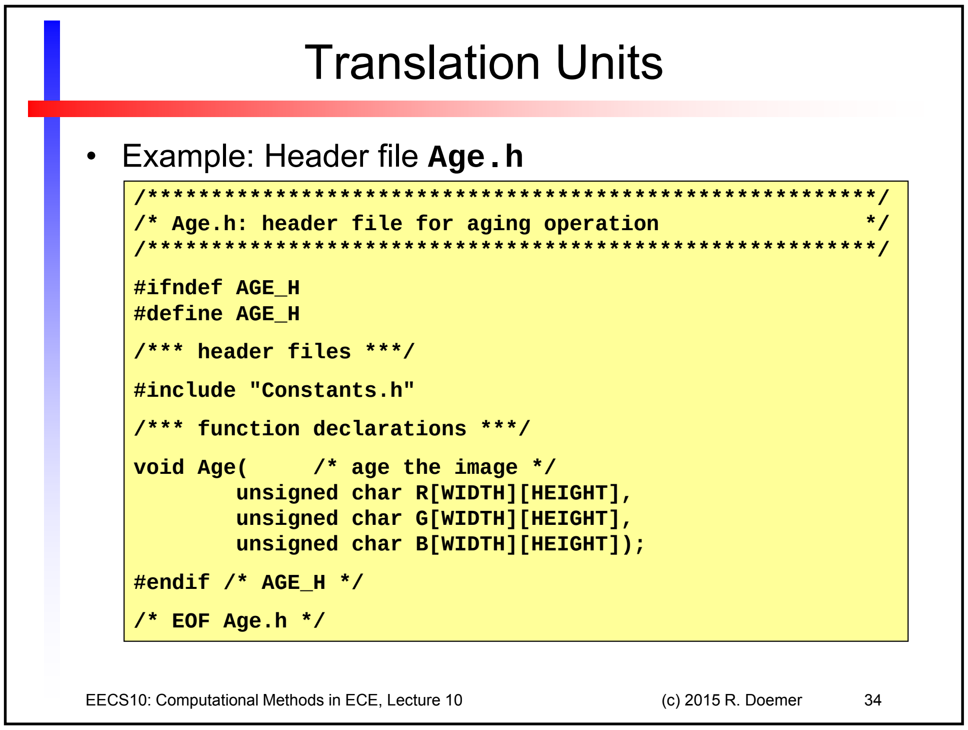
```
/*********************************************************/
/* FileIO.h: header file for I/O module                  */
/*********************************************************/
#ifndef FILE_IO_H
#define FILE_IO_H

#include "Constants.h"

int ReadImage(       /* read image from file */
        char Filename[SLEN],
        unsigned char R[WIDTH][HEIGHT],
        unsigned char G[WIDTH][HEIGHT],
        unsigned char B[WIDTH][HEIGHT]);

int WriteImage(       /* write image to file */
        char Filename[SLEN],
        unsigned char R[WIDTH][HEIGHT],
        unsigned char G[WIDTH][HEIGHT],
        unsigned char B[WIDTH][HEIGHT]);

#endif /* FILE_IO_H */
/* EOF FileIO.h */
```



Translation Units

- Example: Program file **`FileIO.c`**

```
/***************************************************************/
/* FileIO.c: program file for I/O module                      */
/***************************************************************/

#include <stdio.h>
#include "FileIO.h"

/*** function definitions ***/

int ReadImage(char Filename[SLEN],
        unsigned char R[WIDTH][HEIGHT],
        unsigned char G[WIDTH][HEIGHT],
        unsigned char B[WIDTH][HEIGHT])
{   /* ... function body ... */
} /* end of ReadImage */
int WriteImage(char Filename[SLEN],
        unsigned char R[WIDTH][HEIGHT],
        unsigned char G[WIDTH][HEIGHT],
        unsigned char B[WIDTH][HEIGHT])
{   /* ... function body ... */
} /* end of WriteImage */
/* EOF FileIO.c */
```



Translation Units

- Example: Header file **`Age.h`**

```
/***************************************************************/
/* Age.h: header file for aging operation                     */
/***************************************************************/

#ifndef AGE_H
#define AGE_H

/*** header files ***/

#include "Constants.h"

/*** function declarations ***/

void Age(     /* age the image */
        unsigned char R[WIDTH][HEIGHT],
        unsigned char G[WIDTH][HEIGHT],
        unsigned char B[WIDTH][HEIGHT]);

#endif /* AGE_H */

/* EOF Age.h */
```

Translation Units

- Example: Program file **`Age.c`**

```
/*********************************************************/
/* Age.c: program file for aging operation              */
/*********************************************************/

#include “Age.h"

/*** function definitions ***/

/* age the image so that it looks like an old photo */

void Age(
        unsigned char R[WIDTH][HEIGHT],
        unsigned char G[WIDTH][HEIGHT],
        unsigned char B[WIDTH][HEIGHT])
{
    /* ... function body ... */
} /* end of Age */

/* EOF Age.c */
```

Translation Units

- Example: Program file **`Main.c`**

```
/*********************************************************/
/* Main.c: main program file                            */
/*********************************************************/
#include "Constants.h"
#include "FileIO.h"
#include “Age.h"

int main(void)
{   unsigned char R[WIDTH][HEIGHT];
    unsigned char G[WIDTH][HEIGHT];
    unsigned char B[WIDTH][HEIGHT];

    if (ReadImage(“Anteater2015.ppm", R, G, B) != 0)
    { return 10; }
    Age(R, G, B);
    if (WriteImage(“Anteater1965.ppm", R, G, B) != 0)
    { return 10; }

    return 0;
} /* end of main */
/* EOF Main.c */
```

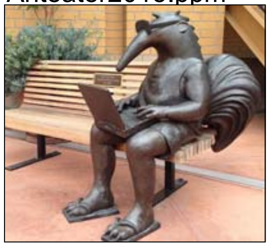
Translation Units

- Example session:

```
% vi Constants.h
% vi FileIO.h
% vi FileIO.c
% vi Age.h
% vi Age.c
% vi Main.c
```

```
% gcc -c FileIO.c -o FileIO.o -Wall –ansi
% gcc -c Age.c -o Age.o -Wall –ansi
% gcc -c Main.c -o Main.o -Wall –ansi
% gcc FileIO.o Age.o Main.o -o PhotoLab2
% PhotoLab2
%
```

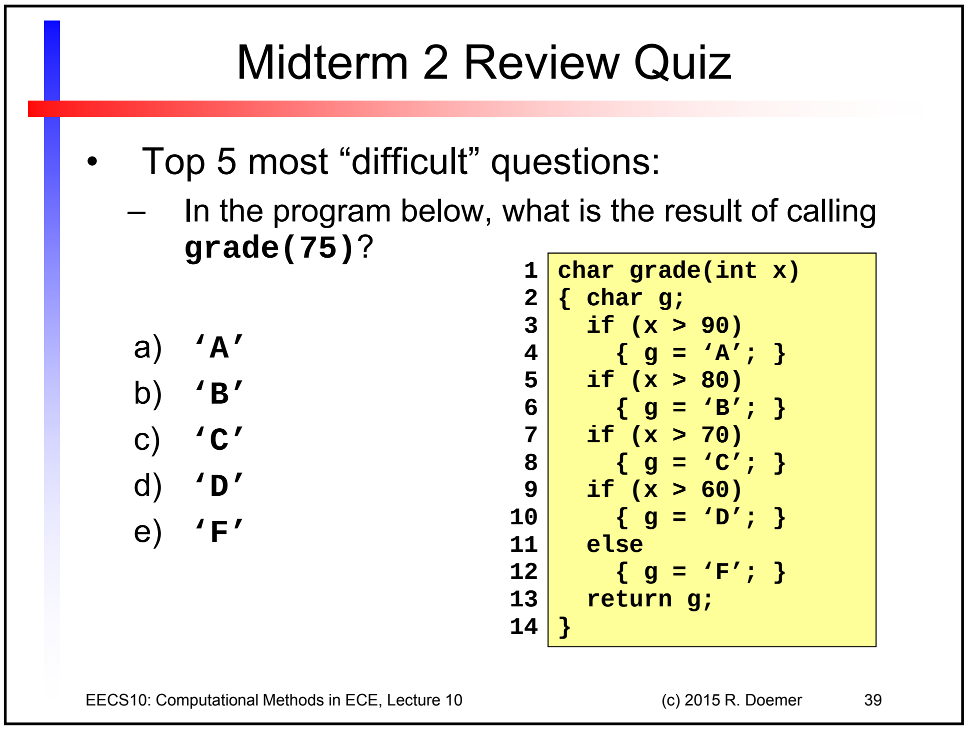
Anteater2015.ppm



Anteater1965.ppm

Lecture 10.3: Overview

- Review
  – Lecture 8.1: Recursion
  – Lecture 8.2: Structures, unions, enumerators
  – Lecture 9.1: Binary data representation, memory
  – Lecture 9.2: Pointers, pointer operations
  – Lecture 9.3: String operations using pointers
  – Lecture 10.1: File processing
  – Lecture 10.2: Translation units
- Review Quiz



Midterm 2 Review Quiz

- Top 5 most “difficult” questions:
  - In the program below, what is the result of calling **`grade(75)`**?

a) **‘A’**
b) **‘B’**
c) **‘C’**
d) **‘D’**
e) **‘F’**

```
char grade(int x)
{ char g;
  if (x > 90)
    { g = ‘A’; }
  if (x > 80)
    { g = ‘B’; }
  if (x > 70)
    { g = ‘C’; }
  if (x > 60)
    { g = ‘D’; }
  else
    { g = ‘F’; }
  return g;
}
```

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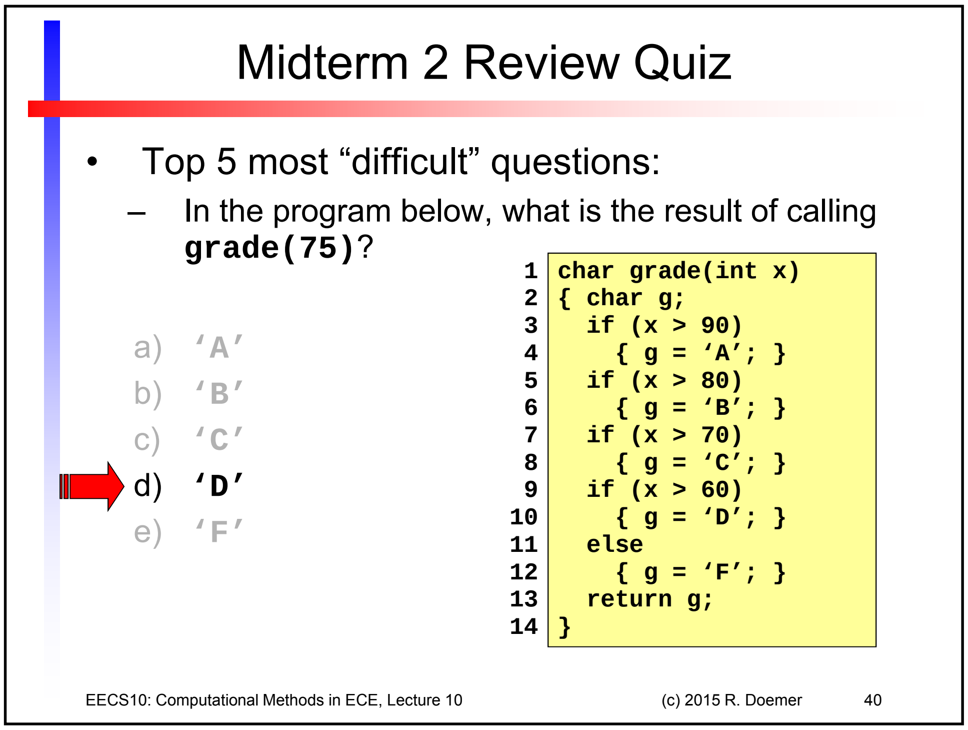

Midterm 2 Review Quiz

- Top 5 most “difficult” questions:
  - In the program below, what is the result of calling **`grade(75)`**?

a) **‘A’**
b) **‘B’**
c) **‘C’**
[✓ d) **‘D’**]
e) **‘F’**

```
char grade(int x)
{ char g;
  if (x > 90)
    { g = ‘A’; }
  if (x > 80)
    { g = ‘B’; }
  if (x > 70)
    { g = ‘C’; }
  if (x > 60)
    { g = ‘D’; }
  else
    { g = ‘F’; }
  return g;
}
```

