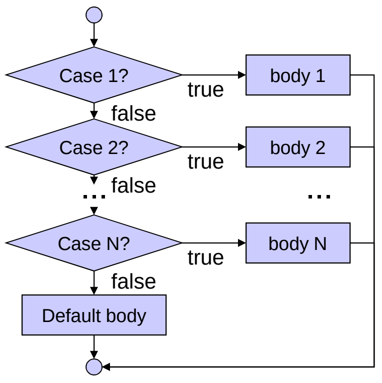
Lecture 5.2: Overview

- Structured Programming
  - Structured jump statements
    - **break** statement in **switch** statement
    - **break** and **continue** in **while** loop
    - **break** and **continue** in **do-while** loop
    - **break** and **continue** in **for** loop
- Arbitrary jump statements
  - **goto** statement
- Debugging
  - Source-level debugger **gdb**
  - Example **Interest2.c**

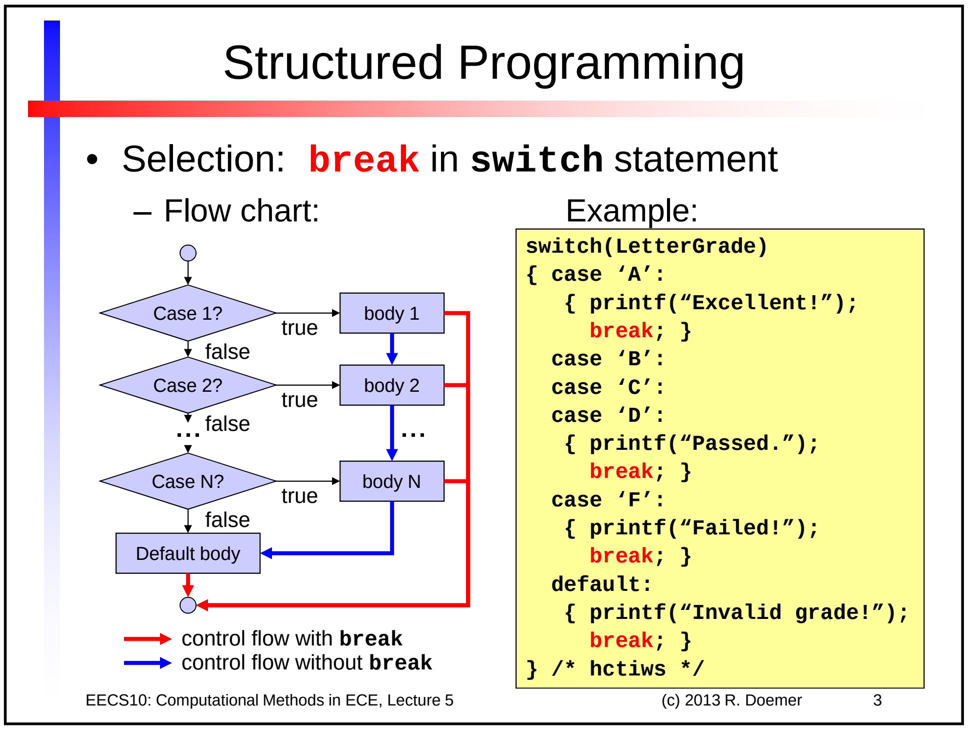
Structured Programming

- Selection: **switch** statement
  - Flow chart:



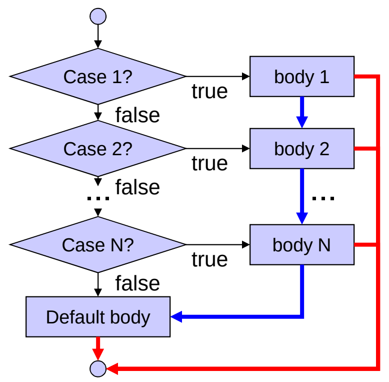
Example:

```
switch(LetterGrade)
{ case 'A':
    { printf("Excellent!");
      break; }
  case 'B':
  case 'C':
  case 'D':
    { printf("Passed.");
      break; }
  case 'F':
    { printf("Failed!");
      break; }
  default:
    { printf("Invalid grade!");
      break; }
} /* hctiws */
```



