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Programação – Aula Teórica 4

Programação Estruturada: Condições e Ciclos (2)

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(Slides Baseados em Deitel e Deitel 2010 e L.P.Reis et al., 2006)

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Structured Programming (2)

Outline

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Objectives

- In this Lesson, you will learn:
  - To be able to use the `for` and do…`while` repetition statements.
  - To understand multiple selection using the `switch` selection statement.
  - To be able to use the `break` and `continue` program control statements
  - To be able to use the logical operators.

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4.1 Introduction

- **This lesson describes:**
  - Additional repetition control structures
    - `for`
    - `Do…while`
  - `switch` multiple selection statement
  - `break` statement
    - Used for exiting immediately and rapidly from certain control structures
  - `continue` statement
    - Used for skipping the remainder of the body of a repetition structure and proceeding with the next iteration of the loop

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4.2 The Essentials of Repetition

- **Loop**
  - Group of instructions computer executes repeatedly while some condition remains `true`
- **Counter-controlled repetition**
  - Definite repetition: know how many times loop will execute
  - Control variable used to count repetitions
- **Sentinel-controlled repetition**
  - Indefinite repetition
  - Used when number of repetitions not known
  - Sentinel value indicates "end of data"

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4.3 Essentials of Counter-Controlled Repetition

- **Counter-controlled repetition requires**
  - The name of a control variable (or loop counter)
  - The initial value of the control variable
  - An increment (or decrement) by which the control variable is modified each time through the loop
  - A condition that tests for the final value of the control variable (i.e., whether looping should continue)

4.3 Essentials of Counter-Controlled Repetition

- **Example:**

```
int counter = 1;                // initialization
while ( counter <= 10 ) {       // repetition condition
   printf( "%d\n", counter );
   ++counter;                   // increment
}
```

  - The statement

```
int counter = 1;
```

    - Names `counter`
    - Defines it to be an integer
    - Reserves space for it in memory
    - Sets it to an initial value of 1

```c
/* Fig. 4.1: fig04_01.c
   Counter-controlled repetition */
#include <stdio.h>

/* function main begins program execution */
int main()
{
   int counter = 1;              /* initialization */

   while ( counter <= 10 ) {     /* repetition condition */
      printf ( "%d\n", counter ); /* display counter */
      ++counter;                 /* increment */
   } /* end while */

   return 0; /* indicate program ended successfully */

} /* end function main */
```

```
1
2
3
4
5
6
7
8
9
10
```

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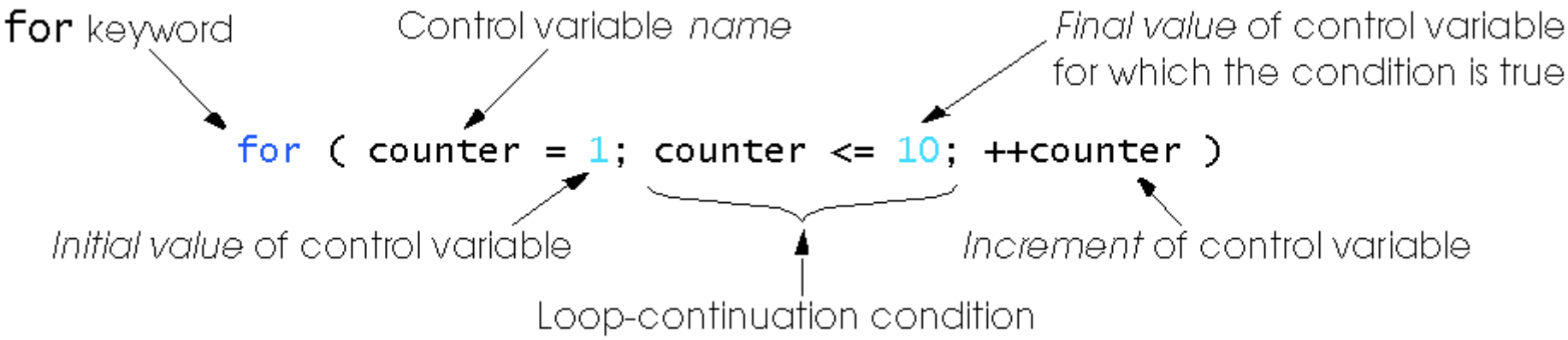
4.3 Essentials of Counter-Controlled Repetition

- **Condensed code**
  - C Programmers would make the program more concise
  - Initialize `counter` to 0
    - ```
      while ( ++counter <= 10 )
            printf( "%d\n, counter );
      ```
      ```

```c
/* Fig. 4.2: fig04_02.c
   Counter-controlled repetition with the for statement */
#include <stdio.h>

/* function main begins program execution */
int main()
{
   int counter; /* define counter */

   /* initialization, repetition condition, and increment
      are all included in the for statement header. */
   for ( counter = 1; counter <= 10; counter++ ) {
      printf( "%d\n", counter );
   } /* end for */

   return 0; /* indicate program ended successfully */

} /* end function main */
```

4.4 The for Repetition Statement



- **Format when using for loops**

  for (*initialization*; *loopContinuationTest*; *increment*)
  statement

- **Example:**

```
for( int counter = 1; counter <= 10; counter++ )
   printf( "%d\n", counter );
```

  – Prints the integers from one to ten

No semicolon (;) after last expression

4.4 The `for` Repetition Statement

- **For loops can usually be rewritten as while loops:**

```
initialization;
while ( loopContinuationTest ) {
  statement;
  increment;
}
```