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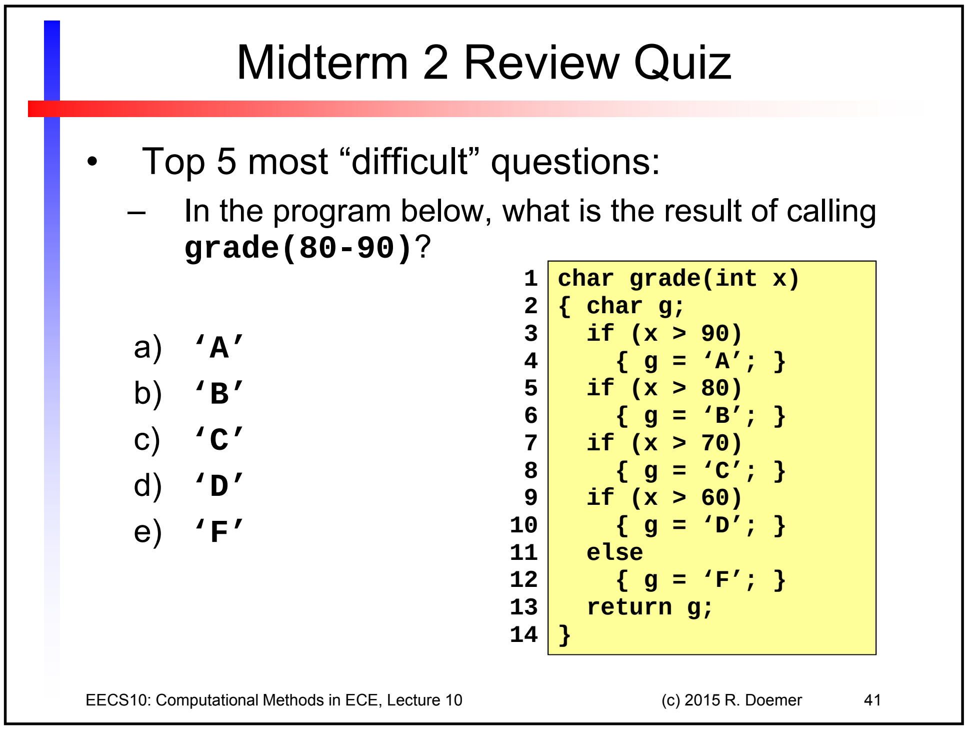
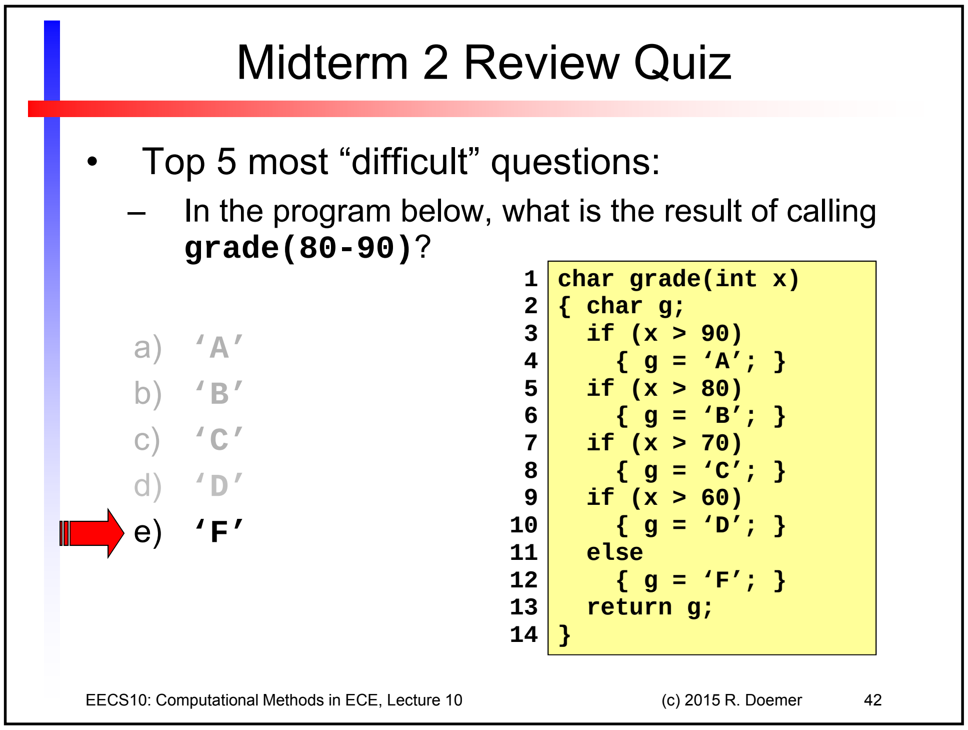


Midterm 2 Review Quiz

- Top 5 most “difficult” questions:
  - In the program below, what is the result of calling **`grade(80-90)`**?

a) **‘A’**
b) **‘B’**
c) **‘C’**
d) **‘D’**
e) **‘F’**

```
char grade(int x)
{ char g;
  if (x > 90)
    { g = ‘A’; }
  if (x > 80)
    { g = ‘B’; }
  if (x > 70)
    { g = ‘C’; }
  if (x > 60)
    { g = ‘D’; }
  else
    { g = ‘F’; }
  return g;
}
```



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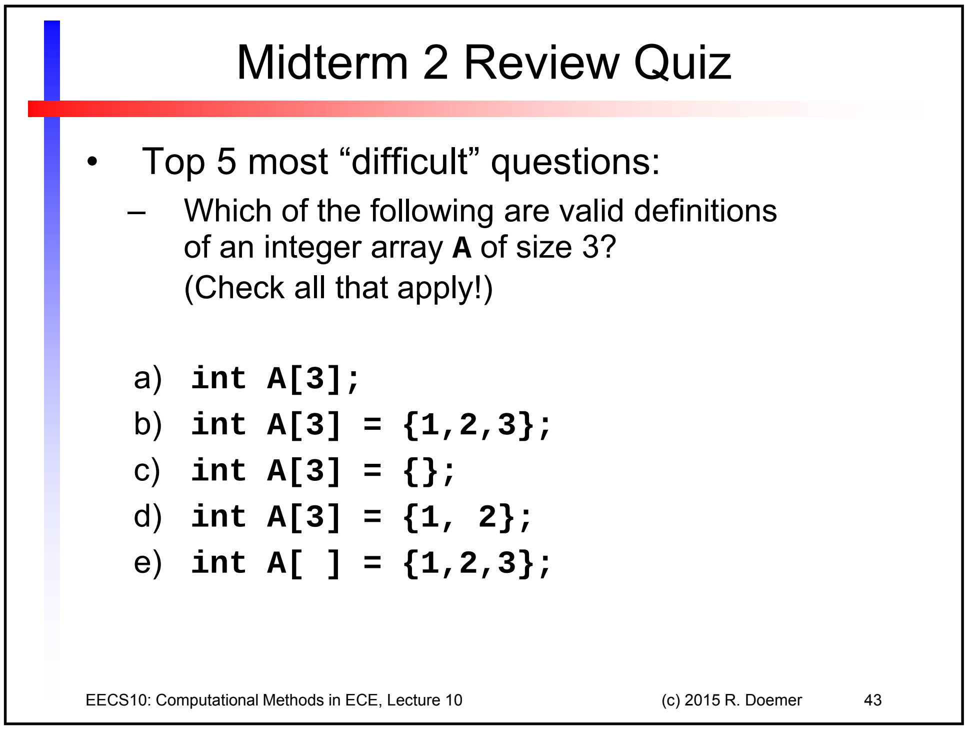
  - In the program below, what is the result of calling **`grade(80-90)`**?

a) **‘A’**
b) **‘B’**
c) **‘C’**
d) **‘D’**
[✓ e) **‘F’**]

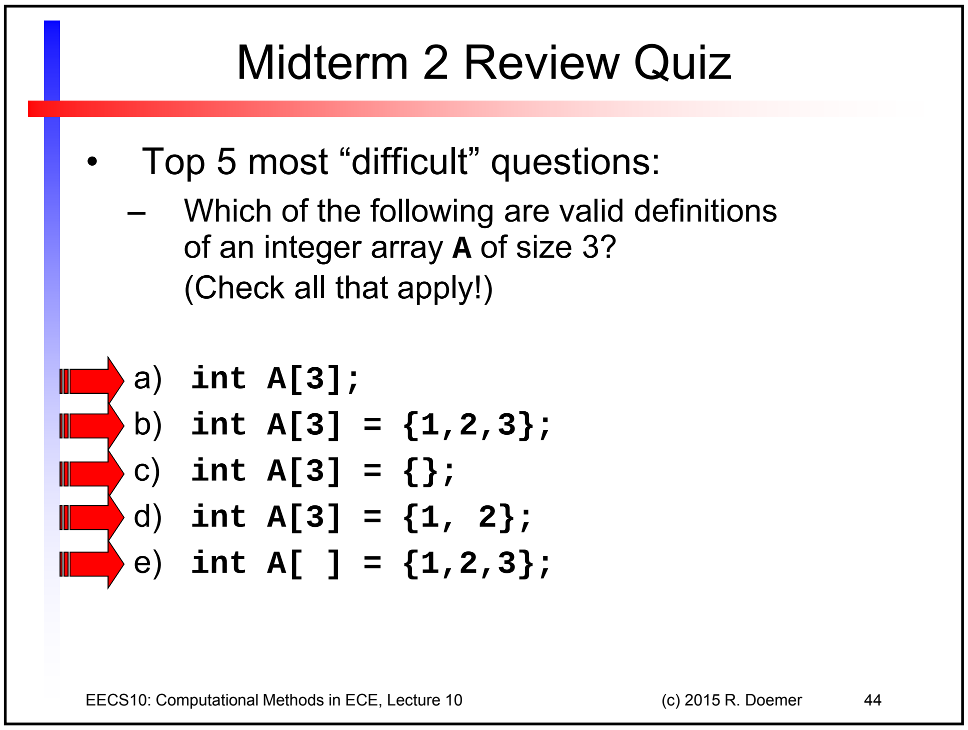
```
char grade(int x)
{ char g;
  if (x > 90)
    { g = ‘A’; }
  if (x > 80)
    { g = ‘B’; }
  if (x > 70)
    { g = ‘C’; }
  if (x > 60)
    { g = ‘D’; }
  else
    { g = ‘F’; }
  return g;
}
```



Midterm 2 Review Quiz

- Top 5 most “difficult” questions:
  - Which of the following are valid definitions of an integer array **A** of size 3? (Check all that apply!)

a) `int A[3];`
b) `int A[3] = {1,2,3};`
c) `int A[3] = {};`
d) `int A[3] = {1, 2};`
e) `int A[ ] = {1,2,3};`



Midterm 2 Review Quiz

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  - Which of the following are valid definitions of an integer array **A** of size 3? (Check all that apply!)

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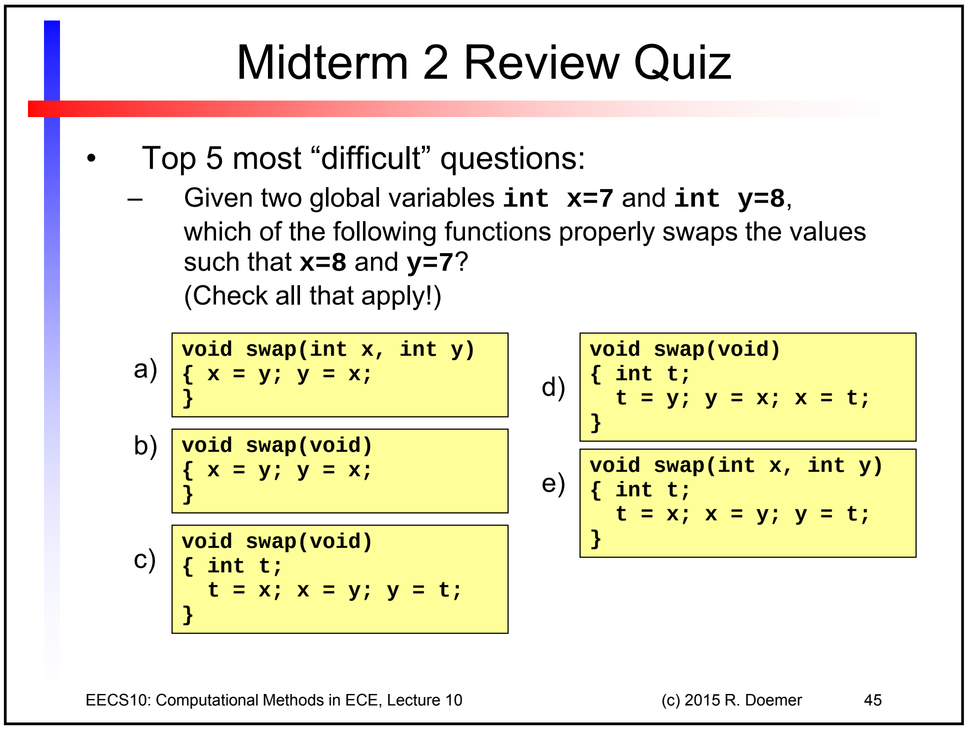
[✓ c)] `int A[3] = {};`
[✓ d)] `int A[3] = {1, 2};`
[✓ e)] `int A[ ] = {1,2,3};`



Midterm 2 Review Quiz

- Top 5 most "difficult" questions:
  - Given two global variables **`int x=7`** and **`int y=8`**, which of the following functions properly swaps the values such that **x=8** and **y=7**? (Check all that apply!)

a)
```
void swap(int x, int y)
{ x = y; y = x;
}
```

b)
```
void swap(void)
{ x = y; y = x;
}
```

c)
```
void swap(void)
{ int t;
  t = x; x = y; y = t;
}
```

d)
```
void swap(void)
{ int t;
  t = y; y = x; x = t;
}
```

e)
```
void swap(int x, int y)
{ int t;
  t = x; x = y; y = t;
}
```

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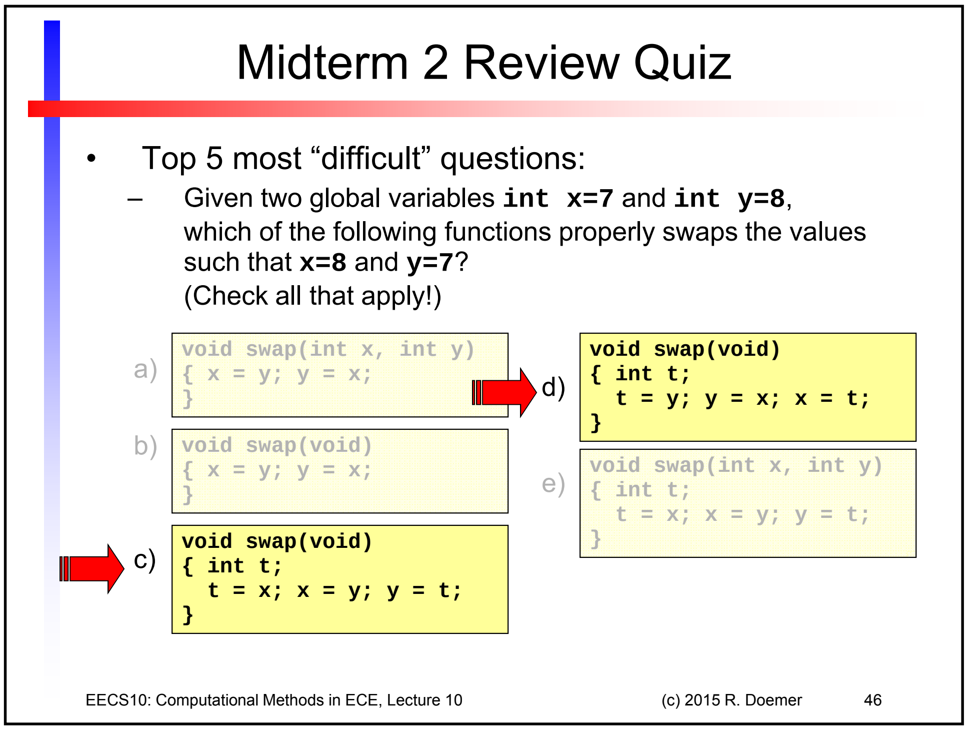

