Selections and Loops

Introduction to Programming and Computational Problem Solving - 2

CSE 8B

Lecture 4

Announcements

- Assignment 1 is due today, 11:59 PM
- Quiz 1 is Oct 7
- Assignment 2 will be released today
  - Due Oct 12, 11:59 PM
- Educational research study
  - Oct 7, weekly survey
- Reading
  - Liang
    - Chapters 3 and 5

Selections and loops

- Selections
  - Relational operators (e.g., less than, equal to)
  - Logical operators (e.g., not, and, or)
  - `if` statements
  - `if-else` statements
  - `switch` statements
- Loops
  - `while` loops
  - `do-while` loops
  - `for` loops

The `boolean` type and operators

- Often in a program you need to compare two values, such as whether `i` is greater than `j`
- Java provides six comparison operators (also known as relational operators) that can be used to compare two values
- The result of the comparison is a Boolean value: `true` or `false`
- For example

```
boolean b = (1 > 2);
```

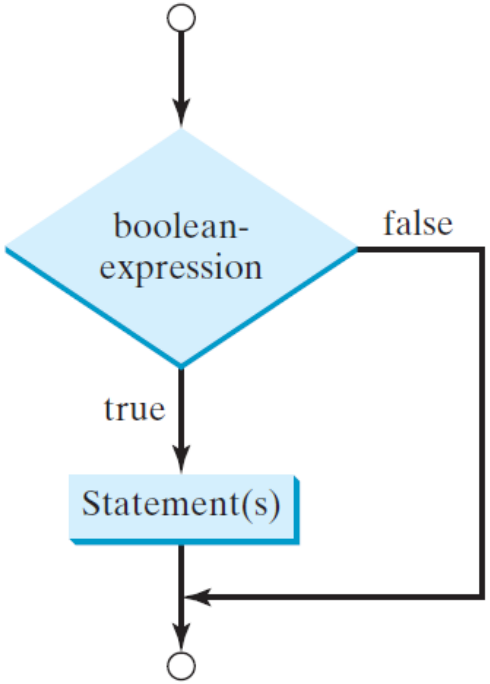
Relational operators

Java Operator	Mathematics Symbol	Name	Example (radius is 5)	Result
`<`	<	less than	`radius < 0`	`false`
`<=`	≤	less than or equal to	`radius <= 0`	`false`
`>`	>	greater than	`radius > 0`	`true`
`>=`	≥	greater than or equal to	`radius >= 0`	`true`
`==`	=	equal to	`radius == 0`	`false`
`!=`	≠	not equal to	`radius != 0`	`true`

`if` statements

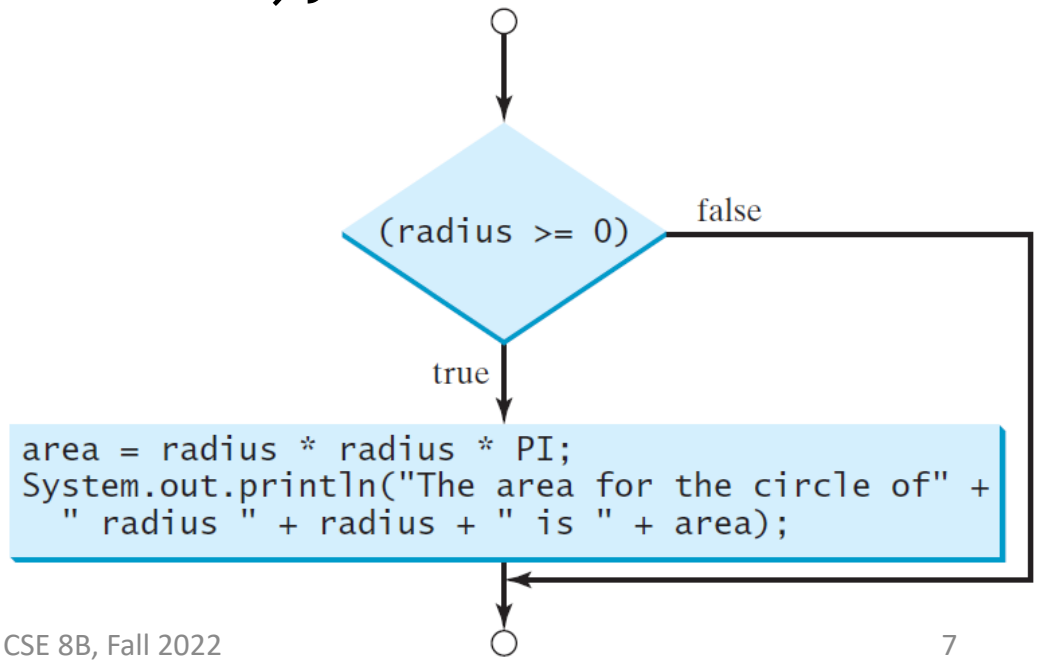
```
if (boolean-expression) {
  statement(s);
}
```