- **Initialization and increment**
  - Can be comma-separated lists
  - Example:

```
for (int i = 0, j = 0;  j + i <= 10; j++, i++)
   printf( "%d\n", j + i );
```

4.5 The `for` Statement : Observations

- **Arithmetic expressions**
  - Initialization, loop-continuation, and increment can contain arithmetic expressions. If x equals 2 and y equals 10

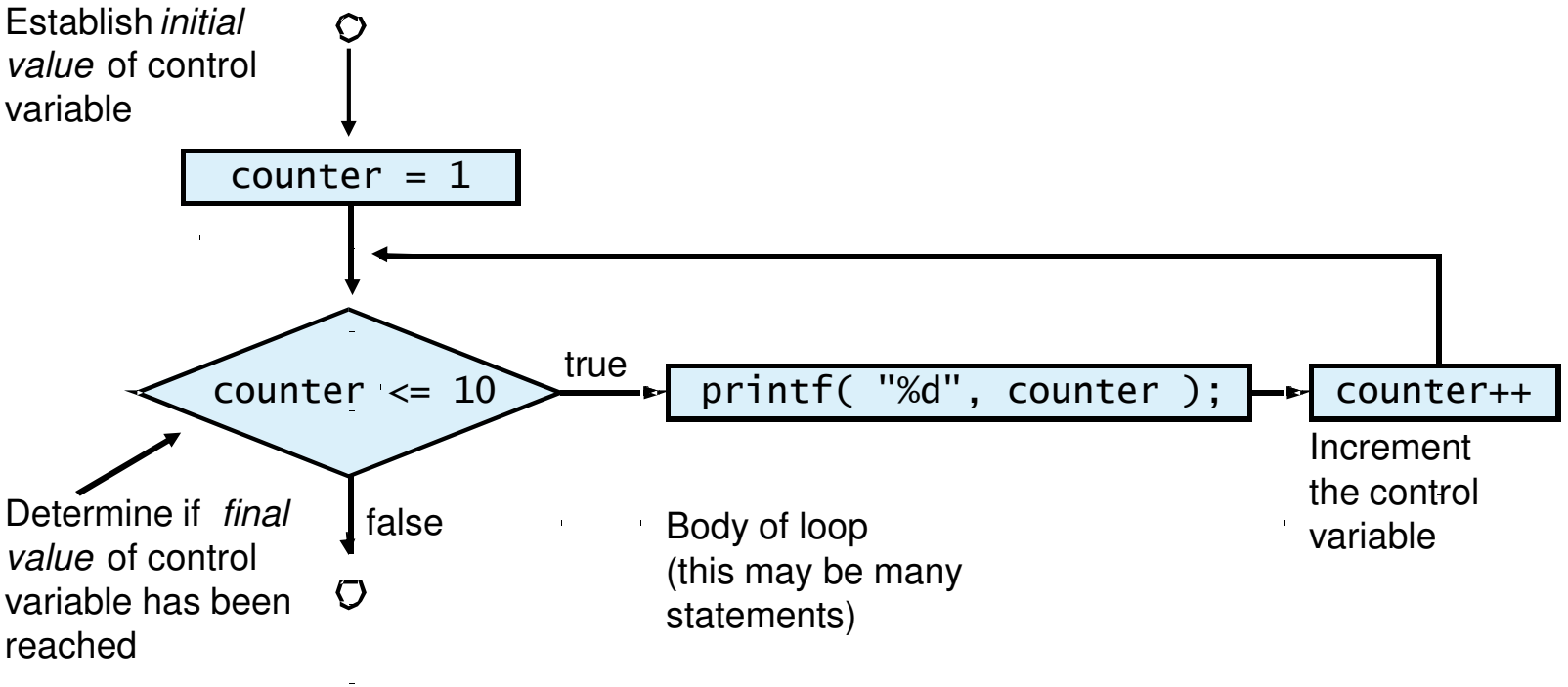
```
for ( j = x; j <= 4 * x * y; j += y / x )
```

  is equivalent to

```
for ( j = 2; j <= 80; j += 5 )
```

- **Notes about the `for` statement:**
  - "Increment" may be negative (decrement)
  - If the loop continuation condition is initially `false`
    - The body of the `for` statement is not performed
    - Control proceeds with the next statement after the `for` statement
  - Control variable
    - Often printed or used inside for body, but not necessary

4.5 The for Statement : Observations



```c
/* Fig. 4.5: fig04_05.c
   Summation with for */
#include <stdio.h>

/* function main begins program execution */
int main()
{
   int sum = 0; /* initialize sum */
   int number;  /* number to be added to sum */

   for ( number = 2; number <= 100; number += 2 ) {
      sum += number; /* add number to sum */
   } /* end for */

   printf( "Sum is %d\n", sum ); /* output sum */

   return 0; /* indicate program ended successfully */

} /* end function main */
```

```
Sum is 2550
```

```c
/* Fig. 4.6: fig04_06.c
   Calculating compound interest */
#include <stdio.h>
#include <math.h>

/* function main begins program execution */
int main()
{
   double amount;             /* amount on deposit */
   double principal = 1000.0; /* starting principal */
   double rate = .05;         /* interest rate */
   int year;                  /* year counter */

   /* output table column head */
   printf( "%4s%21s\n", "Year", "Amount on deposit" );

   /* calculate amount on deposit for each of ten years */
   for ( year = 1; year <= 10; year++ ) {

      /* calculate new amount for specified year */
      amount = principal * pow( 1.0 + rate, year );

      /* output one table row */
      printf( "%4d%21.2f\n", year, amount );
   } /* end for */