Midterm 2 Review Quiz

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  - Given two global variables **`int x=7`** and **`int y=8`**, which of the following functions properly swaps the values such that **x=8** and **y=7**? (Check all that apply!)

a)
```
void swap(int x, int y)
{ x = y; y = x;
}
```

b)
```
void swap(void)
{ x = y; y = x;
}
```

[✓ c)]
```
void swap(void)
{ int t;
  t = x; x = y; y = t;
}
```

[✓ d)]
```
void swap(void)
{ int t;
  t = y; y = x; x = t;
}
```

e)
```
void swap(int x, int y)
{ int t;
  t = x; x = y; y = t;
}
```

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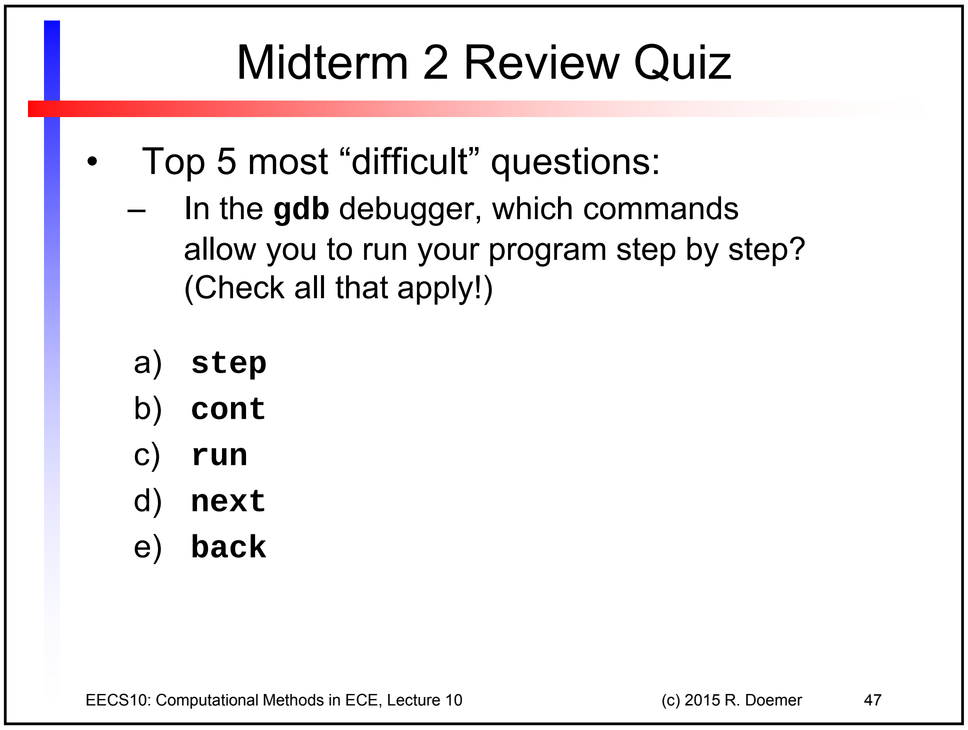
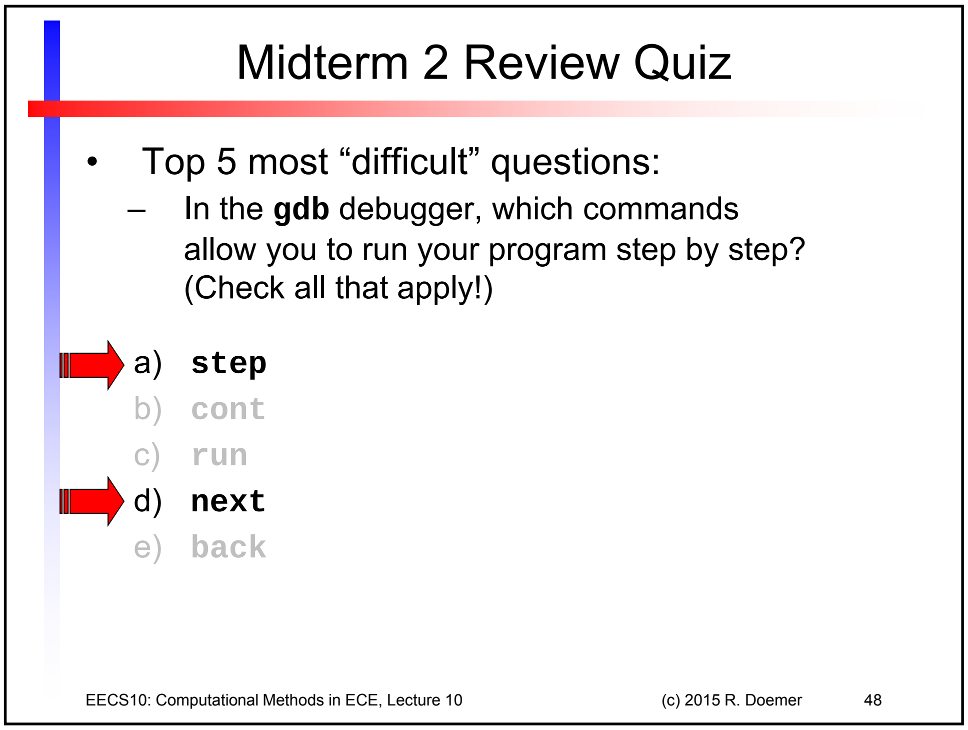


Midterm 2 Review Quiz

- Top 5 most "difficult" questions:
  - In the **gdb** debugger, which commands allow you to run your program step by step? (Check all that apply!)

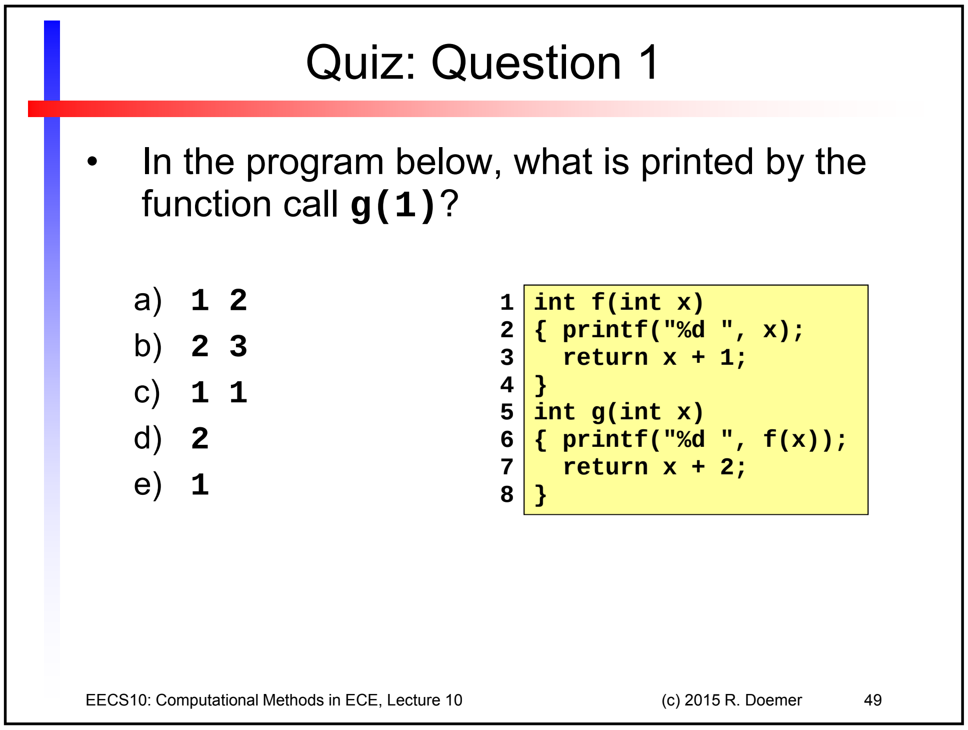
a) `step`
b) `cont`
c) `run`
d) `next`
e) `back`



Midterm 2 Review Quiz

- Top 5 most "difficult" questions:
  - In the **gdb** debugger, which commands allow you to run your program step by step? (Check all that apply!)

[✓ a) `step`]
b) `cont`
c) `run`
[✓ d) `next`]
e) `back`



Quiz: Question 1

- In the program below, what is printed by the function call **`g(1)`**?

a) **1 2**
b) **2 3**
c) **1 1**
d) **2**
e) **1**

```
int f(int x)
{ printf("%d ", x);
  return x + 1;
}
int g(int x)
{ printf("%d ", f(x));
  return x + 2;
}
```

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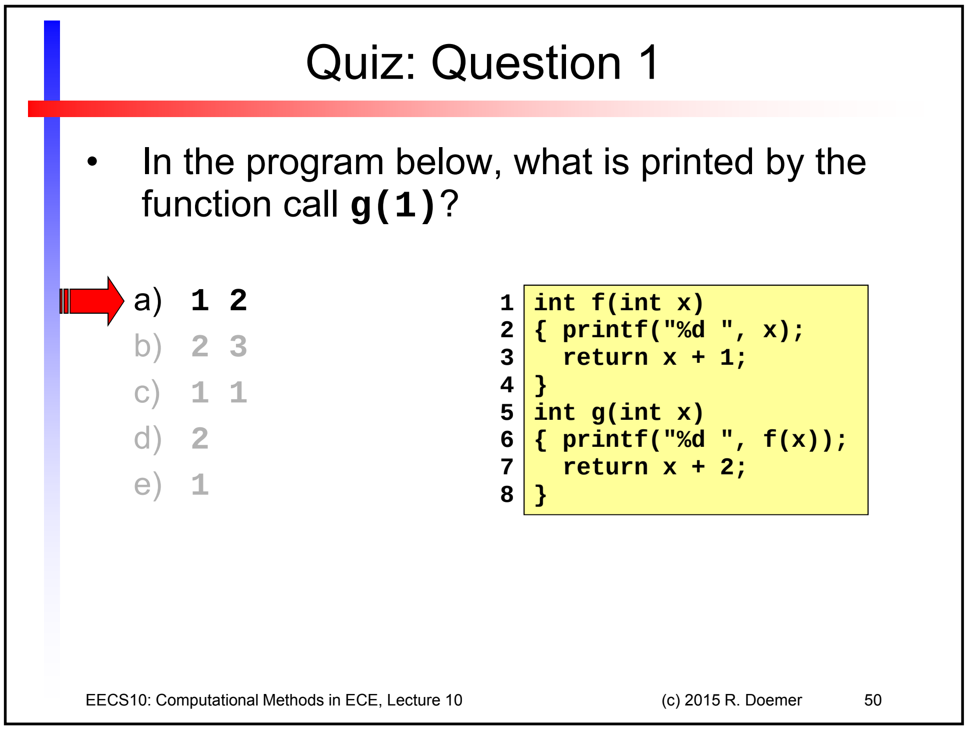

Quiz: Question 1

- In the program below, what is printed by the function call **`g(1)`**?

[✓ a) **1 2**]
b) **2 3**
c) **1 1**
d) **2**
e) **1**

```
int f(int x)
{ printf("%d ", x);
  return x + 1;
}
int g(int x)
{ printf("%d ", f(x));
  return x + 2;
}
```

