

Selections



EECS2030: Advanced
Object Oriented Programming
Fall 2017

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Learning Outcomes

- The Boolean Data Type
- `if` Statement
- Compound vs. Primitive Statement
- Common Errors and Pitfalls
- Logical Operations

Motivating Examples (1.1)

```
1 import java.util.Scanner;
2 public class ComputeArea {
3     public static void main(String[] args) {
4         Scanner input = new Scanner(System.in);
5         final double PI = 3.14;
6         System.out.println("Enter the radius of a circle:");
7         double radiusFromUser = input.nextDouble();
8         double area = radiusFromUser * radiusFromUser * PI;
9         System.out.print("Circle with radius " + radiusFromUser);
10        System.out.println(" has an area of " + area);
11    }
12 }
```

- When the above Java class is run as a Java Application, **Line 4** is executed first, followed by executing **Line 5**, ..., and ended with executing **Line 10**.
- In **Line 7**, the radius value comes from the user. Any problems?

Motivating Examples (1.2)

- If the user enters a positive radius value as expected:

```
Enter the radius of a circle:
```

```
3
```

```
Circle with radius 3.0 has an area of 28.26
```

- However, if the user enters a negative radius value:

```
Enter the radius of a circle:
```

```
-3
```

```
Circle with radius -3.0 has an area of 28.26
```

In this case, the area should *not* have been calculated!

- We need a mechanism to take **selective actions**:
Act differently in response to *valid* and *invalid* input values.

Motivating Examples (2.1)

Problem: Take an integer value from the user, then output a message indicating if the number is negative, zero, or positive.

- Here is an example run of the program:

```
Enter a number:  
5  
You just entered a positive number.
```

- Here is another example run of the program:

```
Enter a number:  
-5  
You just entered a negative number.
```

- Your solution program must accommodate *all* possibilities!

Motivating Examples (2.2)

- So far, you only learned about writing programs that are executed line by line, top to bottom.
- In general, we need a mechanism to allow the program to:
 - Check a list of *conditions*; and
 - *Branch* its execution accordingly.
- e.g., To solve the above problem, we have 3 possible branches:
 1. **If** the user input is negative, then we execute the first branch that prints `You just entered a negative number.`
 2. **If** the user input is zero, then we execute the second branch that prints `You just entered zero.`
 3. **If** the user input is positive, then we execute the third branch that prints `You just entered a positive number.`

The boolean Data Type

- A (data) type denotes a set of related *runtime values*.
- We need a **data type** whose values suggest either a condition *holds*, or it *does not hold*, so that we can take selective actions.
- The Java **boolean** type consists of 2 **literal values**: *true*, *false*
- All **relational expressions** have the boolean type.

Math Symbol	Java Operator	Example (<i>r</i> is 5)	Result
\leq	<code><=</code>	<code>r <= 5</code>	<i>true</i>
\geq	<code>>=</code>	<code>r >= 5</code>	<i>true</i>
$=$	<code>==</code>	<code>r == 5</code>	<i>true</i>
$<$	<code><</code>	<code>r < 5</code>	<i>false</i>
$>$	<code>></code>	<code>r > 5</code>	<i>false</i>
\neq	<code>!=</code>	<code>r != 5</code>	<i>false</i>

Note. You may do the following rewritings:

- `x <= y` `x > y` `x != y` `x == y`
- `!(x > y)` `!(x <= y)` `!(x == y)` `!(x != y)`