```

```
27     return 0; /* indicate program ended successfully */
28
29  } /* end function main */
```

```
Year    Amount on deposit
   1              1050.00
   2              1102.50
   3              1157.63
   4              1215.51
   5              1276.28
   6              1340.10
   7              1407.10
   8              1477.46
   9              1551.33
  10              1628.89
```

4.7 The `switch` Multiple-Selection Statement

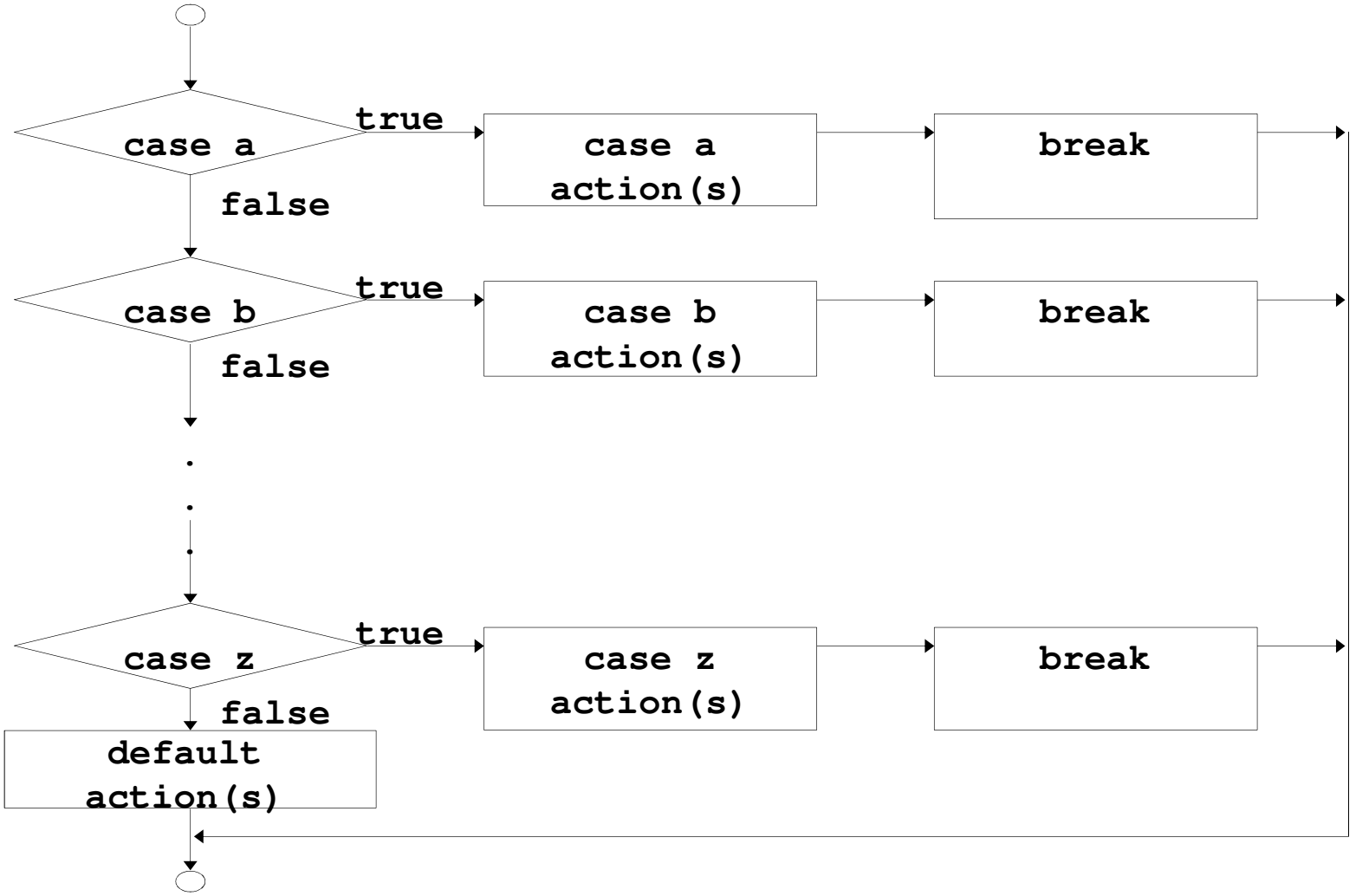
- `switch`
  - Useful when a variable or expression is tested for all the values it can assume and different actions are taken
- **Format**
  - Series of `case` labels and an optional `default` case

```
switch ( value ){
    case '1':
        actions
    case '2':
        actions
    default:
        actions
    }
```

  - `break;` exits from statement

4.7 The `switch` Multiple-Selection Statement

- **Flowchart of the `switch` statement**



```c
/* Fig. 4.7: fig04_07.c
   Counting letter grades */
#include <stdio.h>

/* function main begins program execution */
int main()
{
   int grade;      /* one grade */
   int aCount = 0; /* number of As */
   int bCount = 0; /* number of Bs */
   int cCount = 0; /* number of Cs */
   int dCount = 0; /* number of Ds */
   int fCount = 0; /* number of Fs */

   printf( "Enter the letter grades.\n" );
   printf( "Enter the EOF character to end input.\n" );

   /* loop until user types end-of-file key sequence */
   while ( ( grade = getchar() ) != EOF ) {

      /* determine which grade was input */
      switch ( grade ) { /* switch nested in while */

         case 'A':    /* grade was uppercase A */
         case 'a':    /* or lowercase a */
            ++aCount; /* increment aCount */
            break;    /* necessary to exit switch */