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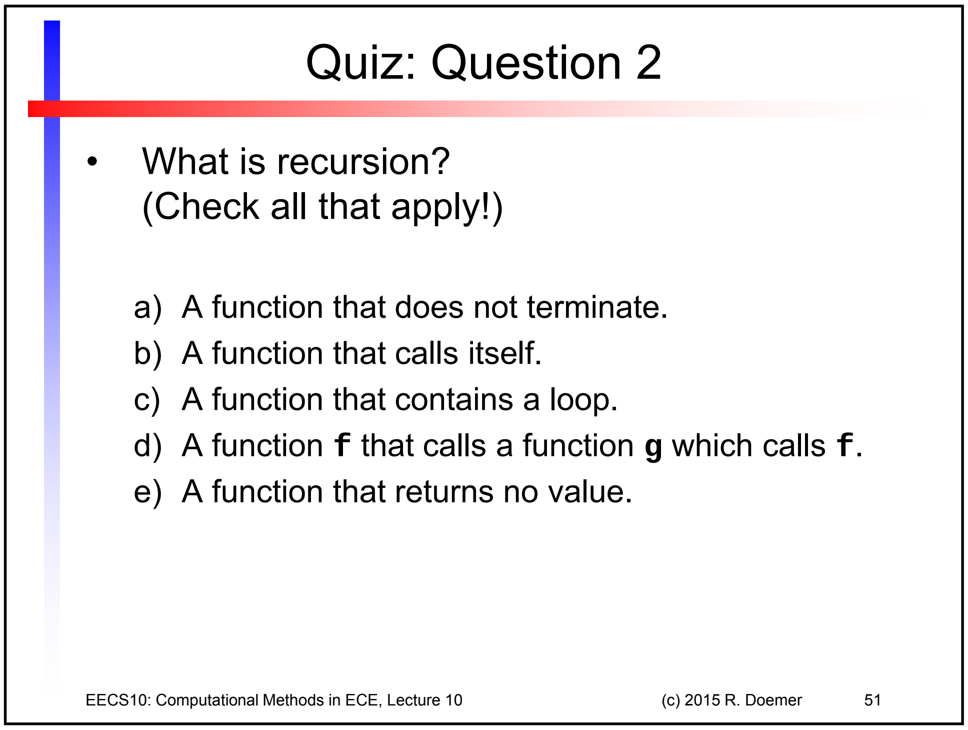
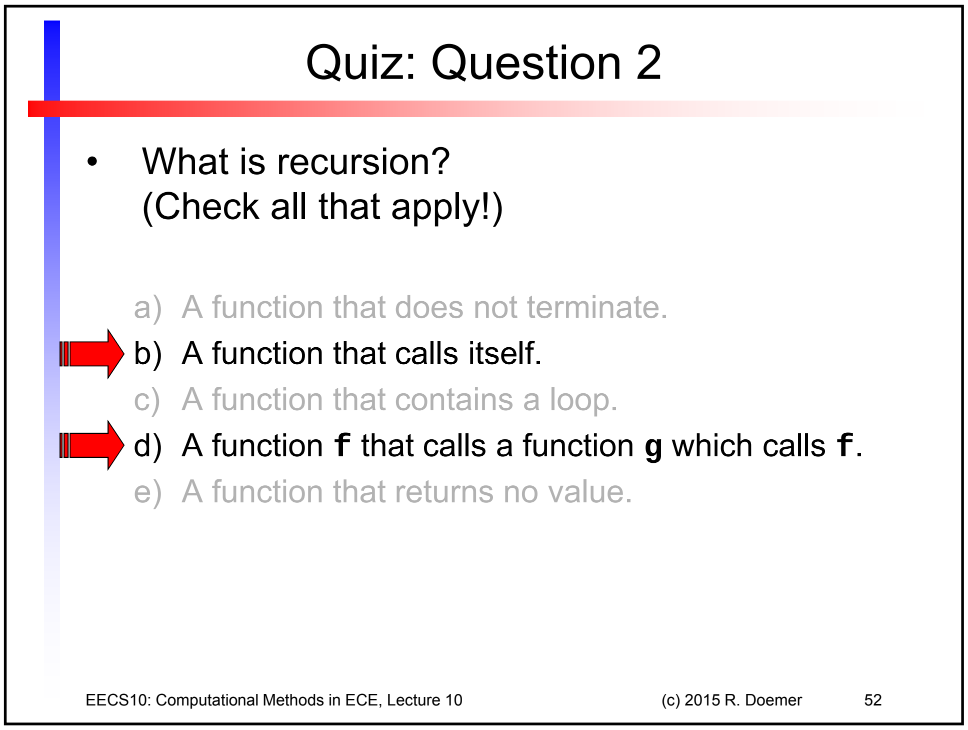


Quiz: Question 2

- What is recursion?
  (Check all that apply!)

a) A function that does not terminate.
b) A function that calls itself.
c) A function that contains a loop.
d) A function **`f`** that calls a function **`g`** which calls **`f`**.
e) A function that returns no value.



Quiz: Question 2

- What is recursion?
  (Check all that apply!)

a) A function that does not terminate.
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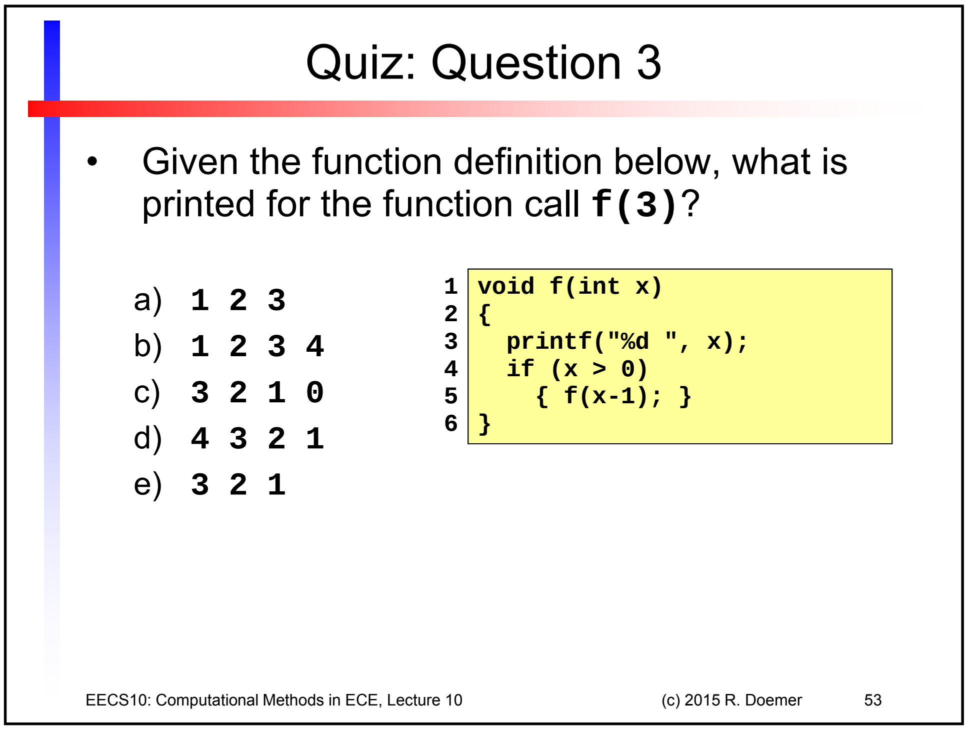

Quiz: Question 3

- Given the function definition below, what is printed for the function call **`f(3)`**?

a) **1 2 3**
b) **1 2 3 4**
c) **3 2 1 0**
d) **4 3 2 1**
e) **3 2 1**

```
void f(int x)
{
  printf("%d ", x);
  if (x > 0)
    { f(x-1); }
}
```

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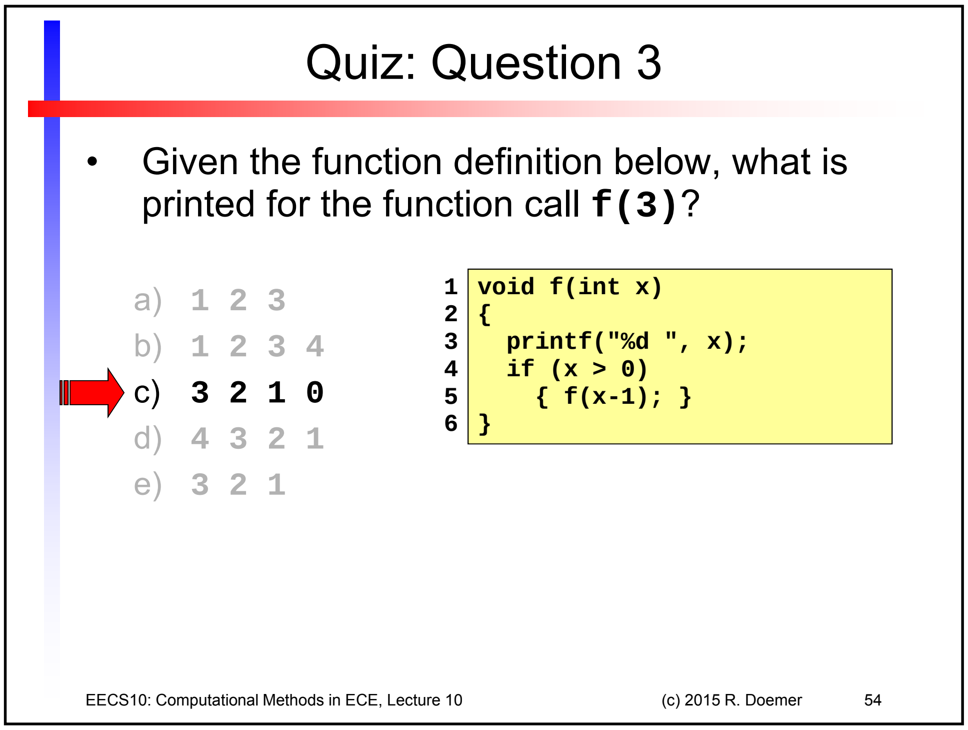

Quiz: Question 3

- Given the function definition below, what is printed for the function call **`f(3)`**?

a) **1 2 3**
b) **1 2 3 4**
[✓ c) **3 2 1 0**]
d) **4 3 2 1**
e) **3 2 1**

```
void f(int x)
{
  printf("%d ", x);
  if (x > 0)
    { f(x-1); }
}
```

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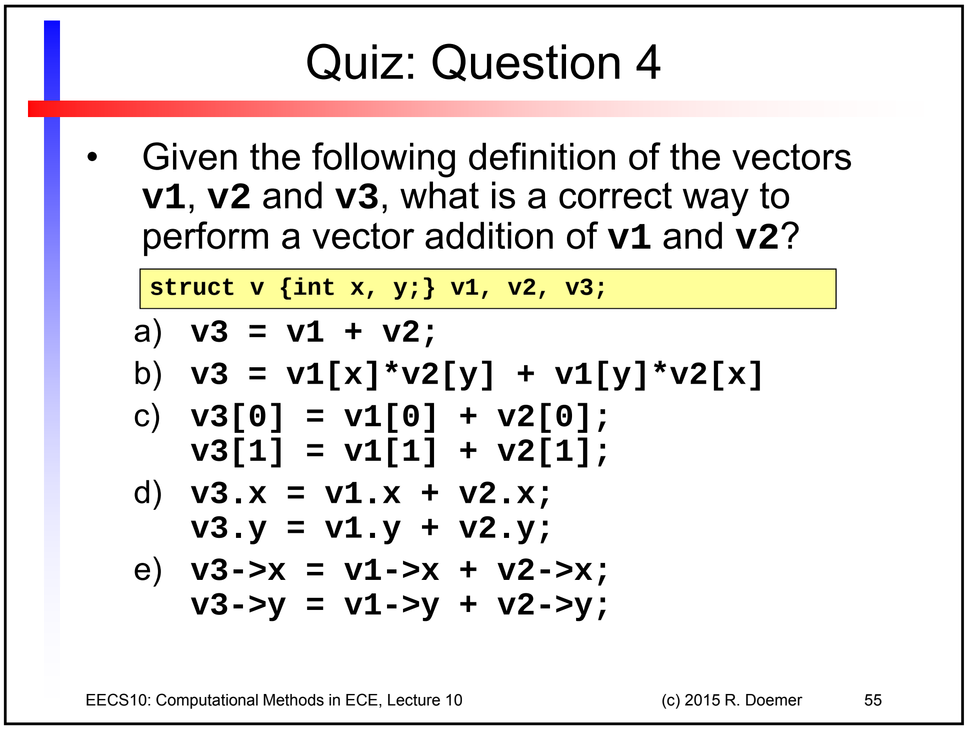


Quiz: Question 4

- Given the following definition of the vectors **v1**, **v2** and **v3**, what is a correct way to perform a vector addition of **v1** and **v2**?

```
struct v {int x, y;} v1, v2, v3;
```