Structured Programming

- Selection: **break** in **switch** statement
  - Flow chart:

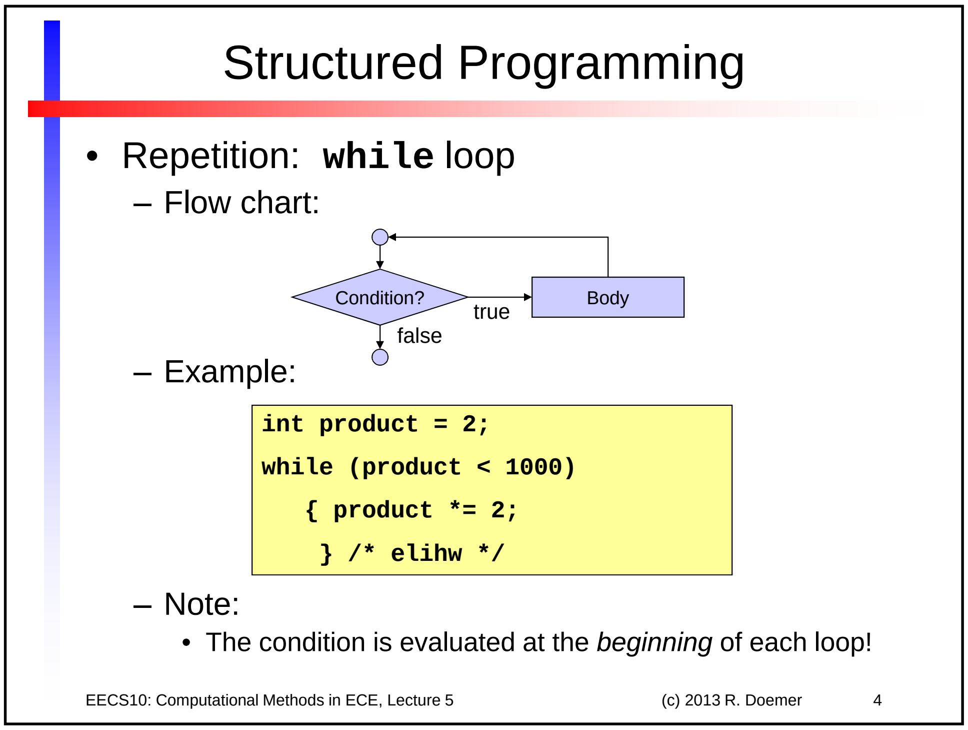


→ control flow with **break**
→ control flow without **break**

Example:

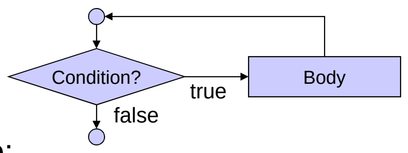
```
switch(LetterGrade)
{ case ‘A’:
   { printf(“Excellent!”);
     break; }
  case ‘B’:
  case ‘C’:
  case ‘D’:
   { printf(“Passed.”);
     break; }
  case ‘F’:
   { printf(“Failed!”);
     break; }
  default:
   { printf(“Invalid grade!”);
     break; }
} /* hctiws */
```

EECS10: Computational Methods in ECE, Lecture 5 (c) 2013 R. Doemer 3



Structured Programming

- Repetition: **while** loop
  - Flow chart:



  - Example:

```
int product = 2;
while (product < 1000)
   { product *= 2;
    } /* elihw */
```

  - Note:
    - The condition is evaluated at the *beginning* of each loop!