Syntax of `if` Statement

```
if ( BooleanExpression1 ) { /* Mandatory */
    Statement1,1; Statement2,1;
}

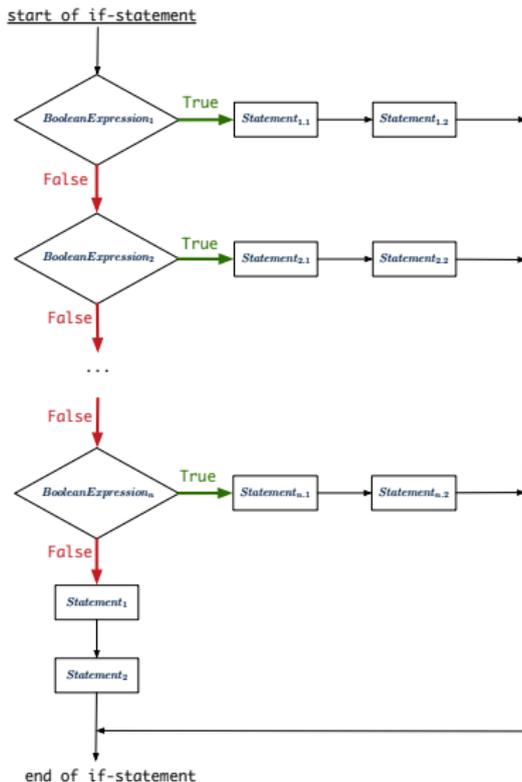
else if ( BooleanExpression2 ) { /* Optional */
    Statement2,1; Statement2,2;
}

... /* as many else-if branches as you like */

else if ( BooleanExpressionn ) { /* Optional */
    Statementn,1; Statementn,2;
}

else { /* Optional */
    /* when all previous branching conditions are false */
    Statement1; Statement2;
}
```

Semantics of `if` Statement (1.1)



Semantics of `if` Statement (1.2)

Consider a *single if statement* as consisting of:

- An `if` branch
- A (possibly empty) list of `else if` branches
- An optional `else` branch

At *runtime*:

- Branches of the `if` statement are *executed* from top to bottom.
- We only evaluate the **condition** of a branch if those conditions of its **preceding branches** evaluate to *false*.
- The **first** branch whose **condition** evaluates to *true* gets its body (i.e., code wrapped within `{` and `}`) *executed*.
 - After this execution, all *later* branches are *ignored*.

Semantics of `if` Statement (2.1)

Only first satisfying branch *executed*; later branches *ignored*.

```
int i = 5;
if(i < 0) {
    System.out.println("i is negative");
}
else if(i < 10) {
    System.out.println("i is less than than 10");
}
else if(i == 10) {
    System.out.println("i is equal to 10");
}
else {
    System.out.println("i is greater than 10");
}
```

i is less than 10

Semantics of `if` Statement (2.2)

No satisfying branches, and no `else` part, then *nothing* is executed.

```
int i = 12;  
if(i < 0) {  
    System.out.println("i is negative");  
}  
else if(i < 10) {  
    System.out.println("i is less than than 10");  
}  
else if(i == 10) {  
    System.out.println("i is equal to 10");  
}
```

Semantics of `if` Statement (2.3)

No satisfying branches, then `else` part, if there, is *executed*.

```
int i = 12;  
if(i < 0) {  
    System.out.println("i is negative");  
}  
else if(i < 10) {  
    System.out.println("i is less than than 10");  
}  
else if(i == 10) {  
    System.out.println("i is equal to 10");  
}  
else {  
    System.out.println("i is greater than 10");  
}
```

```
i is greater than 10
```

Case Study: Error Handling of Input Radius



Problem: Prompt the user for the radius value of a circle. Print an error message if input number is negative; otherwise, print the calculated area.

```
public class ComputeArea {
    public static void main(String[] args) {
        System.out.println("Enter a radius value:");
        Scanner input = new Scanner(System.in);
        double radius = input.nextDouble();
        final double PI = 3.14159;
        if (radius < 0) { /* condition of invalid inputs */
            System.out.println("Error: Negative radius value!");
        }
        else { /* implicit: !(radius < 0), or radius >= 0 */
            double area = radius * radius * PI;
            System.out.println("Area is " + area);
        }
    }
}
```

Case Study: Error Handling of Input Radius (2)



The same problem can be solved by checking the *condition* of valid inputs first.

```
public class ComputeArea2 {
    public static void main(String[] args) {
        System.out.println("Enter a radius value:");
        Scanner input = new Scanner(System.in);
        double radius = input.nextDouble();
        final double PI = 3.14159;
        if (radius >= 0) { /* condition of valid inputs */
            double area = radius * radius * PI;
            System.out.println("Area is " + area);
        }
        else { /* implicit: !(radius >= 0), or radius < 0 */
            System.out.println("Error: Negative radius value!");
        }
    }
}
```

One `if` Stmt vs. Multiple `if` Stmts (1)

```
int i = 5;  
if(i >= 3) {System.out.println("i is >= 3");}  
else if(i <= 8) {System.out.println("i is <= 8");}
```

```
i is >= 3
```

```
int i = 5;  
if(i >= 3) {System.out.println("i is >= 3");}  
if(i <= 8) {System.out.println("i is <= 8");}
```

```
i is >= 3  
i is <= 8
```

Two versions behave *differently* because the two conditions $i \geq 3$ and $i \leq 8$ *may* be satisfied simultaneously.