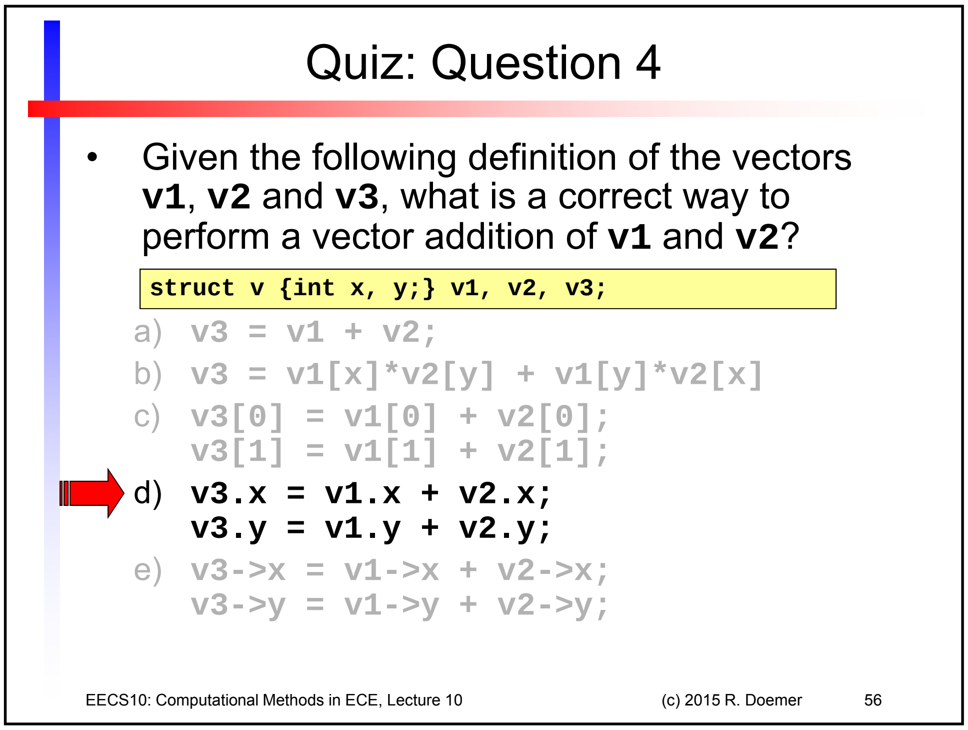
a) `v3 = v1 + v2;`

b) `v3 = v1[x]*v2[y] + v1[y]*v2[x]`

c) `v3[0] = v1[0] + v2[0];`
`v3[1] = v1[1] + v2[1];`

d) `v3.x = v1.x + v2.x;`
`v3.y = v1.y + v2.y;`

e) `v3->x = v1->x + v2->x;`
`v3->y = v1->y + v2->y;`



Quiz: Question 4

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```
struct v {int x, y;} v1, v2, v3;
```

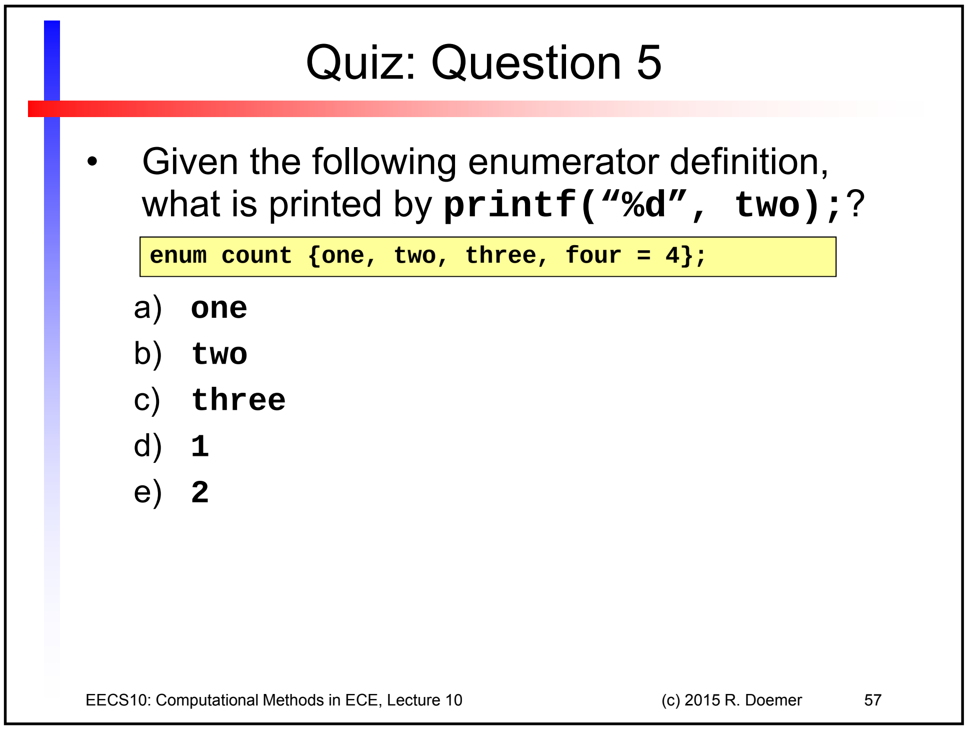
a) `v3 = v1 + v2;`

b) `v3 = v1[x]*v2[y] + v1[y]*v2[x]`

c) `v3[0] = v1[0] + v2[0];`
`v3[1] = v1[1] + v2[1];`

[✓ d)] `v3.x = v1.x + v2.x;`
`v3.y = v1.y + v2.y;`

e) `v3->x = v1->x + v2->x;`
`v3->y = v1->y + v2->y;`



Quiz: Question 5

- Given the following enumerator definition, what is printed by **`printf("%d", two);`**?

```
enum count {one, two, three, four = 4};
```

a) **`one`**
b) **`two`**
c) **`three`**
d) **`1`**
e) **`2`**

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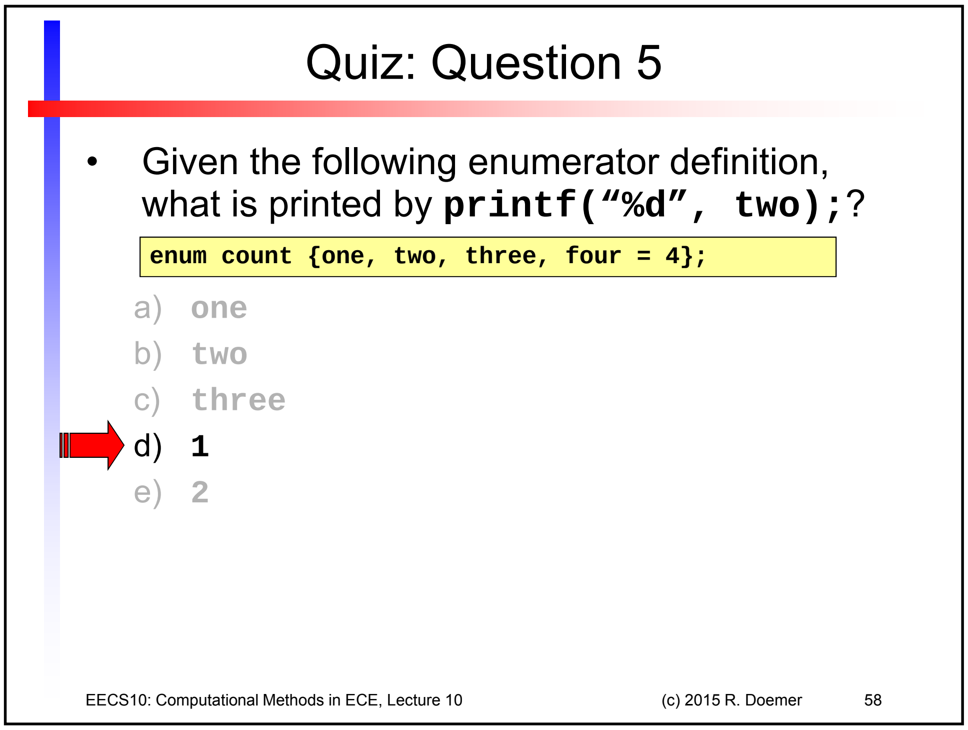

Quiz: Question 5

- Given the following enumerator definition, what is printed by **`printf("%d", two);`**?