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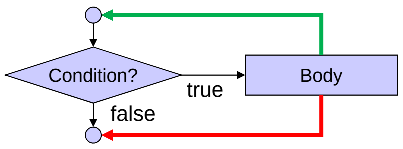
Structured Programming

- Repetition: **`break`**/**`continue`** in **`while`** loop
  - Flow chart:



  - Control flow:

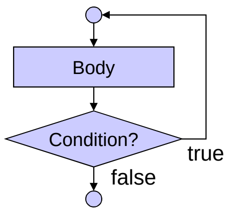
    → control flow with **`break`**

    → control flow with **`continue`**

  - Note:
    - The condition is evaluated at the *beginning* of each loop!

Structured Programming

- Repetition: **`do-while`** loop
  - Flow chart:



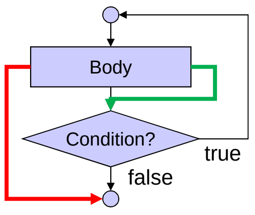
  - Example:

```
int product = 2;
do { product *= 2;
    } while (product < 1000);
```

  - Note:
    - The condition is evaluated at the *end* of each loop!

Structured Programming

- Repetition: **break**/**continue** in **do-while** loop
  - Flow chart:



  - Control flow:

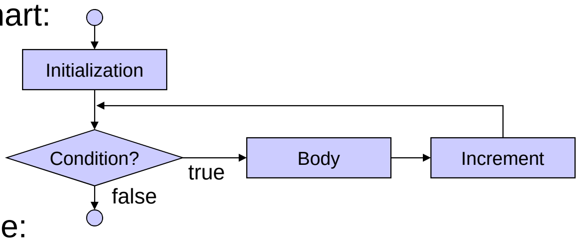
    → control flow with **break**

    → control flow with **continue**

  - Note:
    - The condition is evaluated at the *end* of each loop!

Structured Programming

- Repetition: **for** loop
  - Flow chart:



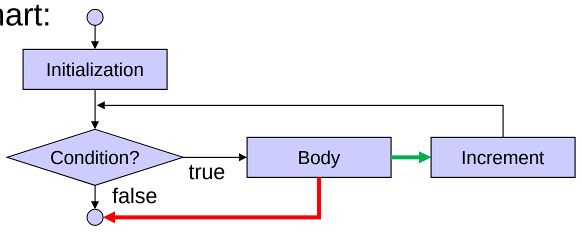
  - Example:

```
for(i = 0; i < 10; i++)
   { printf(“i = %d\n”, i);
    } /* rof */
```

  - Syntax:
    - **for(*initialization*; *condition*; *increment*)**
      { *body* }

Structured Programming

- Repetition: `break`/`continue` in `for` loop
  - Flow chart:



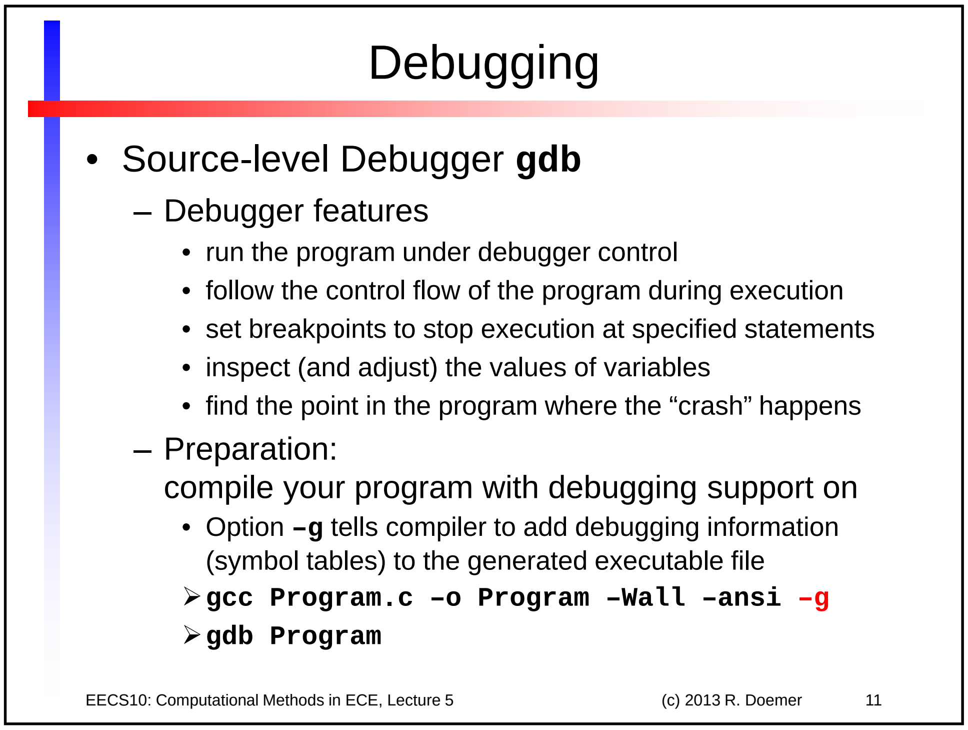
  - Control flow:
    - → control flow with `break`
    - → control flow with `continue`
  - Syntax:
    - `for(`*`initialization`*`;` *`condition`*`;` *`increment`*`)`
      `{` *`body`* `}`