Braces are optional for a single statement; however, it is best practice (less error prone) to **always use braces**



`if` statements

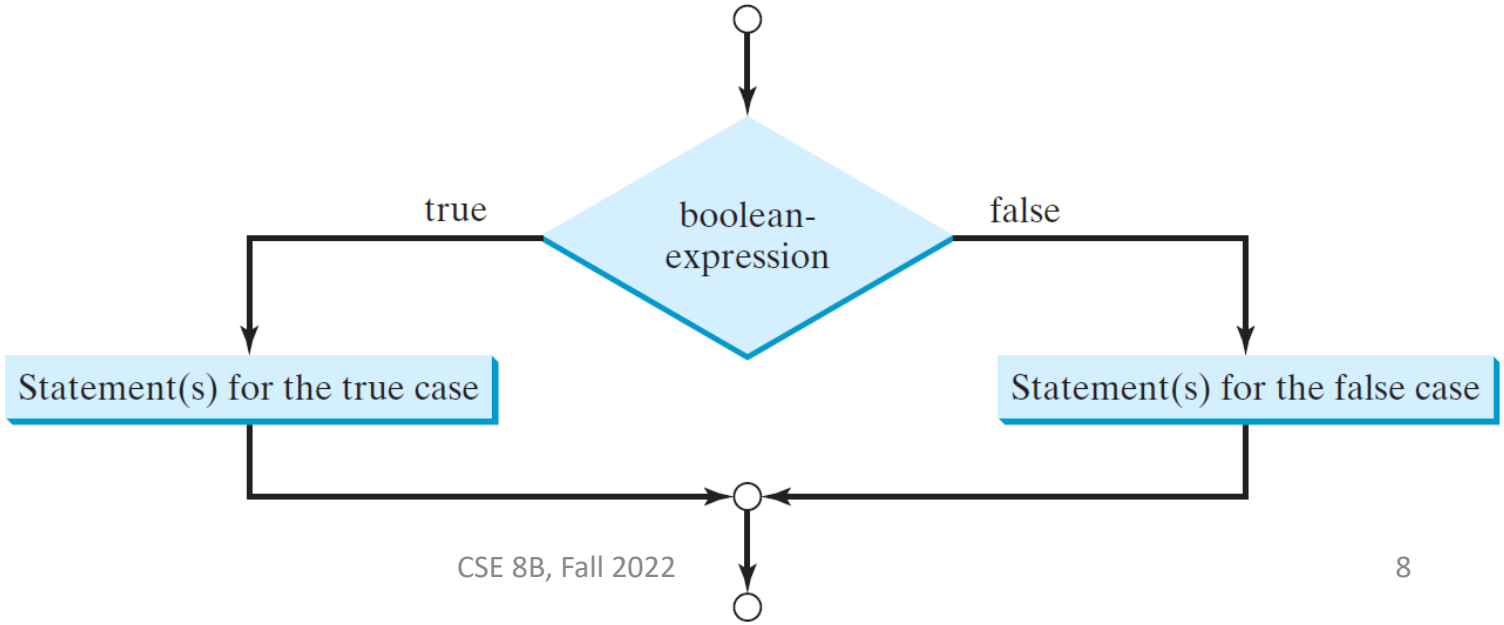
```
if (radius >= 0) {
  area = radius * radius * PI;
  System.out.println("The area for
  the circle of radius "
    + radius + " is " + area);
}
```



if-else statements

```
if (boolean-expression) {
  statement(s)-for-the-true-case;
}
else {
  statement(s)-for-the-false-case;
}
```

Braces are optional for a single statement; however, it is best practice (less error prone) to **always use braces**



if-else statements

```
if (radius >= 0) {
  area = radius * radius * 3.14159;
  System.out.println("The area for the "
    + "circle of radius " + radius +
    " is " + area);
}
else {
  System.out.println("Negative input");
}
```