```
enum count {one, two, three, four = 4};
```

a) **`one`**
b) **`two`**
c) **`three`**
[✓ d) **`1`**]
e) **`2`**

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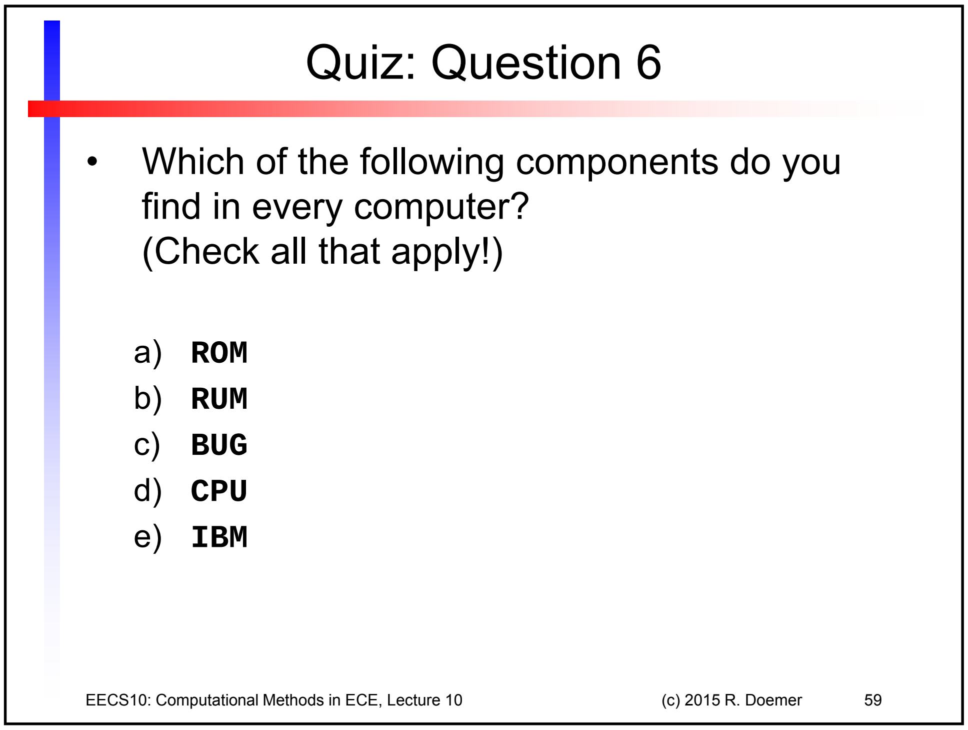

Quiz: Question 6

- Which of the following components do you find in every computer?
  (Check all that apply!)

a) **`ROM`**
b) **`RUM`**
c) **`BUG`**
d) **`CPU`**
e) **`IBM`**

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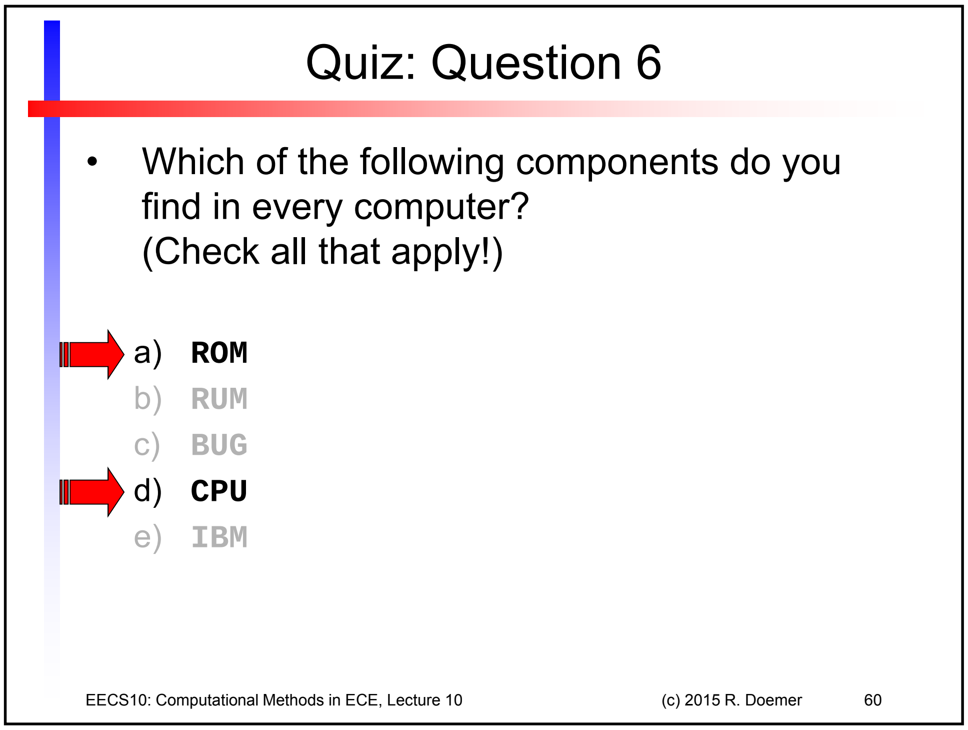

Quiz: Question 6

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  (Check all that apply!)

[✓ a) **`ROM`**]
b) **`RUM`**
c) **`BUG`**
[✓ d) **`CPU`**]
e) **`IBM`**

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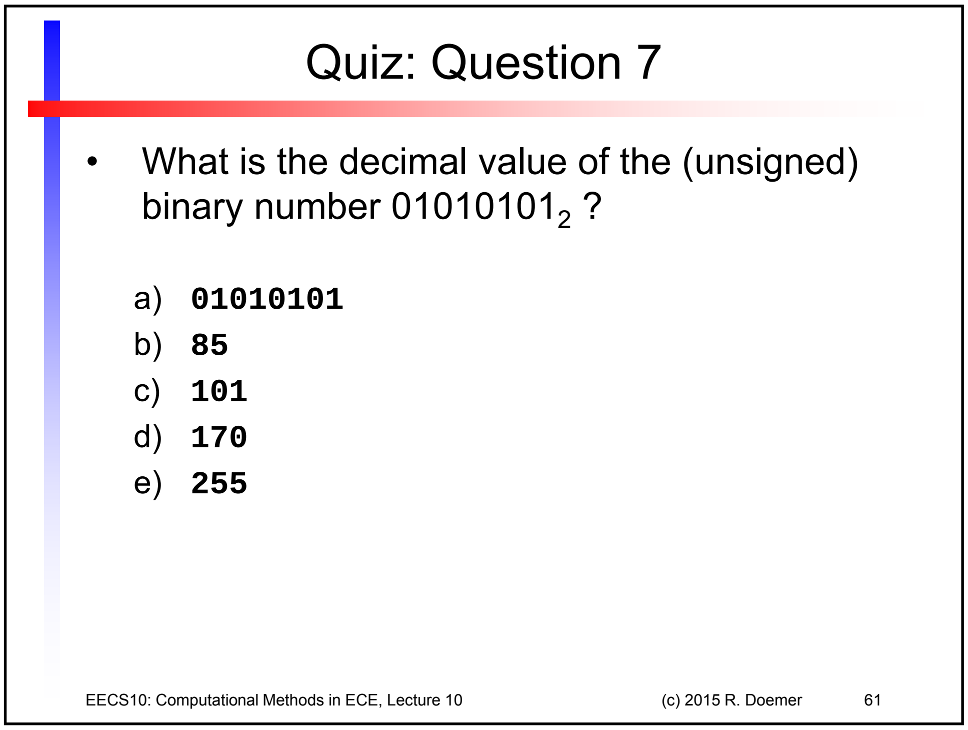
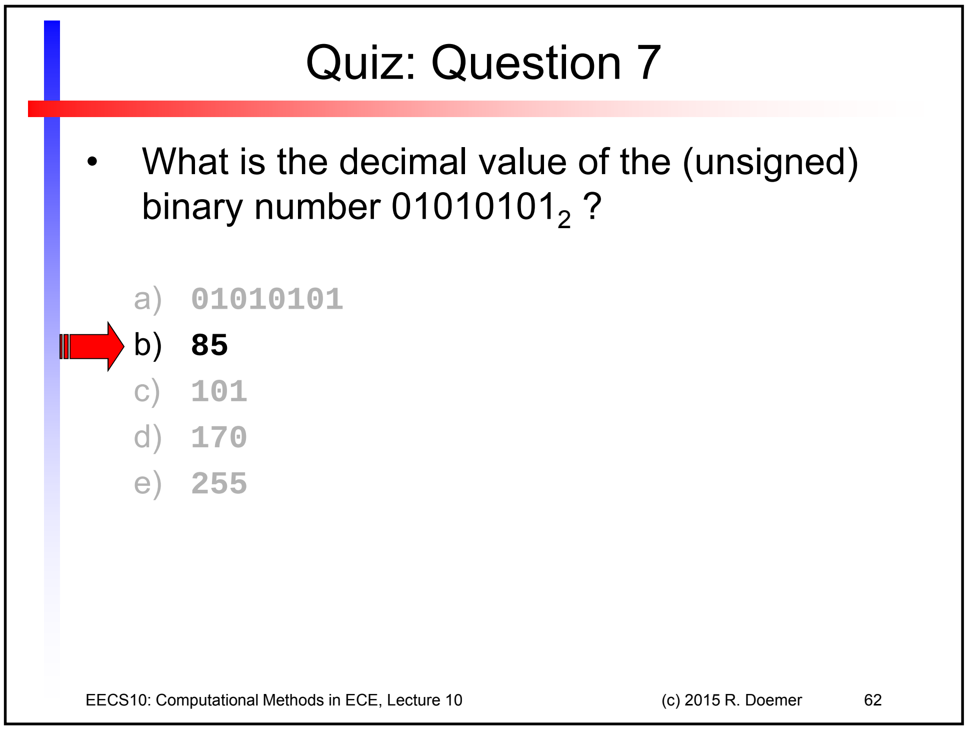


Quiz: Question 7

- What is the decimal value of the (unsigned) binary number 01010101_2 ?

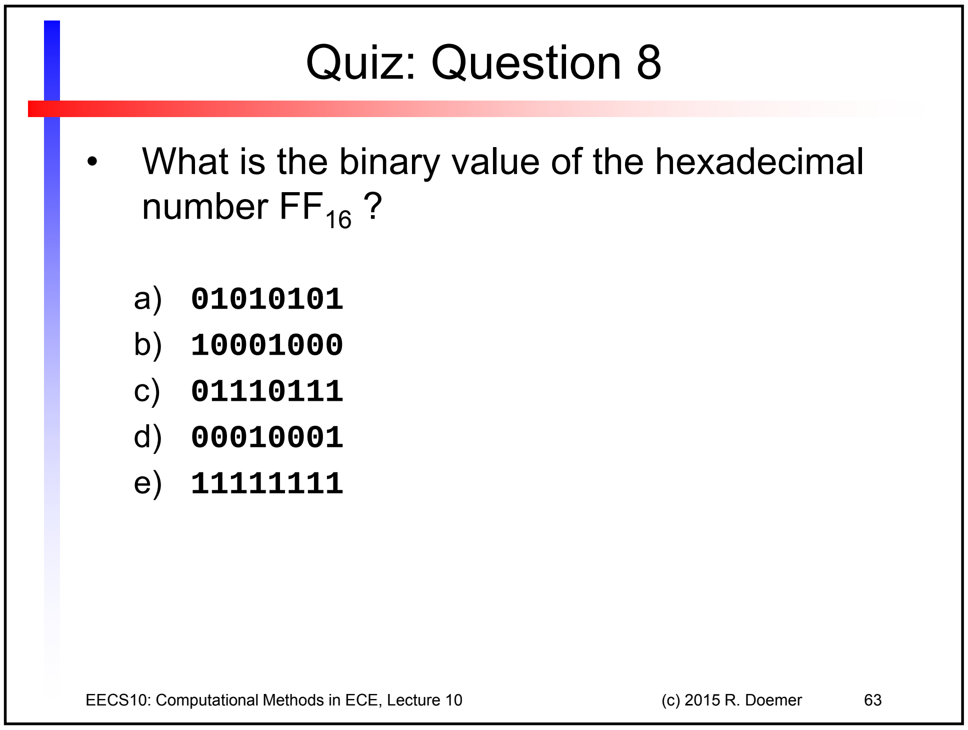
  a) **01010101**
  b) **85**
  c) **101**
  d) **170**
  e) **255**



Quiz: Question 7

- What is the decimal value of the (unsigned) binary number 01010101_2 ?

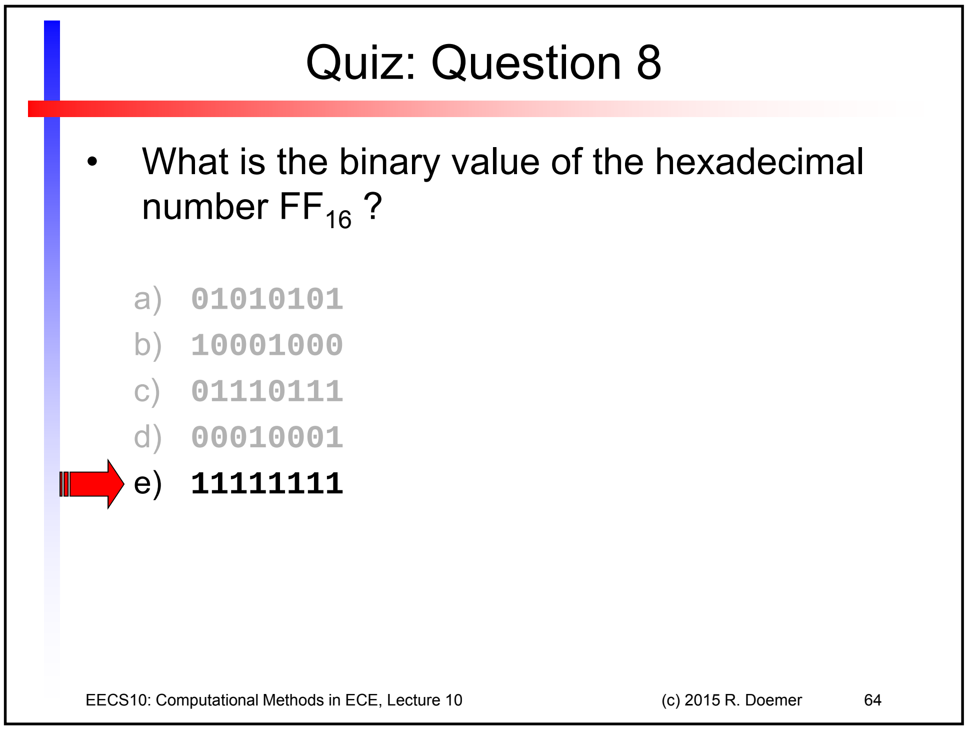
  a) **01010101**
  [✓ b) **85**]
  c) **101**
  d) **170**
  e) **255**



Quiz: Question 8

- What is the binary value of the hexadecimal number FF_{16} ?

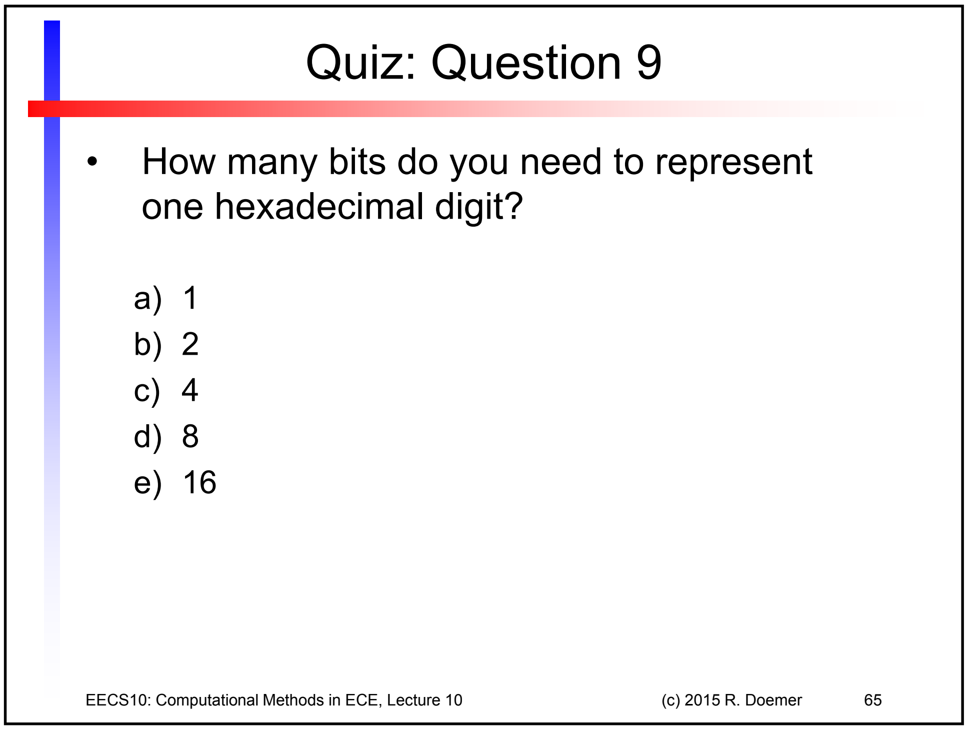
a) **`01010101`**
b) **`10001000`**
c) **`01110111`**
d) **`00010001`**
e) **`11111111`**



Quiz: Question 8

- What is the binary value of the hexadecimal number FF_{16} ?

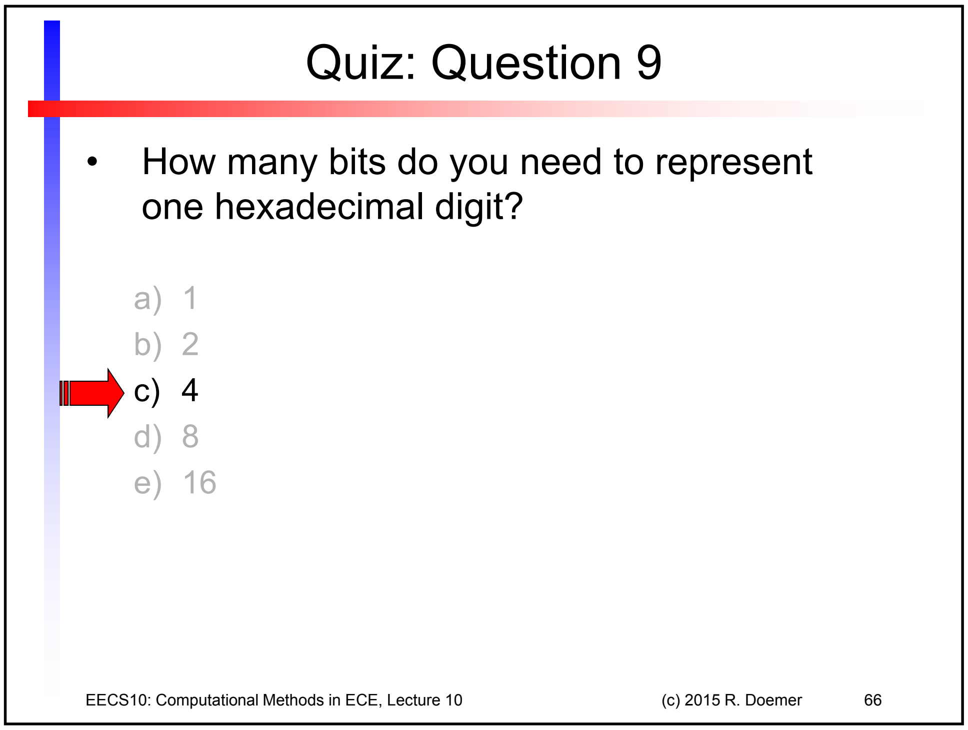
a) `01010101`
b) `10001000`
c) `01110111`
d) `00010001`
[✓ e) **`11111111`**]



Quiz: Question 9

- How many bits do you need to represent one hexadecimal digit?

  a) 1
  b) 2
  c) 4
  d) 8
  e) 16



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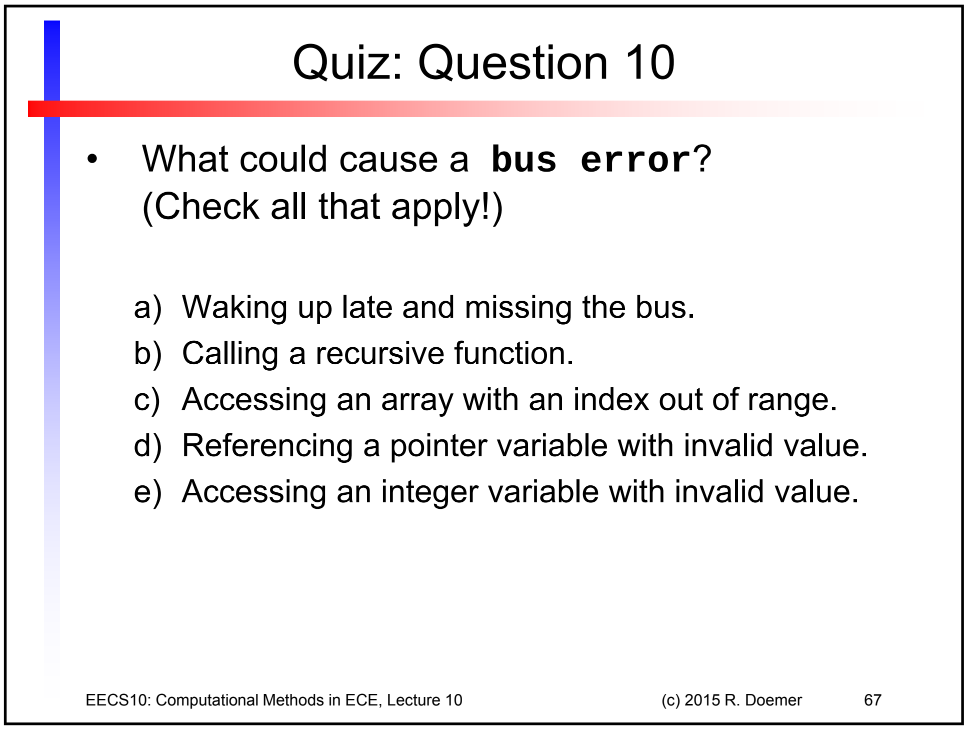
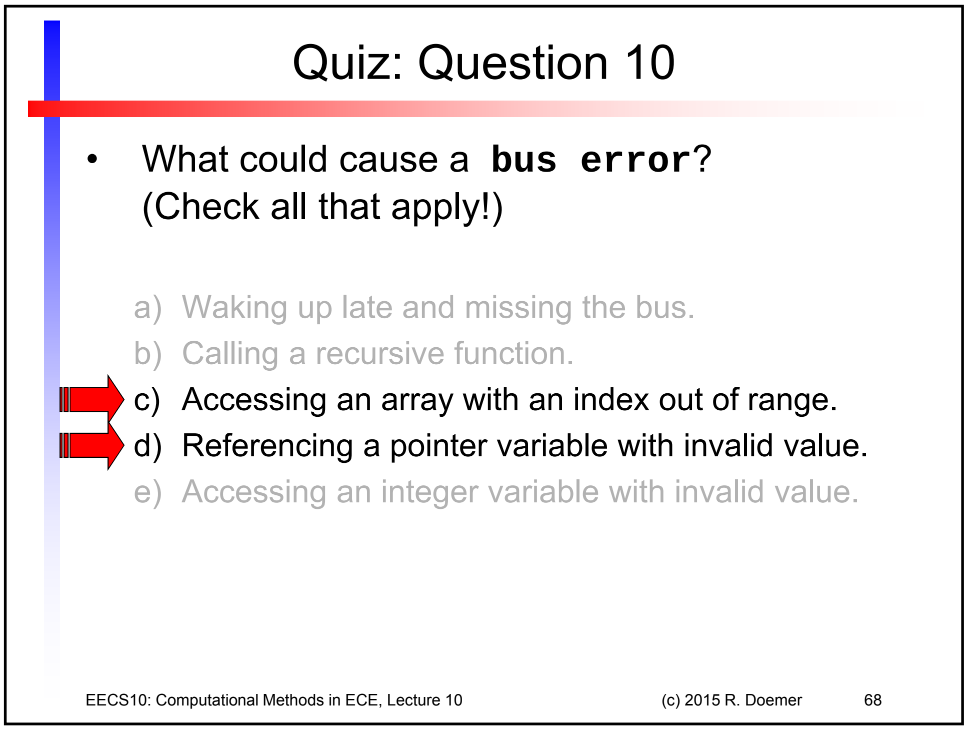


Quiz: Question 10

- What could cause a **`bus error`**? (Check all that apply!)

a) Waking up late and missing the bus.
b) Calling a recursive function.
c) Accessing an array with an index out of range.
d) Referencing a pointer variable with invalid value.
e) Accessing an integer variable with invalid value.



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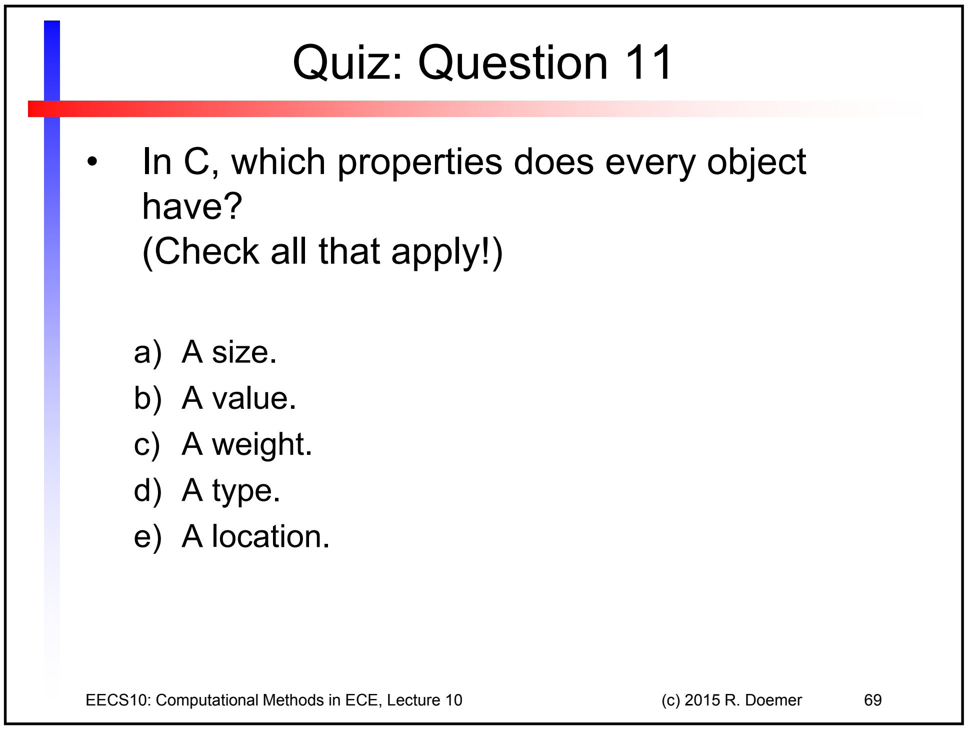
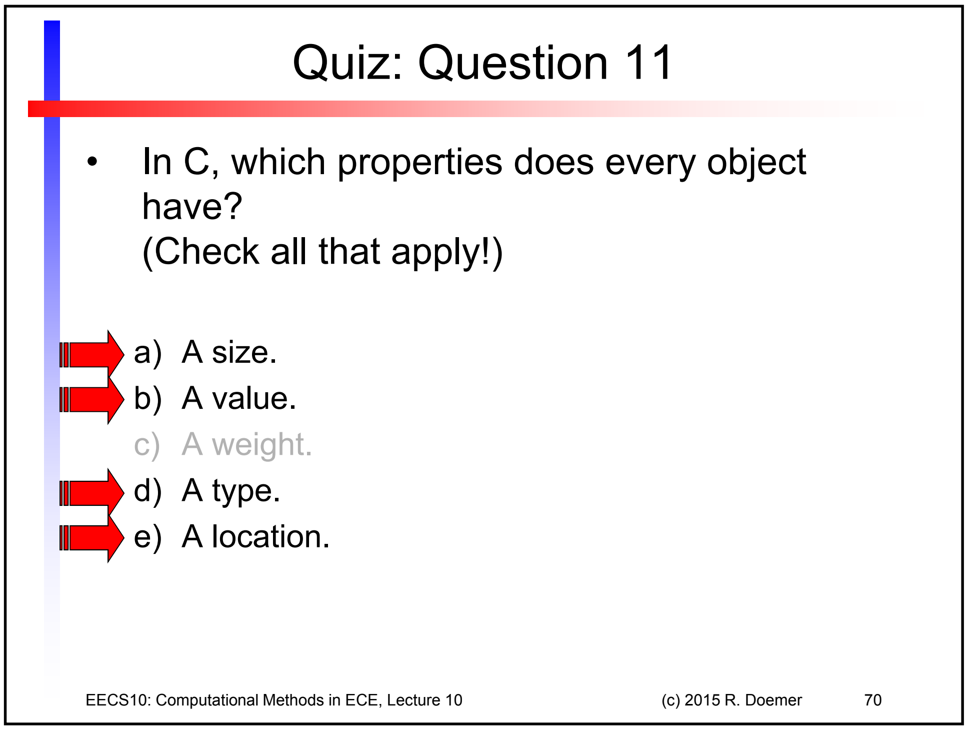


Quiz: Question 11

- In C, which properties does every object have?
  (Check all that apply!)

a) A size.
b) A value.
c) A weight.
d) A type.
e) A location.



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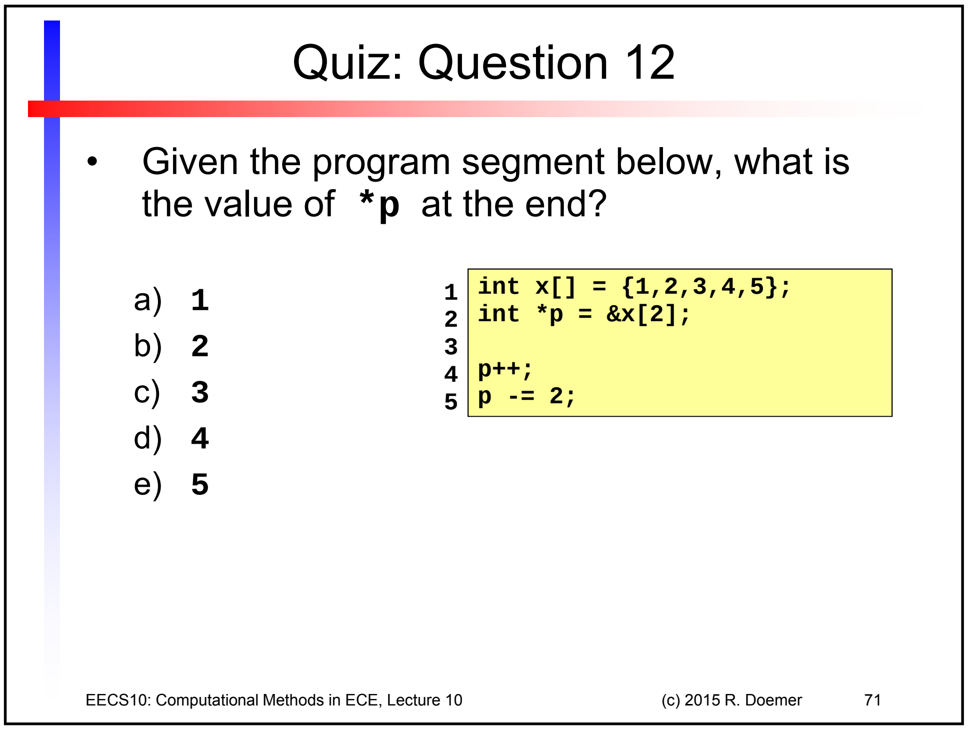

Quiz: Question 12

- Given the program segment below, what is the value of **`*p`** at the end?

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