Arbitrary Control Flow

- Arbitrary jumps: `goto` statement
  - `goto` statement jumps to the specified *labeled* statement (within the same function)
  - Example:

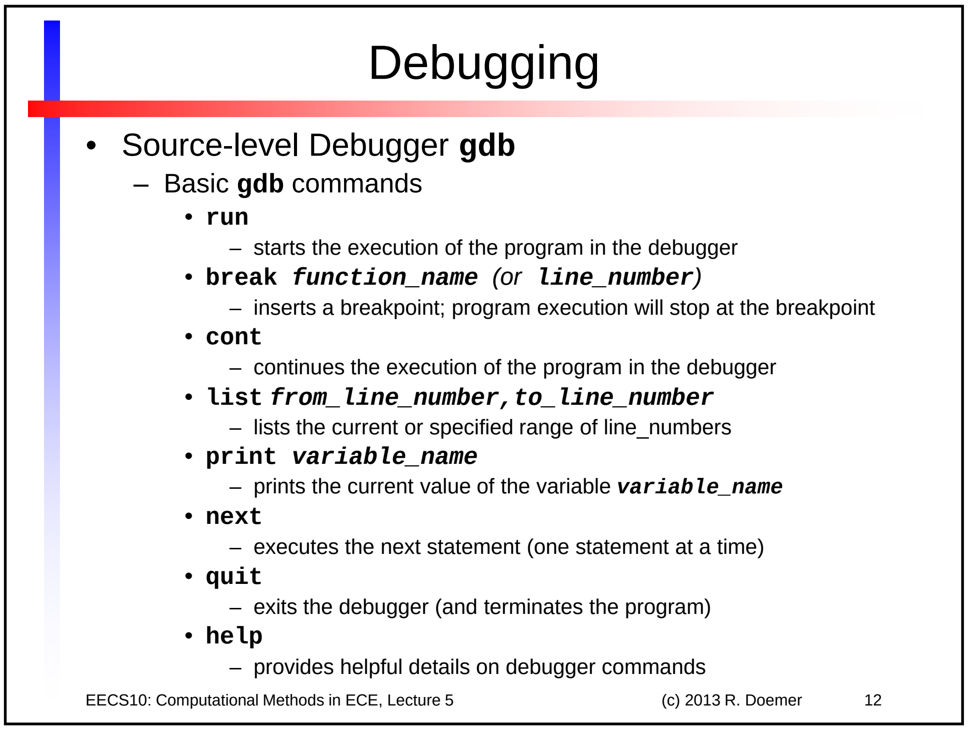
```
begin:  count = 0;
        goto next;
repeat: if (count > 100)
          { goto end; }
next:   count++;
        if (count == 77)
          { goto next; }
        goto repeat;
end:    printf("%d", count);
```

  - Warning:
    - `goto` statement allows *un-structured* programming!
    - `goto` statement should be avoided whenever possible!