```

```
29          case 'B':    /* grade was uppercase B */
30          case 'b':    /* or lowercase b */
31             ++bCount; /* increment bCount */
32             break;    /* exit switch */
33
34          case 'C':    /* grade was uppercase C */
35          case 'c':    /* or lowercase c */
36             ++cCount; /* increment cCount */
37             break;    /* exit switch */
38
39          case 'D':    /* grade was uppercase D */
40          case 'd':    /* or lowercase d */
41             ++dCount; /* increment dCount */
42             break;    /* exit switch */
43
44          case 'F':    /* grade was uppercase F */
45          case 'f':    /* or lowercase f */
46             ++fCount; /* increment fCount */
47             break;    /* exit switch */
48
49          case '\n':   /* ignore newlines, */
50          case '\t':   /* tabs, */
51          case ' ':    /* and spaces in input */
52             break;    /* exit switch */
53
```

```
54            default:     /* catch all other characters */
55               printf( "Incorrect letter grade entered." );
56               printf( " Enter a new grade.\n" );
57               break;    /* optional; will exit switch anyway */
58         } /* end switch */
59
60      } /* end while */
61
62      /* output summary of results */
63      printf( "\nTotals for each letter grade are:\n" );
64      printf( "A: %d\n", aCount ); /* display number of A grades */
65      printf( "B: %d\n", bCount ); /* display number of B grades */
66      printf( "C: %d\n", cCount ); /* display number of C grades */
67      printf( "D: %d\n", dCount ); /* display number of D grades */
68      printf( "F: %d\n", fCount ); /* display number of F grades */
69
70      return 0; /* indicate program ended successfully */
71
72   } /* end function main */
```

```
Enter the letter grades.
Enter the EOF character to end input.
a
b
c
C
A
d
f
C
E
Incorrect letter grade entered. Enter a new grade.
D
A
b
^Z

Totals for each letter grade are:
A: 3
B: 2
C: 3
D: 2
F: 1
```

4.8 The do…while Repetition Statement

- **The do…while repetition statement**
  - Similar to the while structure
  - Condition for repetition tested after the body of the loop is performed
    - All actions are performed at least once
  - Format:

```
do {
   statement;
} while ( condition );
```

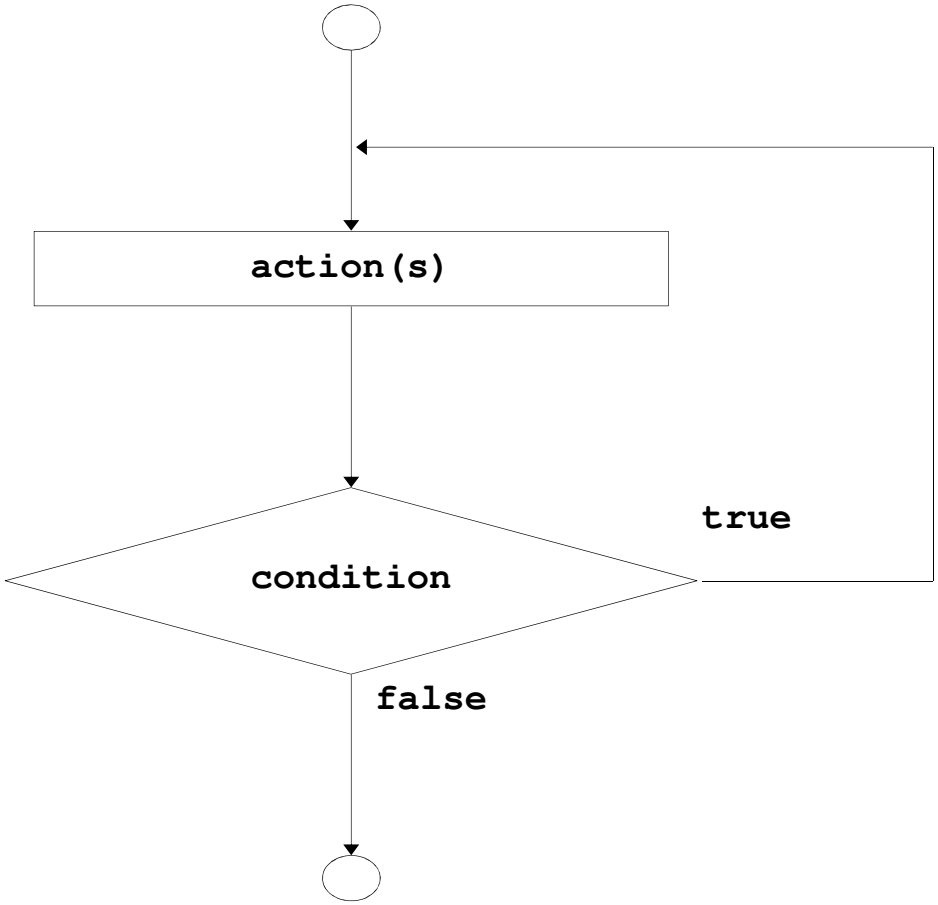
- **Example (letting counter = 1):**

```
do {
   printf( "%d  ", counter );
} while (++counter <= 10);
```