Conditional operator

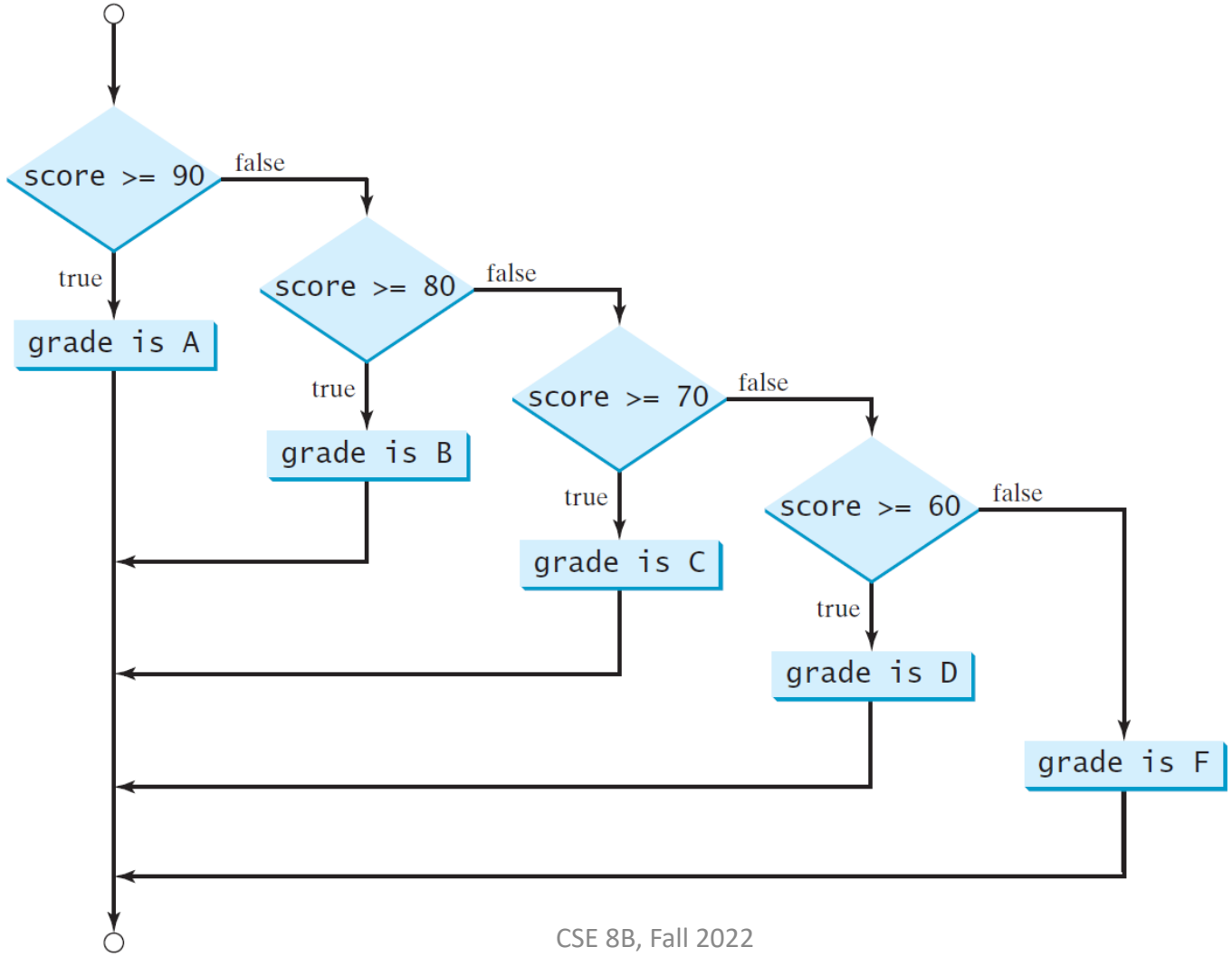
```
(boolean-expression) ? expression1 : expression2
```

```
if (x > 0) {
  y = 1;
}
else {
  y = -1;
}
```

is equivalent to

```
y = (x > 0) ? 1 : -1;
```

Multiple `if-else` statements



Multiple `if-else` statements

```
if (score >= 90.0)
  System.out.print("A");
else
  if (score >= 80.0)
    System.out.print("B");
  else
    if (score >= 70.0)
      System.out.print("C");
    else
      if (score >= 60.0)
        System.out.print("D");
      else
        System.out.print("F");
```

(a)