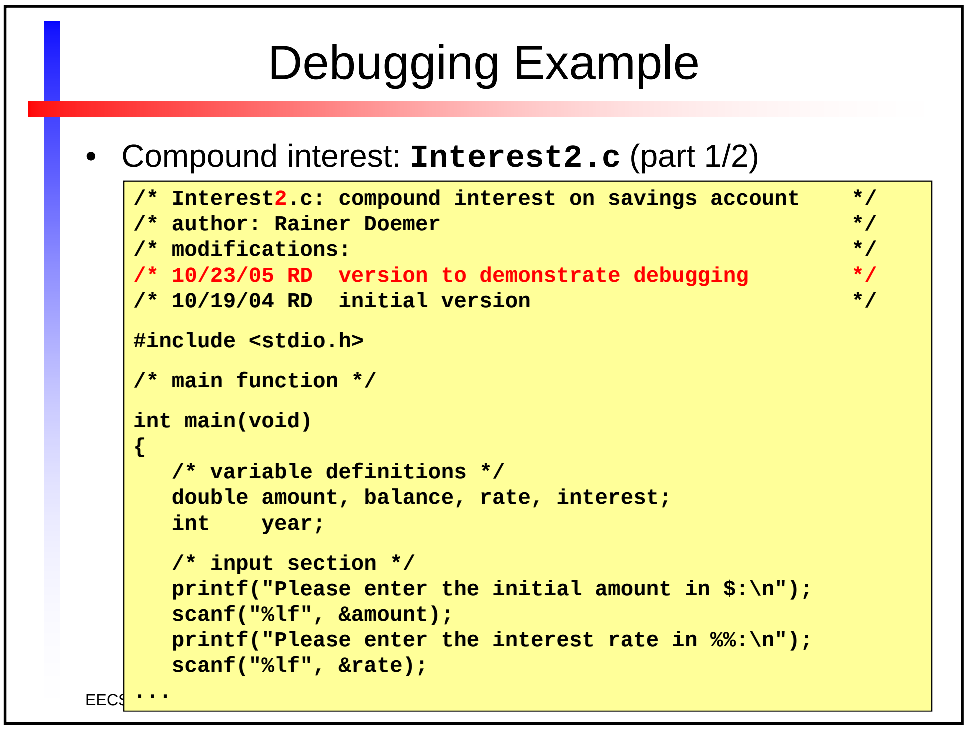
Debugging

- Source-level Debugger **gdb**
  - Debugger features
    - run the program under debugger control
    - follow the control flow of the program during execution
    - set breakpoints to stop execution at specified statements
    - inspect (and adjust) the values of variables
    - find the point in the program where the “crash” happens
  - Preparation:
    compile your program with debugging support on
    - Option **`-g`** tells compiler to add debugging information (symbol tables) to the generated executable file
    - ➢ **`gcc Program.c -o Program -Wall -ansi -g`**
    - ➢ **`gdb Program`**



Debugging

- Source-level Debugger **gdb**
  - Basic **gdb** commands
    - **`run`**
      - starts the execution of the program in the debugger
    - **`break`** ***`function_name`*** *(or* ***`line_number`****)*
      - inserts a breakpoint; program execution will stop at the breakpoint
    - **`cont`**
      - continues the execution of the program in the debugger
    - **`list`** ***`from_line_number,to_line_number`***
      - lists the current or specified range of line_numbers
    - **`print`** ***`variable_name`***
      - prints the current value of the variable ***`variable_name`***
    - **`next`**
      - executes the next statement (one statement at a time)
    - **`quit`**
      - exits the debugger (and terminates the program)
    - **`help`**
      - provides helpful details on debugger commands



Debugging Example

- Compound interest: **`Interest2.c`** (part 1/2)

```
/* Interest2.c: compound interest on savings account    */
/* author: Rainer Doemer                                */
/* modifications:                                       */
/* 10/23/05 RD  version to demonstrate debugging        */
/* 10/19/04 RD  initial version                         */

#include <stdio.h>

/* main function */

int main(void)
{
   /* variable definitions */
   double amount, balance, rate, interest;
   int    year;

   /* input section */
   printf("Please enter the initial amount in $:\n");
   scanf("%lf", &amount);
   printf("Please enter the interest rate in %%:\n");
   scanf("%lf", &rate);
...
```