  - Prints the integers from 1 to 10

4.8 The do…while Repetition Statement

- **Flowchart of the do…while repetition statement**



```c
/* Fig. 4.9: fig04_09.c
   Using the do/while repetition statement */
#include <stdio.h>

/* function main begins program execution */
int main()
{
   int counter = 1; /* initialize counter */

   do {
      printf( "%d  ", counter ); /* display counter */
   } while ( ++counter <= 10 ); /* end do...while */

   return 0; /* indicate program ended successfully */

} /* end function main */
```

```
1  2  3  4  5  6  7  8  9  10
```

4.9 The `break` and `continue` Statements

- `break`
  - Causes immediate exit from a `while`, `for`, do…`while` or `switch` statement
  - Program execution continues with the first statement after the structure
  - Common uses of the `break` statement
    - Escape early from a loop
    - Skip the remainder of a `switch` statement

```c
/* Fig. 4.11: fig04_11.c
   Using the break statement in a for statement */
#include <stdio.h>

/* function main begins program execution */
int main()
{
   int x; /* counter */

   /* loop 10 times */
   for ( x = 1; x <= 10; x++ ) {

      /* if x is 5, terminate loop */
      if ( x == 5 ) {
         break; /* break loop only if x is 5 */
      } /* end if */

      printf( "%d ", x ); /* display value of x */
   } /* end for */

   printf( "\nBroke out of loop at x == %d\n", x );

   return 0; /* indicate program ended successfully */

} /* end function main */
```

```
1 2 3 4
Broke out of loop at x == 5
```

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4.9 The `break` and `continue` Statements

- `continue`
  - Skips the remaining statements in the body of a `while`, `for` or do…`while` statement
    - Proceeds with the next iteration of the loop
  - `while` and do…`while`
    - Loop-continuation test is evaluated immediately after the `continue` statement is executed
  - `for`
    - Increment expression is executed, then the loop-continuation test is evaluated

```c
/* Fig. 4.12: fig04_12.c
   Using the continue statement in a for statement */
#include <stdio.h>

/* function main begins program execution */
int main()
{
   int x; /* counter */

   /* loop 10 times */
   for ( x = 1; x <= 10; x++ ) {

      /* if x is 5, continue with next iteration of loop */
      if ( x == 5 ) {
         continue; /* skip remaining code in loop body */
      } /* end if */

      printf( "%d ", x ); /* display value of x */
   } /* end for */

   printf( "\nUsed continue to skip printing the value 5\n" );

   return 0; /* indicate program ended successfully */

} /* end function main */
```

```
1 2 3 4 6 7 8 9 10
Used continue to skip printing the value 5
```

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4.10 Logical Operators

- **&& (logical AND)**
  - Returns `true` if both conditions are `true`
- **|| (logical OR)**
  - Returns `true` if either of its conditions are `true`
- **! (logical NOT, logical negation)**
  - Reverses the truth/falsity of its condition
  - Unary operator, has one operand
- **Useful as conditions in loops**

Expression	Result
`true && false`	`false`
`true || false`	`true`
`!false`	`true`

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4.10 Logical Operators

expression1	expression2	expression1 && expression2
0	0	0
0	nonzero	0
nonzero	0	0
nonzero	nonzero	1

Fig. 4.13 Truth table for the && (logical AND) operator.

expression1	expression2	expression1 || expression2
0	0	0
0	nonzero	1
nonzero	0	1
nonzero	nonzero	1

Fig. 4.14 Truth table for the logical OR (||) operator.

expression	! expression
0	1
nonzero	0

Fig. 4.15 Truth table for operator ! (logical negation).

4.10 Logical Operators

Operators						Associativity	Type
++	--	+	-	!	(type)	right to left	unary
*	/	%				left to right	multiplicative
+	-					left to right	additive
<	<=	>	>=			left to right	relational
==	!=					left to right	equality
&&						left to right	logical AND
||						left to right	logical OR
?:						right to left	conditional
=	+=	-=	*=	/=	%=	right to left	assignment
,						left to right	comma

Fig. 4.16 Operator precedence and associativity.

4.11 Confusing Equality (==) and Assignment (=) Operators

- **Very dangerous error!**
  - Does not ordinarily cause syntax errors
  - Any expression that produces a value can be used in control structures
  - Nonzero values are `true`, zero values are `false`
  - Example using ==:

```
if (payCode == 4) printf( "You get a bonus!\n" );
```

    - Checks payCode, if it is 4 then a bonus is awarded
  - Example, replacing == with =:

```
if (payCode = 4) printf( "You get a bonus!\n" );
```

    - This sets payCode to 4
    - 4 is nonzero, so expression is `true`, and bonus awarded no matter what the payCode was
  - Logic error, not a syntax error