```
int x[] = {1,2,3,4,5};
int *p = &x[2];

p++;
p -= 2;
```

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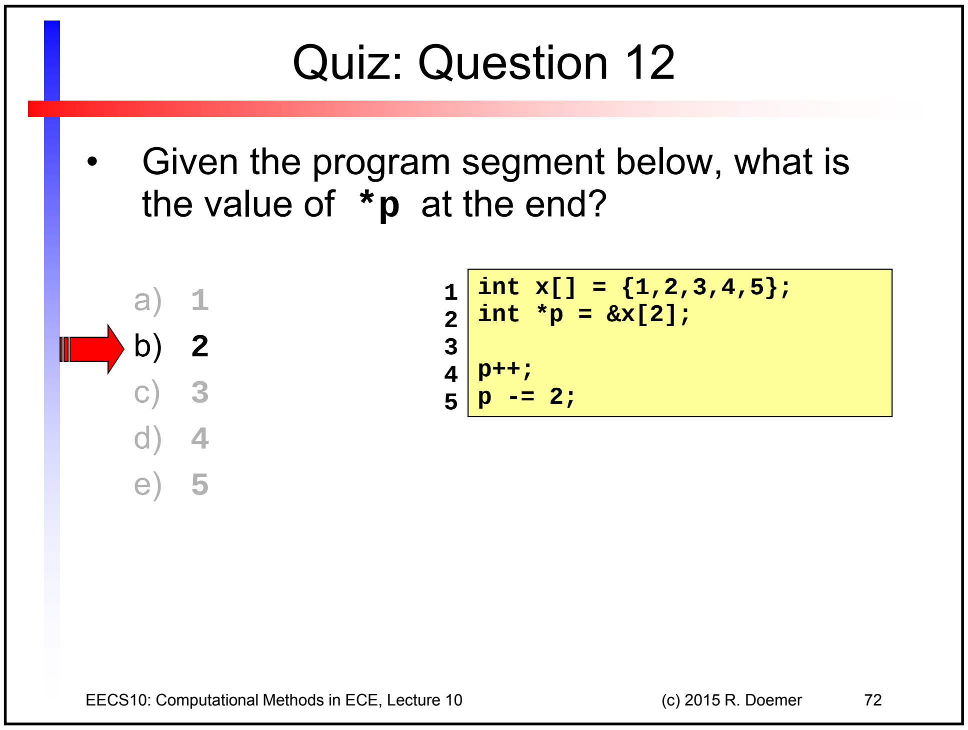

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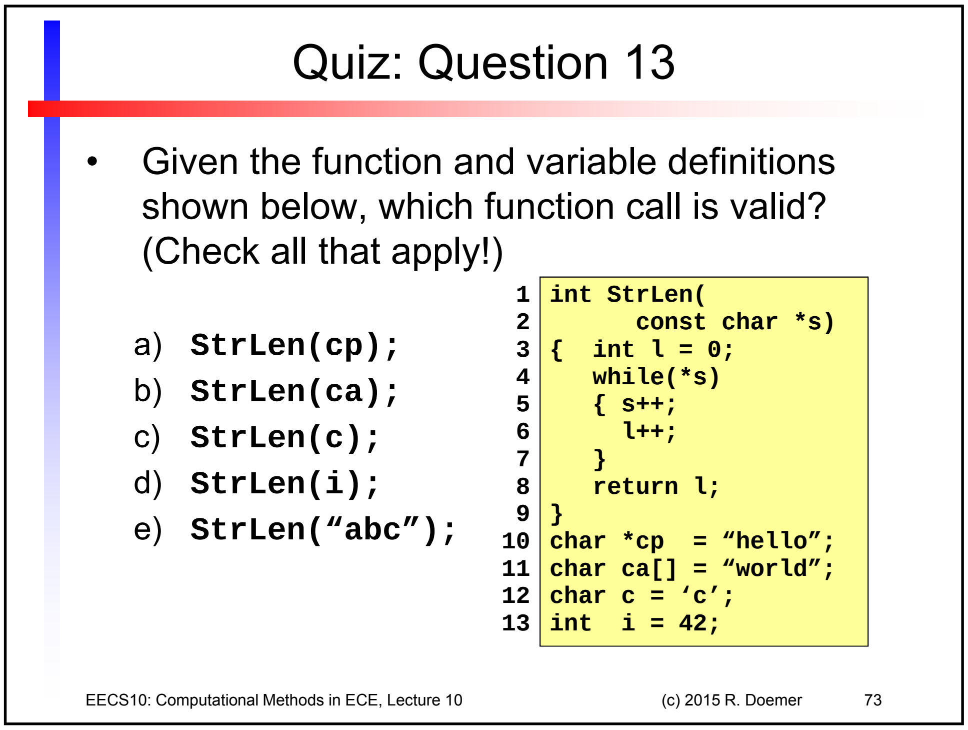

Quiz: Question 13

- Given the function and variable definitions shown below, which function call is valid? (Check all that apply!)

a) **`StrLen(cp);`**
b) **`StrLen(ca);`**
c) **`StrLen(c);`**
d) **`StrLen(i);`**
e) **`StrLen(“abc”);`**