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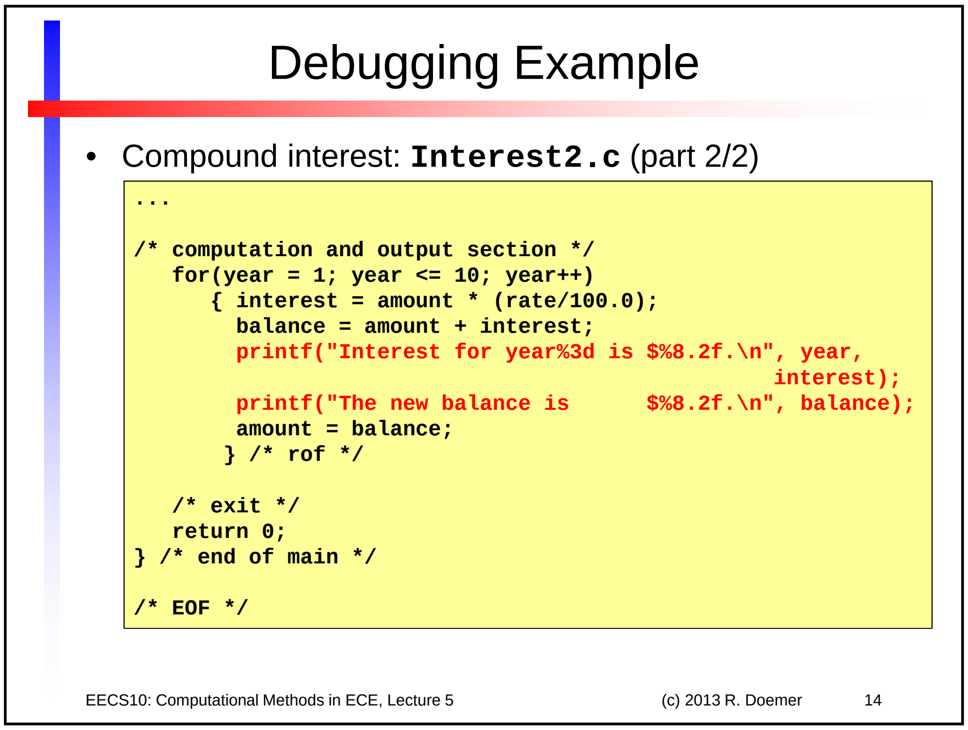


Debugging Example

- Compound interest: **`Interest2.c`** (part 2/2)

```
...

/* computation and output section */
   for(year = 1; year <= 10; year++)
      { interest = amount * (rate/100.0);
        balance = amount + interest;
        printf("Interest for year%3d is $%8.2f.\n", year,
                                                  interest);
        printf("The new balance is      $%8.2f.\n", balance);
        amount = balance;
       } /* rof */

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

/* EOF */
```