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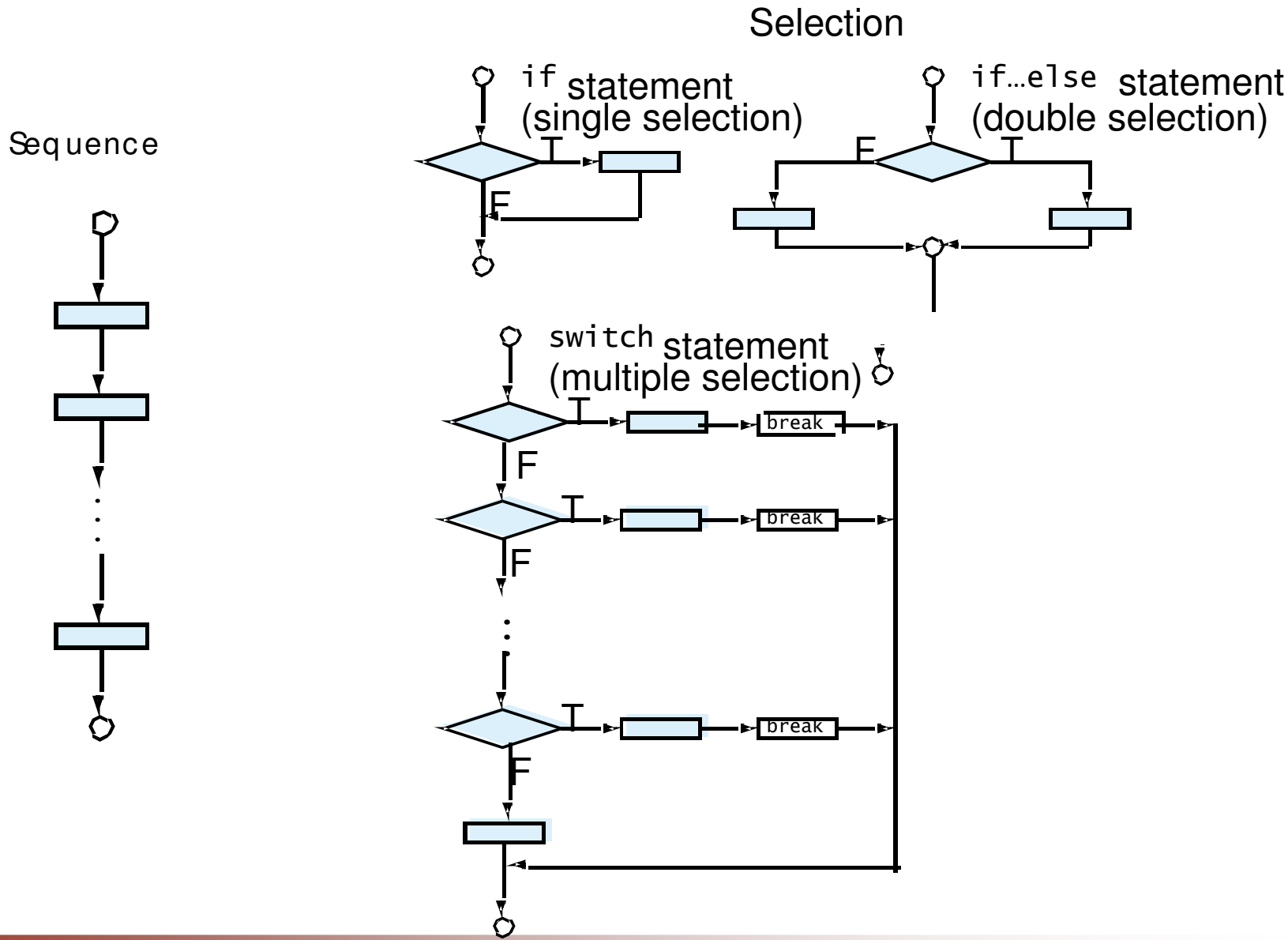
4.11 Confusing Equality (==) and Assignment (=) Operators

- **lvalues**
  - Expressions that can appear on the left side of an equation
  - Their values can be changed, such as variable names
    - `x = 4;`
- **rvalues**
  - Expressions that can only appear on the right side of an equation
  - Constants, such as numbers
    - Cannot write `4 = x;`
    - Must write `x = 4;`
  - lvalues can be used as rvalues, but not vice versa
    - `y = x;`