Equivalent

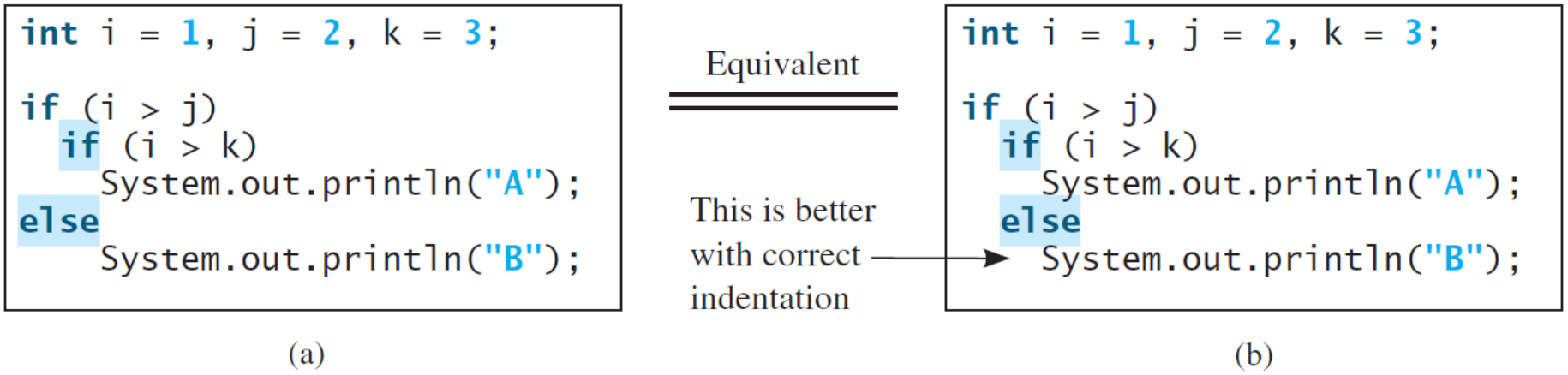
This is better

```
if (score >= 90.0)
  System.out.print("A");
else if (score >= 80.0)
  System.out.print("B");
else if (score >= 70.0)
  System.out.print("C");
else if (score >= 60.0)
  System.out.print("D");
else
  System.out.print("F");
```

(b)

Nested statements

- The `else` clause matches the **most recent** `if` clause in the same block



Braces are optional for a single statement; however, it is best practice (less error prone) to **always use braces**

Nothing is printed

Nested statements

- To force the `else` clause to match the first `if` clause, you must add a pair of braces

```
int i = 1;
int j = 2;
int k = 3;
if (i > j) {
  if (i > k)
    System.out.println("A");
}
else
  System.out.println("B");
```

Braces are optional for a single statement; however, it is best practice (less error prone) to **always use braces**

B is printed

Less error prone

```
if (number % 2 == 0)
  even = true;
else
  even = false;
```

(a)

Equivalent

```
boolean even
  = number % 2 == 0;
```

(b)

```
if (even == true)
  System.out.println(
    "It is even.");
```

(a)

Equivalent

```
if (even)
  System.out.println(
    "It is even.");
```

(b)

Logical operators

Operator	Name	Description
!	not	logical negation
&&	and	logical conjunction
||	or	logical disjunction
^	exclusive or (xor)	logical exclusion

Truth table for operator !

p	!p	Example: `age = 24` and `weight = 140`
`true`	`false`	`!(age > 18)` is `false`, because `(age > 18)` is `true`
`false`	`true`	`!(weight == 150)` is `true`, because `(weight == 150)` is `false`

Truth table for operator &&

p_1	p_2	p_1 && p_2	**Example:** `age = 24` **and** `weight = 140`
`false`	`false`	`false`	`(age <= 18) && (weight < 140)` is `false`, because both conditions are `false`
`false`	`true`	`false`	`(age <= 18) && (weight >= 140)` is `false`, because `(age <= 18)` is `false`
`true`	`false`	`false`	`(age > 18) && (weight > 140)` is `false`, because `(weight > 140)` is `false`
`true`	`true`	`true`	`(age > 18) && (weight >= 140)` is `true`, because both conditions are `true`

Truth table for operator ||

p_1	p_2	p_1 || p_2	**Example:** `age = 24` **and** `weight = 140`
`false`	`false`	`false`	`(age > 34) || (weight >= 150)` is `false`, because both conditions are `false`
`false`	`true`	`true`	`(age > 34) || (weight <= 140)` is `true`, because `(weight <= 140)` is `true`
`true`	`false`	`true`	`(age > 14) || (weight >= 150)` is `false`, because `(age > 14)` is `true`
`true`	`true`	`true`	`(age > 14) || (weight <= 140)` is `true`, because both conditions are `true`

Truth table for operator ^

p_1	p_2	p_1 ^ p_2	**Example:** `age = 24` **and** `weight = 140`
`false`	`false`	`false`	`(age > 34) ^ (weight > 140)` is `false`, because both conditions are `false`
`false`	`true`	`true`	`(age > 34) ^ (weight >= 140)` is `true`, because `(age > 34)` is `false` and `(weight >= 140)` is `true`
`true`	`false`	`true`	`(age > 14) ^ (weight > 140)` is `true`, because `(age > 14)` is `true` and `(weight > 140)` is `false`
`true`	`true`	`false`	`(age > 14) ^ (weight >= 140)` is `false`, because both conditions are `true`