EECS10: Computational Methods in ECE, Lecture 5 (c) 2013 R. Doemer 14

Debugging Example

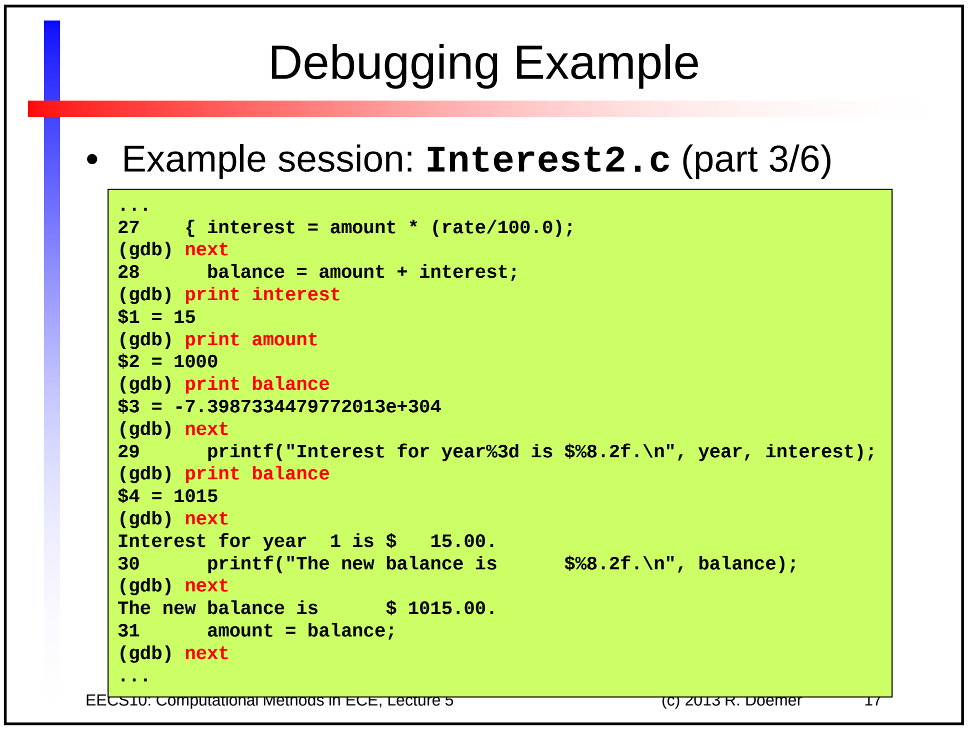
- Example session: **`Interest2.c`** (part 1/6)

```
% vi Interest2.c
% gcc Interest2.c -o Interest2 -g -Wall -ansi
% Interest2
Please enter the initial amount in $:
1000
Please enter the interest rate in %:
1.5
Interest for year  1 is $   15.00.
The new balance is      $ 1015.00.
Interest for year  2 is $   15.22.
The new balance is      $ 1030.22.
...
Interest for year 10 is $   17.15.
The new balance is      $ 1160.54.
% gdb Interest2
GNU gdb 6.3
Copyright 2004 Free Software Foundation, Inc.
GDB is free software, ...
There is absolutely no warranty for GDB.
This GDB was configured as "sparc-sun-solaris2.7"...
(gdb)
...
```

Debugging Example

- Example session: **`Interest2.c`** (part 2/6)

```
...
(gdb) break main
Breakpoint 1 at 0x106ac: file Interest2.c, line 20.
(gdb) run
Starting program: /users/faculty/doemer/eecs10/Interest/Interest2
Breakpoint 1, main () at Interest2.c:20
20          printf("Please enter the initial amount in $:\n");
(gdb) next
Please enter the initial amount in $:
21          scanf("%lf", &amount);
(gdb) next
1000
22          printf("Please enter the interest rate in %%:\n");
(gdb) next
Please enter the interest rate in %:
23          scanf("%lf", &rate);
(gdb) next
1.5
26          for(year = 1; year <= 10; year++)
(gdb) next
...
```