One `if` Stmt vs. Multiple `if` Stmts (2)

```
int i = 2;  
if(i <= 3) {System.out.println("i is <= 3");}  
else if(i >= 8) {System.out.println("i is >= 8");}
```

```
i is <= 3
```

```
int i = 2;  
if(i <= 3) {System.out.println("i is <= 3");}  
if(i >= 8) {System.out.println("i is >= 8");}
```

```
i is <= 3
```

Two versions behave *the same* because the two conditions $i \leq 3$ and $i \geq 8$ *cannot* be satisfied simultaneously.

Two-Way `if` Statement without `else` Part

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

An `if` statement with the missing `else` part is equivalent to an `if` statement with an `else` part that does nothing.

```
if (radius >= 0) {  
    area = radius * radius * PI;  
    System.out.println("Area for the circle of is " + area);  
}  
else {  
    /* Do nothing. */  
}
```

Multi-Way `if` Statement with `else` Part

```
if (score >= 80.0) {  
    System.out.println("A"); }  
else { /* score < 80.0 */  
    if (score >= 70.0) {  
        System.out.println("B"); }  
    else { /* score < 70.0 */  
        if (score >= 60.0) {  
            System.out.println("C"); }  
        else { /* score < 60.0 */  
            System.out.println("F");  
        }  
    }  
}
```

```
if (score >= 80.0) {  
    System.out.println("A");  
}  
else if (score >= 70.0) {  
    System.out.println("B");  
}  
else if (score >= 60.0) {  
    System.out.println("C");  
}  
else {  
    System.out.println("F");  
}
```

Exercise: Draw the corresponding flow charts for both programs. Convince yourself that they are equivalent.

Multi-Way `if` Statement without `else` Part

```
String lettGrade = "F";  
if (score >= 80.0) {  
    letterGrade = "A";  
}  
else if (score >= 70.0) {  
    letterGrade = "B";  
}  
else if (score >= 60.0) {  
    letterGrade = "C";  
}
```

In this case, since we already assign a initial, default value "F" to variable `letterGrade`, so when all the branch conditions evaluate to *false*, then the default value is kept.

Compare the above example with the example in slide 43.

Primitive Statement vs. Compound Statement

- A **statement** is a block of Java code that modifies value(s) of some variable(s).
- An assignment (=) statement is a *primitive statement*:
It only modifies its left-hand-side (LHS) variable.
- An `if` statement is a *compound statement*:
Each of its branches may modify more than one variables via other statements (e.g., assignments, `if` statements).

Compound if Statement: Example

```
1 int x = input.nextInt();
2 int y = 0;
3 if (x >= 0) {
4     System.out.println("x is positive");
5     if (x > 10) { y = x * 2; }
6     else if (x < 10) { y = x % 2; }
7     else { y = x * x; }
8 }
9 else { /* x < 0 */
10     System.out.println("x is negative");
11     if(x < -5) { y = -x; }
12 }
```

Exercise: Draw a flow chart for the above compound statement.

Logical Operators

- *Logical* operators are used to create **compound** Boolean expressions.
 - Similar to *arithmetic* operators for creating compound number expressions.
 - *Logical* operators can combine Boolean expressions that are built using the *relational* operators.

e.g., `1 <= x && x <= 10`

e.g., `x < 1 || x > 10`

- We consider three logical operators:

Java Operator	Description	Meaning
!	logical negation	not
&&	logical conjunction	and
	logical disjunction	or

Logical Negation

- Logical *negation* is a *unary* operator (i.e., one operand being a Boolean expression).
- The result is the “negated” value of its operand.