Short-circuit operators

- && and || are short-circuit operators
- `p1 && p2`
  - If `p1` or `p2` is `false`, then `p1 && p2` is `false`
  - `p1` is evaluated first
    - If `p1` is `true`, then `p2` **is** evaluated
    - If `p1` is `false`, then `p2` **is not** evaluated
- `p1 || p2`
  - If `p1` or `p2` is `true`, then `p1 || p2` is `true`
  - `p1` is evaluated first
    - If `p1` is `true`, then `p2` **is not** evaluated
    - If `p1` is `false`, then `p2` **is** evaluated

switch statements

- When the value in a case statement matches the value of the switch-expression, the statements starting from this case are executed until either a break statement or the end of the switch statement is reached

```
switch (switch-expression) {
  case value1:  statement(s)1;
           break;
  case value2: statement(s)2;
           break;
  …
  case valueN: statement(s)N;
           break;
  default: statement(s)-for-default;
}
```

`switch` statements

- The switch-expression must yield a value of `char`, `byte`, `short`, `int` or `String` type and must always be enclosed in parentheses
- The `value1`, ..., and `valueN` must have the *same data type* as the value of the switch-expression
- The resulting statements in the `case` statement are executed when the value in the `case` statement matches the value of the switch-expression
- Note that `value1`, ..., and `valueN` are *constant expressions* (i.e., they cannot contain variables in the expression, such as `1 + x`)

```
switch (switch-expression) {
  case value1: statement(s)1;
               break;
  case value2: statement(s)2;
               break;
  …
  case valueN: statement(s)N;
               break;
  default: statement(s)-for-default;
}
```