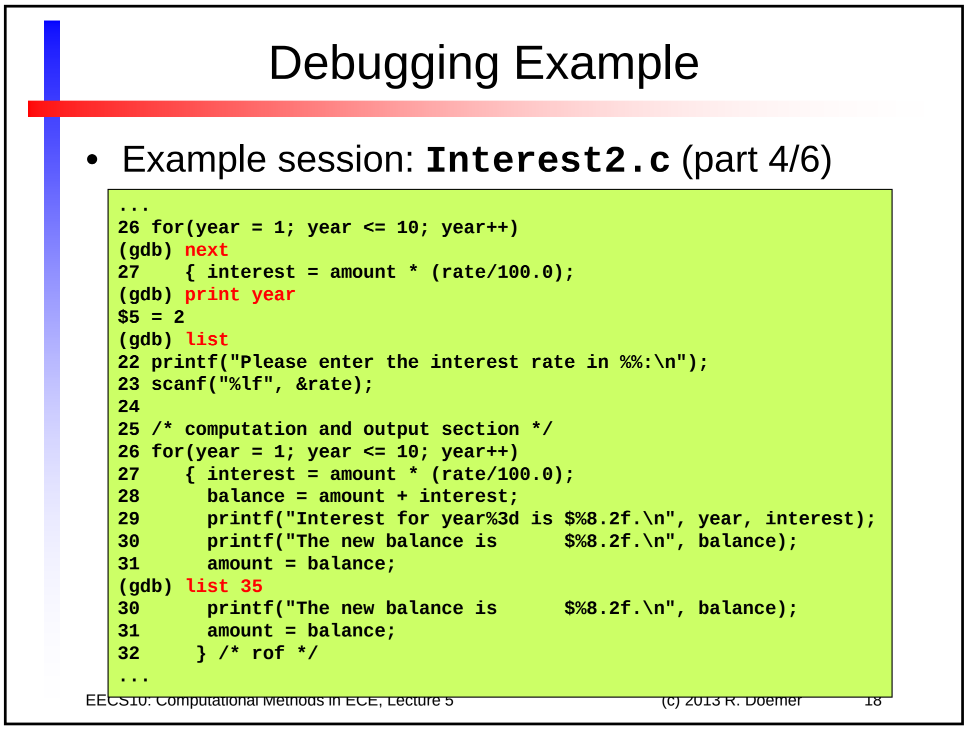


Debugging Example

- Example session: **`Interest2.c`** (part 3/6)

```
...
27    { interest = amount * (rate/100.0);
(gdb) next
28      balance = amount + interest;
(gdb) print interest
$1 = 15
(gdb) print amount
$2 = 1000
(gdb) print balance
$3 = -7.3987334479772013e+304
(gdb) next
29      printf("Interest for year%3d is $%8.2f.\n", year, interest);
(gdb) print balance
$4 = 1015
(gdb) next
Interest for year  1 is $   15.00.
30      printf("The new balance is      $%8.2f.\n", balance);
(gdb) next
The new balance is      $ 1015.00.
31      amount = balance;
(gdb) next
...
```

EECS10: Computational Methods in ECE, Lecture 5 (c) 2013 R. Doemer 17



Debugging Example

- Example session: **`Interest2.c`** (part 4/6)

```
...
26 for(year = 1; year <= 10; year++)
(gdb) next
27    { interest = amount * (rate/100.0);
(gdb) print year
$5 = 2
(gdb) list
22 printf("Please enter the interest rate in %%:\n");
23 scanf("%lf", &rate);
24
25 /* computation and output section */
26 for(year = 1; year <= 10; year++)
27    { interest = amount * (rate/100.0);
28      balance = amount + interest;
29      printf("Interest for year%3d is $%8.2f.\n", year, interest);
30      printf("The new balance is      $%8.2f.\n", balance);
31      amount = balance;
(gdb) list 35
30      printf("The new balance is      $%8.2f.\n", balance);
31      amount = balance;
32     } /* rof */
...
```

EECS10: Computational Methods in ECE, Lecture 5 (c) 2013 R. Doemer 18

Debugging Example

- Example session: **`Interest2.c`** (part 5/6)

```
...
33
34 /* exit */
35 return 0;
36 } /* end of main */
37
38 /* EOF */
(gdb) break 35
Breakpoint 2 at 0x1079c: file Interest2.c, line 35.
(gdb) cont
Continuing.
Interest for year  2 is $   15.22.
The new balance is      $ 1030.22.
Interest for year  3 is $   15.45.
The new balance is      $ 1045.68.
...
Interest for year 10 is $   17.15.
The new balance is      $ 1160.54.

Breakpoint 2, main () at Interest2.c:35
35 return 0;
...
```

Debugging Example

- Example session: **`Interest2.c`** (part 6/6)

```
...
(gdb) print balance
$6 = 1160.5408250251503
(gdb) cont
Continuing.

Program exited normally.
(gdb) quit
%
```