Operand	op	!op
<i>true</i>		<i>false</i>
<i>false</i>		<i>true</i>

```

double radius = input.nextDouble();
boolean isPositive = radius > 0;
if (!isPositive) { /* not the case that isPositive is true */
    System.out.println("Error: negative radius value.");
}
else {
    System.out.println("Area is " + radius * radius * PI);
}

```

Logical Conjunction

- Logical **conjunction** is a *binary* operator (i.e., two operands, each being a Boolean expression).
- The conjunction is *true* only when both operands are *true*.
- If one of the operands is *false*, their conjunction is *false*.

Left Operand op1	Right Operand op2	op1 && op2
<i>true</i>	<i>true</i>	<i>true</i>
<i>true</i>	<i>false</i>	<i>false</i>
<i>false</i>	<i>true</i>	<i>false</i>
<i>false</i>	<i>false</i>	<i>false</i>

```

double age = input.nextInt();
boolean isOldEnough = age >= 45;
boolean isNotTooOld = age < 65
if (!isOldEnough) { /* young */ }
else if (isOldEnough && isNotTooOld) { /* middle-aged */ }
else { /* senior */ }
  
```

Logical Disjunction

- Logical **disjunction** is a *binary* operator (i.e., two operands, each being a Boolean expression).
- The disjunction is *false* only when both operands are *false*.
- If one of the operands is *true*, their disjunction is *true*.

Left Operand op1	Right Operand op2	op1 op2
<i>false</i>	<i>false</i>	<i>false</i>
<i>true</i>	<i>false</i>	<i>true</i>
<i>false</i>	<i>true</i>	<i>true</i>
<i>true</i>	<i>true</i>	<i>true</i>

- ```

double age = input.nextInt();
boolean isSenior = age >= 65;
boolean isChild = age < 18
if (isSenior || isChild) { /* discount */ }
else { /* no discount */ }

```

# Logical Laws (1)

- The *negation* of a strict inequality is a non-strict inequality.

| Relation   | Negation      | Equivalence |
|------------|---------------|-------------|
| $i > j$    | $!(i > j)$    | $i \leq j$  |
| $i \geq j$ | $!(i \geq j)$ | $i < j$     |
| $i < j$    | $!(i < j)$    | $i \geq j$  |
| $i \leq j$ | $!(i \leq j)$ | $i > j$     |

- e.g.,

```

if($i > j$) {
 /* Action 1 */
}
else { /* implicit: $!(i > j)$, equivalent to $i \leq j$ */
 /* Action 2 */
}

```

- Action 1 is executed when  $i > j$
- Action 2 is executed when  $i \leq j$ .

## Logical Laws (2.1)

Say we have two Boolean expressions  $B_1$  and  $B_2$ :

- What does  $!(B_1 \ \&\& \ B_2)$  mean?

It is **not** the case that both  $B_1$  and  $B_2$  are *true*.

- What does  $!B_1 \ || \ !B_2$  mean?

It is either  $B_1$  is *false*,  $B_2$  is *false*, or both are *false*.

- Both expressions are equivalent! [proved by the truth table]

| $B_1$        | $B_2$        | $!(B_1 \ \&\& \ B_2)$ | $!B_1 \    \ !B_2$ |
|--------------|--------------|-----------------------|--------------------|
| <i>true</i>  | <i>true</i>  | <i>false</i>          | <i>false</i>       |
| <i>true</i>  | <i>false</i> | <i>true</i>           | <i>true</i>        |
| <i>false</i> | <i>true</i>  | <i>true</i>           | <i>true</i>        |
| <i>false</i> | <i>false</i> | <i>true</i>           | <i>true</i>        |

## Logical Laws (2.2)

```
if(0 <= i && i <= 10) { /* Action 1 */ }
else { /* Action 2 */ }
```

- When is *Action 2* executed?

$i < 0 \ || \ i > 10$

```
if(i < 0 && false) { /* Action 1 */ }
else { /* Action 2 */ }
```

- When is *Action 1* executed?
- When is *Action 2* executed?

*false*  
*true*

```
if(i < 0 && i > 10) { /* Action 1 */ }
else { /* Action 2 */ }
```

- When is *Action 1* executed?
- When is *Action 2* executed?