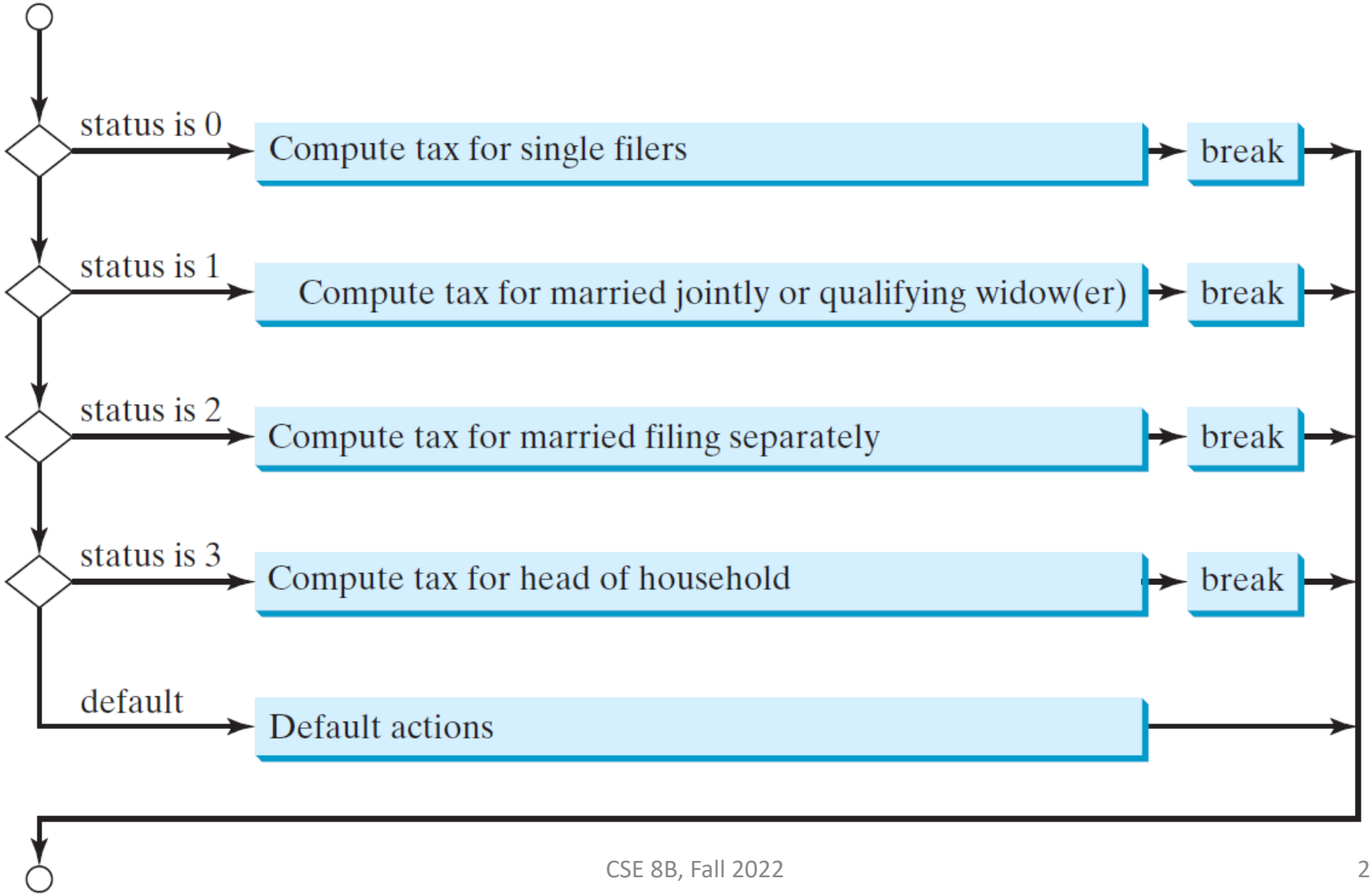
`switch` statements

- The keyword `break` is optional, but it should be used at the end of each case in order to terminate the remainder of the `switch` statement
  - If the `break` statement is not present, the next case statement will be executed
- The `default` case, which is optional, can be used to perform actions when none of the specified cases matches the switch-expression

```
switch (switch-expression) {
  case value1: statement(s)1;
               break;
  case value2: statement(s)2;
               break;
  …
  case valueN: statement(s)N;
               break;
  default: statement(s)-for-default;
}
```

The `default` case is optional; however, it is best practice (less error prone) to **always have a `default` case**

`switch` statements



switch statements

```
switch (status) {
  case 0:  compute taxes for single filers;
           break;
  case 1:  compute taxes for married file jointly;
           break;
  case 2:  compute taxes for married file separately;
           break;
  case 3:  compute taxes for head of household;
           break;
  default: System.out.println("Error: invalid status");
           System.exit(1);
}
```

The `default` case is optional; however, it is best practice (less error prone) to **always have a `default` case**

switch statements

```
switch (day) {
  case 1:
  case 2:
  case 3:
  case 4:
  case 5:
System.out.println("Weekday");
break;
  case 0:
  case 6:
System.out.println("Weekend");
}
```

Fall-through

Fall-through

Operator precedence

- `()`, `var++`, `var--`
- `++var`, `--var`, `+`, `-` (unary plus and minus), `!` (not)
- (type) casting
- *, /, % (multiplication, division, and remainder)
- +, - (binary addition and subtraction)
- <, <=, >, >= (relational operators)
- ==, != (equality)
- ^ (exclusive or)
- && (and)
- || (or)
- =, +=, -=, *=, /=, %= (assignment operators)

Operator associativity

- When two operators with the same precedence are evaluated, the associativity of the operators determines the order of evaluation
- All binary operators except assignment operators are left-associative

  `a - b + c - d` is equivalent to `((a - b) + c) - d`
- Assignment operators are right-associative

  `a = b += c = 5` is equivalent to `a = (b += (c = 5))`

Operator precedence and associativity

- The expression in the parentheses is evaluated first
  - Parentheses can be nested, in which case the expression in the inner parentheses is executed first
- When evaluating an expression without parentheses, the operators are applied according to the precedence rule and the associativity rule
- If operators with the same precedence are next to each other, their associativity determines the order of evaluation