```
int StrLen(
      const char *s)
{  int l = 0;
   while(*s)
   { s++;
     l++;
   }
   return l;
}
char *cp  = “hello”;
char ca[] = “world”;
char c = ‘c’;
int  i = 42;
```

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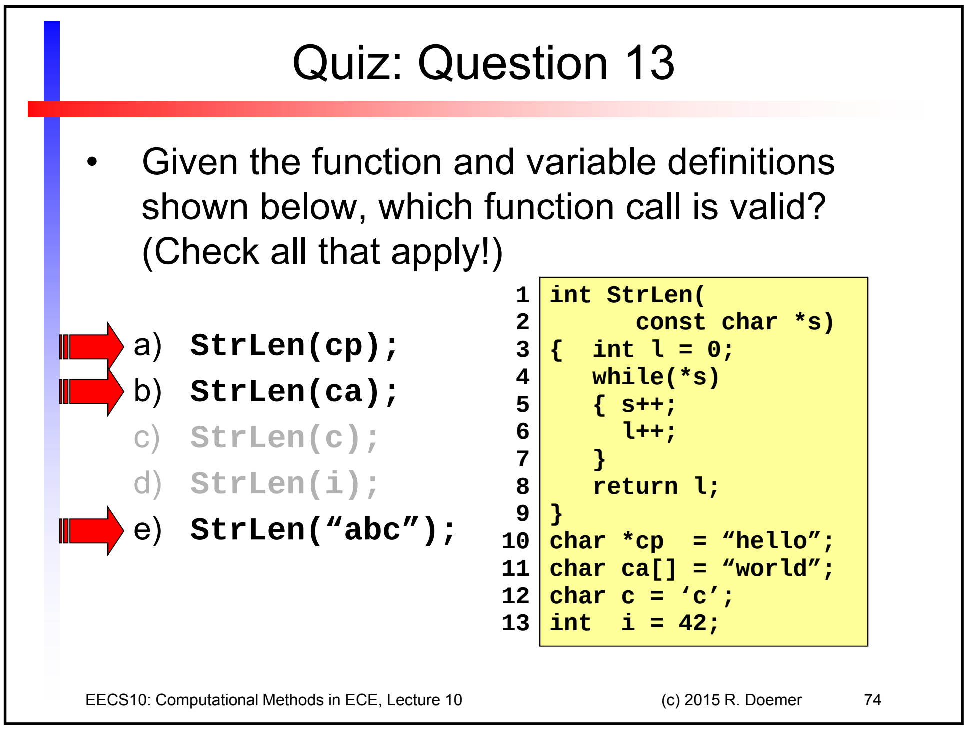

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```

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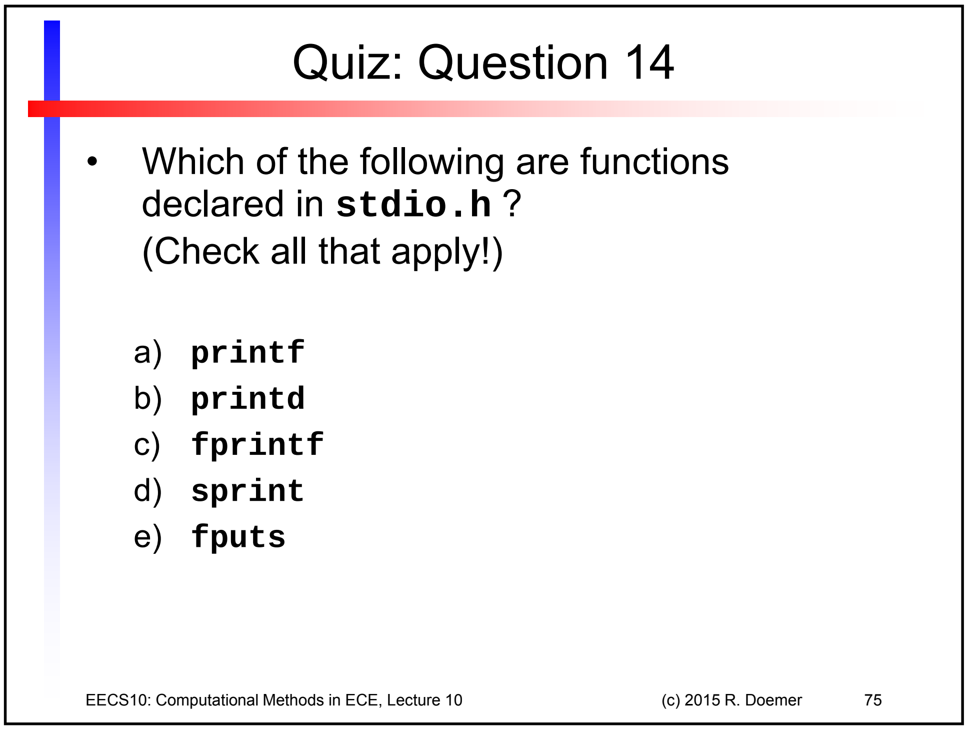
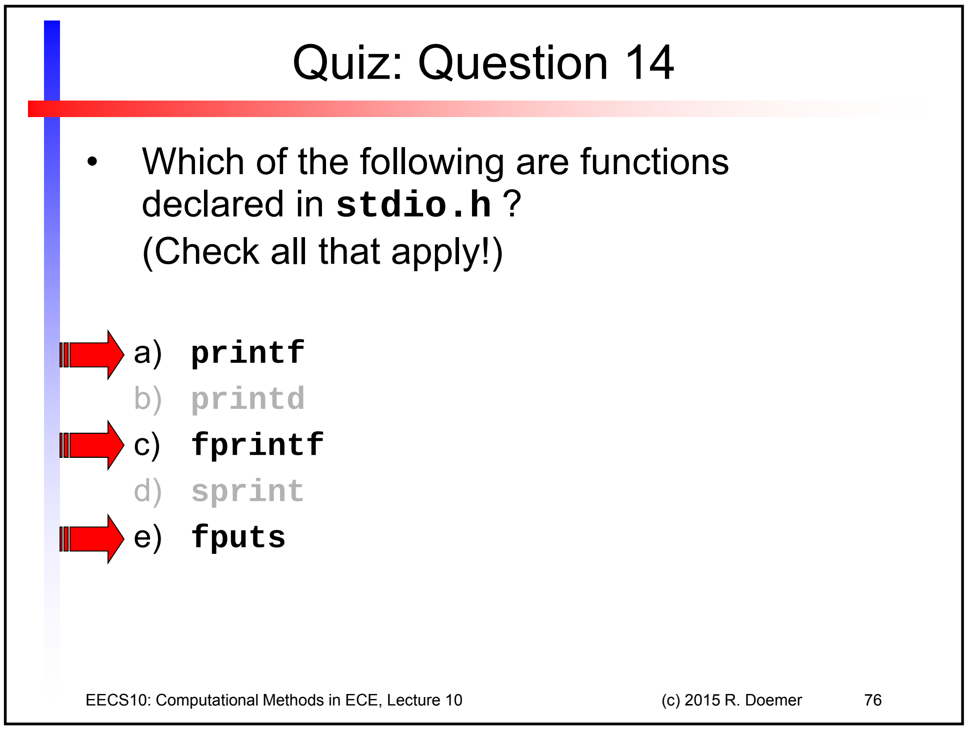


Quiz: Question 14

- Which of the following are functions declared in **`stdio.h`** ? (Check all that apply!)

  a) **`printf`**
  b) **`printd`**
  c) **`fprintf`**
  d) **`sprint`**
  e) **`fputs`**



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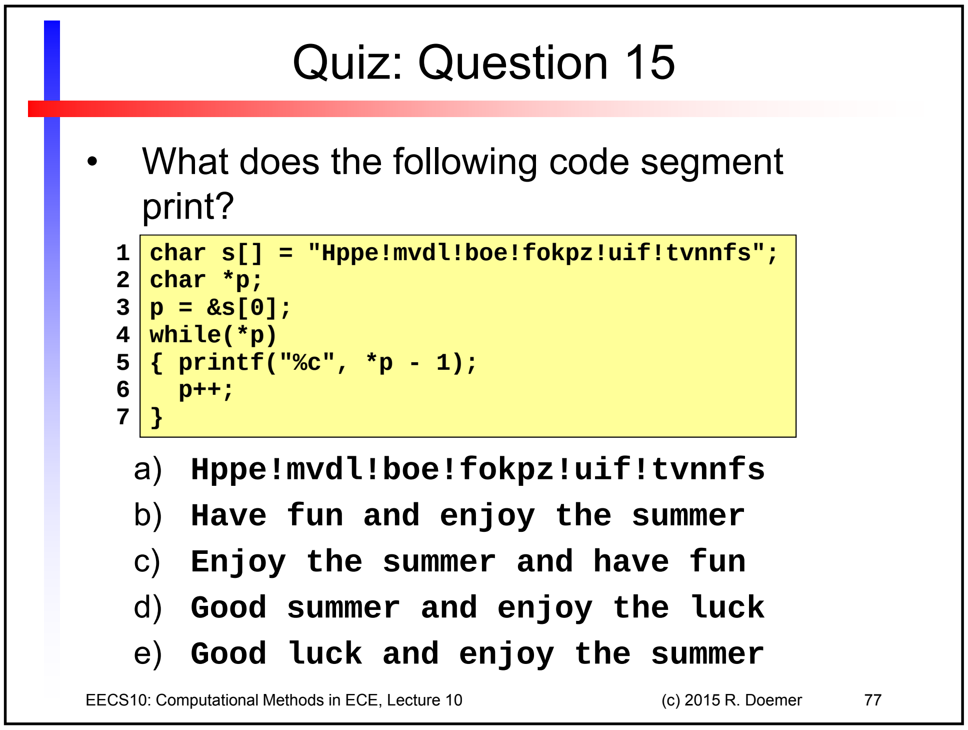
  d) **`sprint`**
  [✓ e) **`fputs`**]

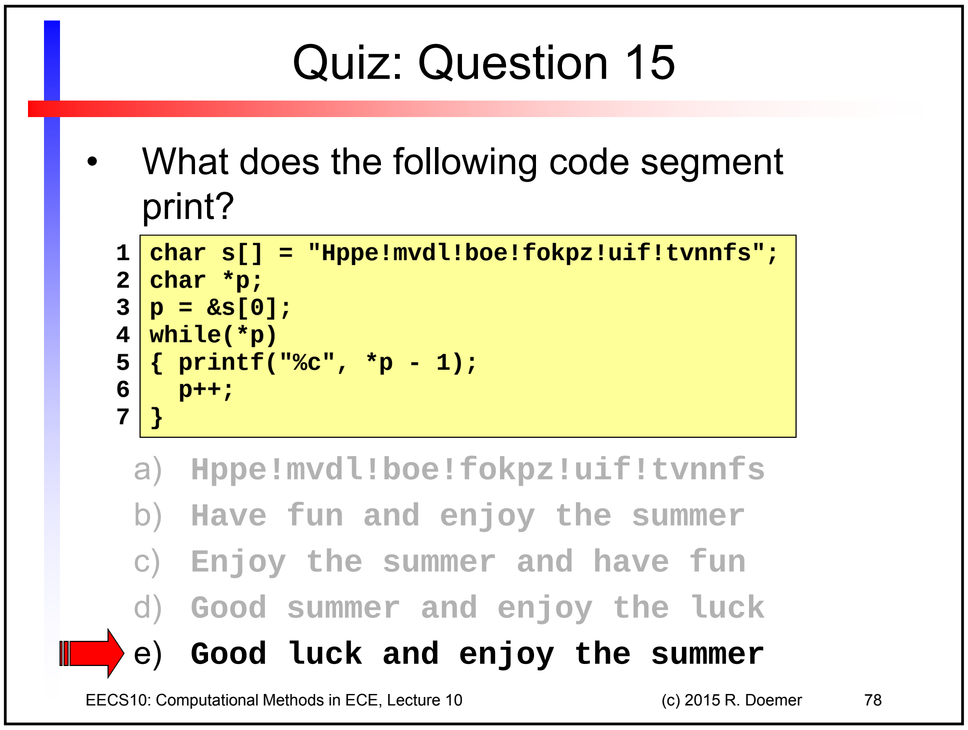


Quiz: Question 15

- What does the following code segment print?

```
char s[] = "Hppe!mvdl!boe!fokpz!uif!tvnnfs";
char *p;
p = &s[0];
while(*p)
{ printf("%c", *p - 1);
  p++;
}
```

a) **Hppe!mvdl!boe!fokpz!uif!tvnnfs**
b) **Have fun and enjoy the summer**
c) **Enjoy the summer and have fun**
d) **Good summer and enjoy the luck**
e) **Good luck and enjoy the summer**



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  p++;
}
```

a) **Hppe!mvdl!boe!fokpz!uif!tvnnfs**
b) **Have fun and enjoy the summer**
c) **Enjoy the summer and have fun**
d) **Good summer and enjoy the luck**
[✓ e) **Good luck and enjoy the summer**]