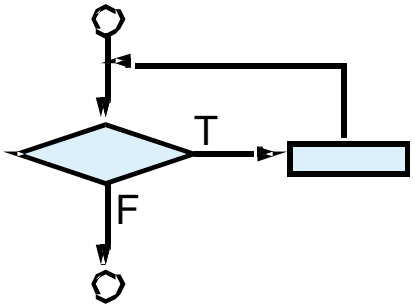
4.12 Structured-Programming Summary



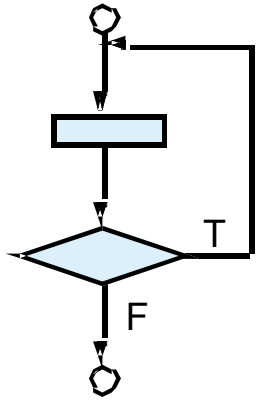
4.12 Structured-Programming Summary

Repetition

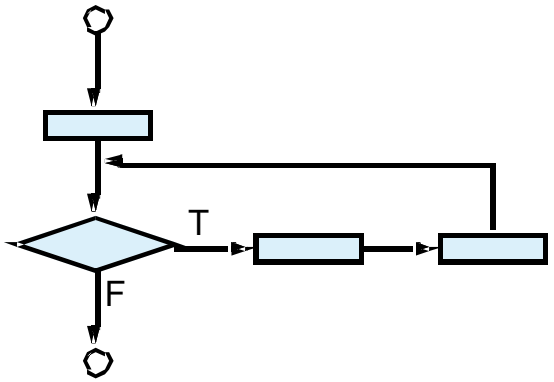
`while` statement



`do...while` statement



`for` statement



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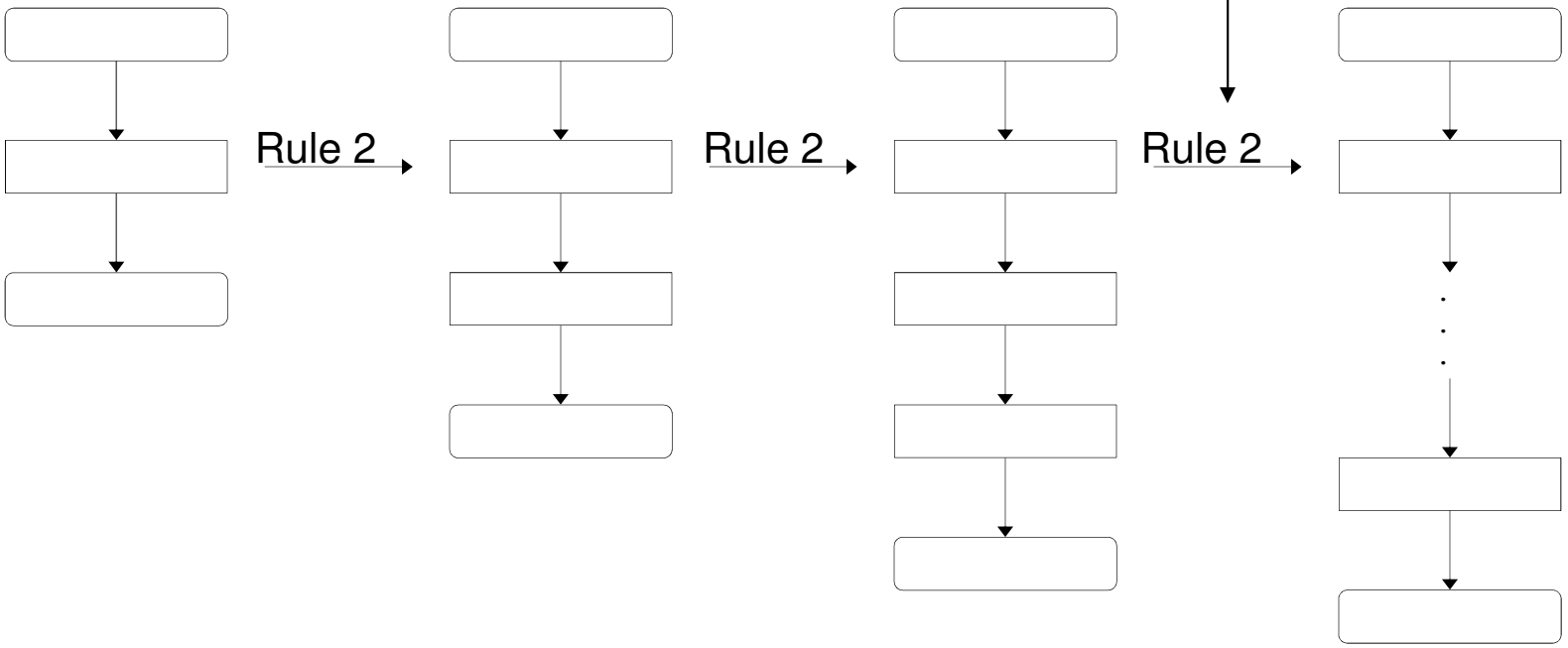
4.12 Structured-Programming Summary

- **Structured programming**
  - Easier than unstructured programs to understand, test, debug and, modify programs
- **Rules for structured programming**
  - Rules developed by programming community
  - Only single-entry/single-exit control structures are used
  - Rules:
    1. Begin with the “simplest flowchart”
    2. Stacking rule: Any rectangle (action) can be replaced by two rectangles (actions) in sequence
    3. Nesting rule: Any rectangle (action) can be replaced by any control structure (sequence, `if`, `if…else`, `switch`, `while`, `do…while` or `for`)
    4. Rules 2 and 3 can be applied in any order and multiple times