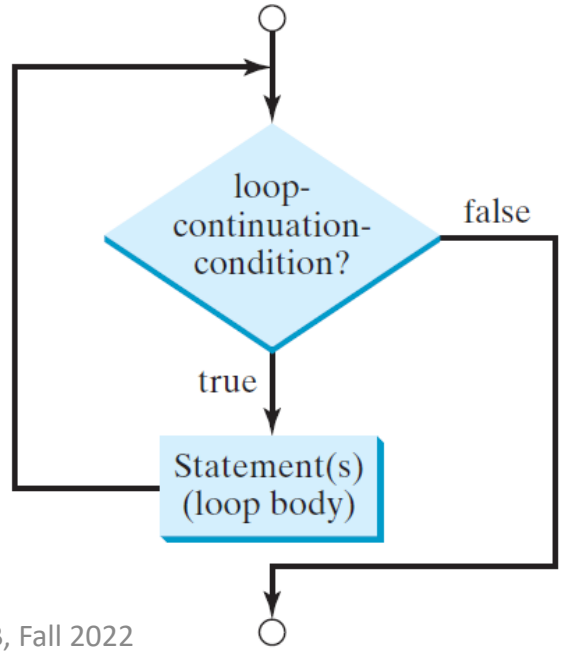
Loops

- `while` loops
- `do-while` loops
- `for` loops

`while` loops

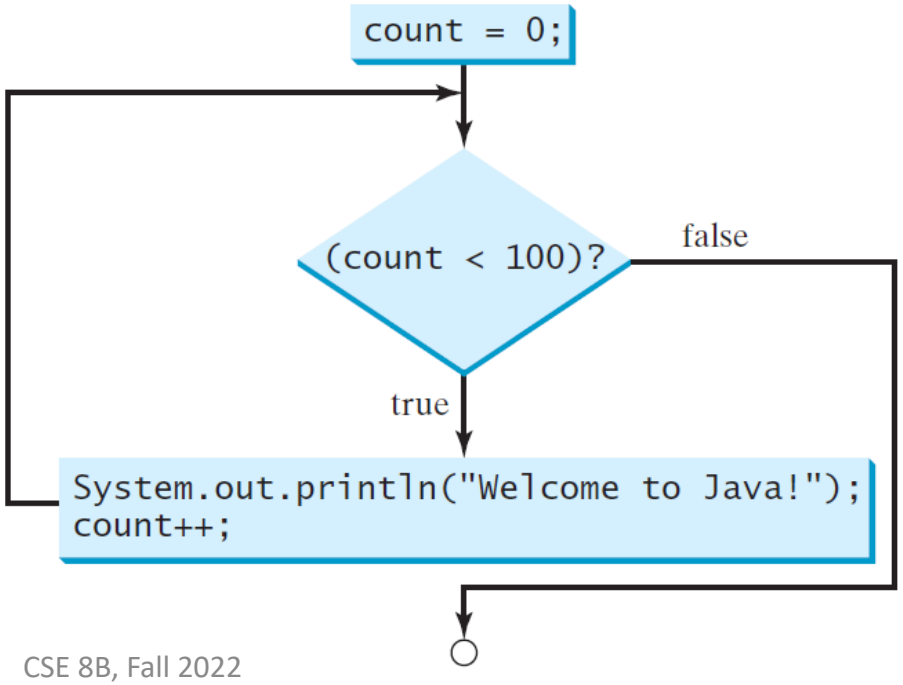
- Executes statements repeatedly while the condition is true

```
while (loop-continuation-condition) {
  // loop-body
  Statement(s);
}
```



while loops

```
int count = 0;
while (count < 100) {
  System.out.println("Welcome to Java");
  count++;
}
```



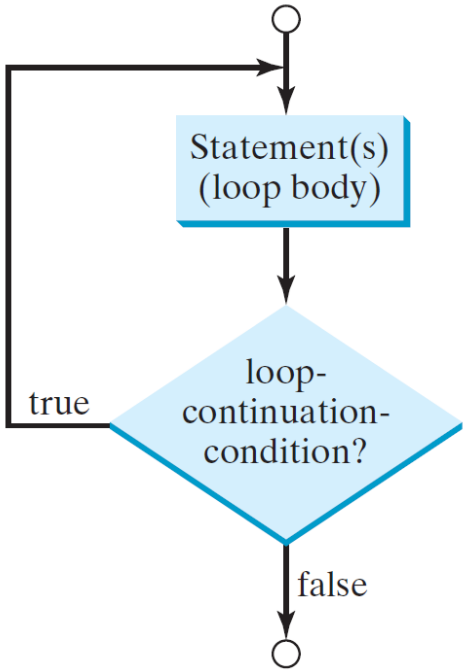
Ending a loop with a sentinel value

- Often the number of times a loop is executed is not predetermined
- You may use an input value to signify the end of the loop
- Such a value is known as a *sentinel value*
- For example, a program reads and calculates the sum of an unspecified number of integers. The input 0 signifies the end of the input.

do-while loops

- Execute the loop body first, then checks the loop continuation condition

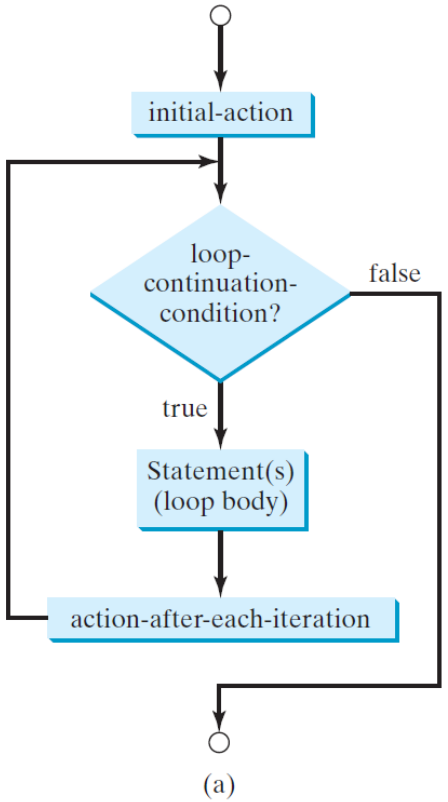
```
do {
  // Loop body
  Statement(s);
} while (loop-continuation-condition);
```