4.12 Structured-Programming Summary

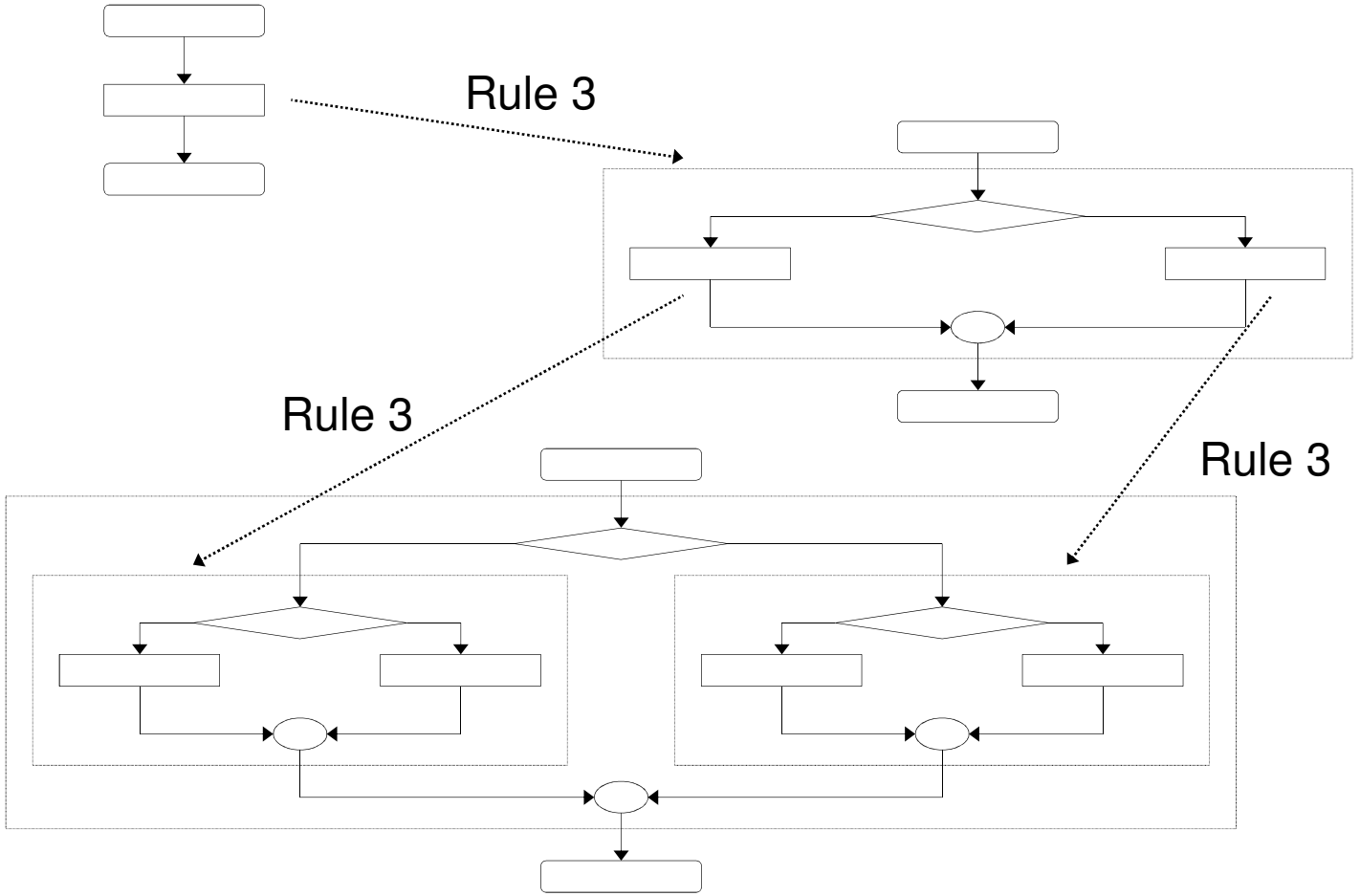
Rule 1 - Begin with the simplest flowchart

Rule 2 - Any rectangle can be replaced by two rectangles in sequence



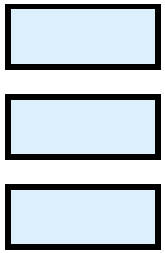
4.12 Structured-Programming Summary

Rule 3 - Replace any rectangle with a control structure

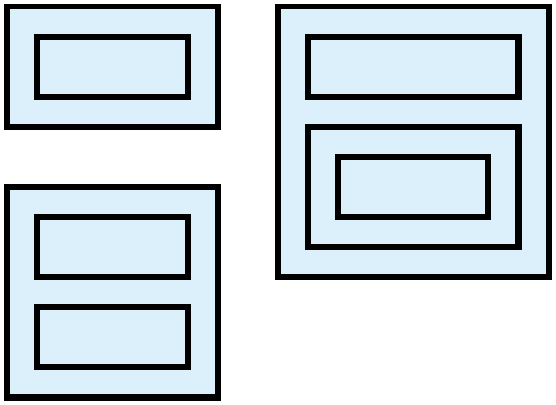


4.12 Structured-Programming Summary

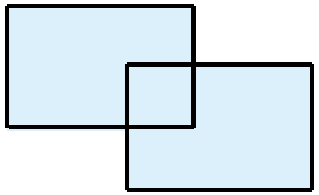
Stacked building blocks



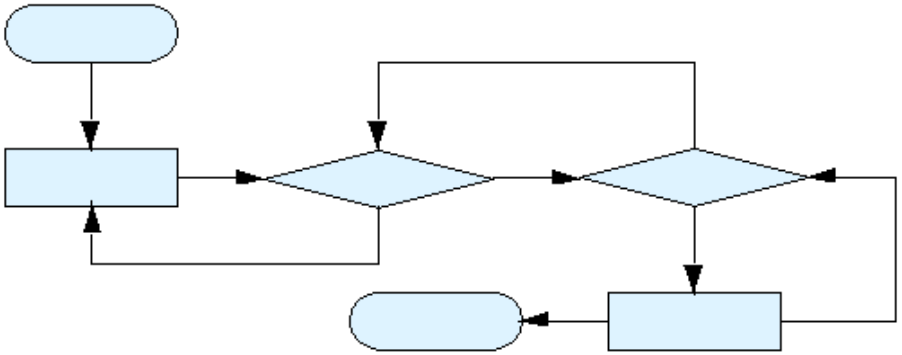
Nested building blocks



Overlapping building blocks
(Illegal in structured programs)



unstructured flowchart



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4.12 Structured-Programming Summary

- **All programs can be broken down into 3 controls**
  - Sequence – handled automatically by compiler
  - Selection – `if`, `if…else` or `switch`
  - Repetition – `while`, `do…while` or `for`
    - Can only be combined in two ways
      - Nesting (rule 3)
      - Stacking (rule 2)
  - Any selection can be rewritten as an `if` statement, and any repetition can be rewritten as a `while` statement

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Questões?

Programação – Aula Teórica 4

Programação Estruturada: Condições e Ciclos (2)

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