for loops

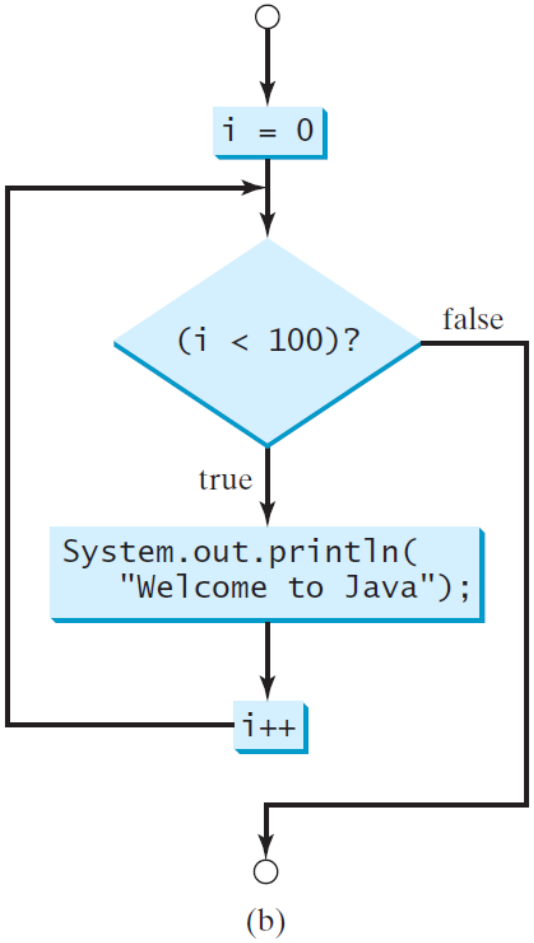
- A concise syntax for writing loops

```
for (initial-action; loop-continuation-condition;
   action-after-each-iteration) {
    // loop body
    Statement(s);
}
```



for loops

```
int i;
for (i = 0; i < 100; i++) {
  System.out.println(
     "Welcome to Java!");
}
```



(b)

for loops

- The initial-action in a for loop can be a list of zero or more comma-separated expressions
- The action-after-each-iteration in a for loop can be a list of zero or more comma-separated statements
- However, it is best practice (less error prone) **not to use comma-separated** expressions and statements

```
for (int i = 0, j = 0; (i + j < 10); i++, j++) {
  // Do something
}
```

Loops and floating-point accuracy

- Remember, calculations involving floating-point numbers are approximated because these numbers are not stored with complete accuracy
- As such, **do not use floating-point values for equality checking in a loop control**

```
double sum = 0;
double item = 1;
while (item != 0) { // No guarantee item will be 0
  sum += item;
  item -= 0.1;
}
System.out.println(sum);
```

Infinite loops

- If the loop-continuation-condition in a for loop is omitted, it is implicitly true

```
for ( ; ; ) {
  // Do something
}
```

(a)

Equivalent

```
while (true) {
  // Do something
}
```

(b)

Loops

- The three forms of loop statements, `while`, `do-while`, and `for`, are expressively equivalent
  - You can write a loop in any of these three forms

```
while (loop-continuation-condition) {
  // Loop body
}
```

(a)

Equivalent

```
for ( ; loop-continuation-condition; )
  // Loop body
}
```

(b)

```
for (initial-action;
     loop-continuation-condition;
     action-after-each-iteration) {
  // Loop body;
}
```

(a)

Equivalent

```
initial-action;
while (loop-continuation-condition) {
  // Loop body;
  action-after-each-iteration;
}
```

(b)

Loops

- Use the loop form that is most intuitive and comfortable
  - A `for` loop may be used if the number of repetitions is known
  - A `while` loop may be used if the number of repetitions is not known
  - A `do-while` loop can be used to replace a `while` loop if the loop body must be executed before testing the continuation condition

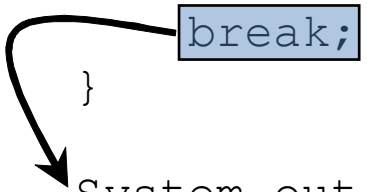
break

- Immediately terminate the loop

```
public class TestBreak {
  public static void main(String[] args) {
    int sum = 0;
    int number = 0;

    while (number < 20) {
      number++;
      sum += number;
      if (sum >= 100)
        break;
    }

    System.out.println("The number is " + number);
    System.out.println("The sum is " + sum);
  }
}
```



continue

- End the current iteration
  - Program control goes to the end of the loop body

```
public class TestContinue {
  public static void main(String[] args) {
    int sum = 0;
    int number = 0;

    while (number < 20) {
      number++;
      if (number == 10 || number == 11)
        continue;
      sum += number;
    }

    System.out.println("The sum is " + sum);
  }
}
```

Nested loops

- Loops can be nested
- For example, nested `for` loops are often used to handle two-dimensional data

```
for (int i = 0; i < numRows; i++) {
  // Handle i-th row
  for (int j = 0; j < numColumns; j++) {
    // Handle j-th column on i-th row
  }
}
```

Next Lecture

- Methods
- Reading
  - Liang
    - Chapter 6