*false*  
*true*

**Lesson:** Be careful not to write branching conditions that use `&&` but always evaluate to *false*.

# Logical Laws (3.1)

Say we have two Boolean expressions  $B_1$  and  $B_2$ :

- What does  $!(B_1 \ || \ B_2)$  mean?

It is **not** the case that either  $B_1$  is *true*,  $B_2$  is *true*, or both are *true*.

- What does  $!B_1 \ \&\& \ !B_2$  mean?

Both  $B_1$  and  $B_2$  are *false*.

- Both expressions are equivalent! [proved by the truth table]

| $B_1$        | $B_2$        | $!(B_1 \    \ B_2)$ | $!B_1 \ \&\& \ !B_2$ |
|--------------|--------------|---------------------|----------------------|
| <i>true</i>  | <i>true</i>  | <i>false</i>        | <i>false</i>         |
| <i>true</i>  | <i>false</i> | <i>false</i>        | <i>false</i>         |
| <i>false</i> | <i>true</i>  | <i>false</i>        | <i>false</i>         |
| <i>false</i> | <i>false</i> | <i>true</i>         | <i>true</i>          |

## Logical Laws (3.2)

```
if(i < 0 || i > 10) { /* Action 1 */ }
else { /* Action 2 */ }
```

- When is *Action 2* executed? `0 <= i && i <= 10`

```
if(i < 0 || true) { /* Action 1 */ }
else { /* Action 2 */ }
```

- When is *Action 1* executed? *true*
- When is *Action 2* executed? *false*

```
if(i < 10 || i >= 10) { /* Action 1 */ }
else { /* Action 2 */ }
```

- When is *Action 1* executed? *true*
- When is *Action 2* executed? `i >= 10 && i < 10` (i.e., *false*)

**Lesson:** Be careful not to write branching conditions that use `||` but always evaluate to *true*.

# Logical Operators: Short-Circuit Evaluation

- Both *Boolean operators* `&&` and `||` evaluate from left to right.
- Operator `&&` continues to evaluate only when operands so far evaluate to *true*.

```
if (x != 0 && y / x > 2) {
 /* do something */
}
else {
 /* print error */ }
```

- Operator `||` continues to evaluate only when operands so far evaluate to *false*.

```
if (x == 0 || y / x <= 2) {
 /* print error */
}
else {
 /* do something */ }
```

# Operator Precedence

- Operators with *higher* precedence are evaluated before those with *lower* precedence.  
e.g., `2 + 3 * 5`
- For the three **logical operators**, negation (!) has the highest precedence, then conjunction (&&), then disjunction (||).  
e.g., `false || true && false` means
  - `true || (true && false)`, rather than
  - `(true || true) && false`
- When unsure, use *parentheses* to force the precedence.

# Operator Associativity

- When operators with the *same precedence* are grouped together, we evaluate them from left to right.

e.g.,  $1 + 2 - 3$  means

$((1 + 2) - 3)$

e.g., `false || true || false` means

`((false || true) || false)`

# Common Error 1: Missing Braces (1)

*Confusingly, braces can be omitted* if the block contains a **single** statement.

```
final double PI = 3.1415926;
Scanner input = new Scanner(System.in);
double radius = input.nextDouble();
if (radius >= 0)
 System.out.println("Area is " + radius * radius * PI);
```

In the above code, it is as if we wrote:

```
final double PI = 3.1415926;
Scanner input = new Scanner(System.in);
double radius = input.nextDouble();
if (radius >= 0) {
 System.out.println("Area is " + radius * radius * PI);
}
```

## Common Error 1: Missing Braces (2)

Your program will *misbehave* when a block is supposed to execute **multiple statements**, but you forget to enclose them within braces.

```
final double PI = 3.1415926;
Scanner input = new Scanner(System.in);
double radius = input.nextDouble();
double area = 0;
if (radius >= 0)
 area = radius * radius * PI;
 System.out.println("Area is " + area);
```

This program will **mistakenly** print “Area is 0.0” when a *negative* number is input by the user, why? Fix?

```
if (radius >= 0) {
 area = radius * radius * PI;
 System.out.println("Area is " + area);
```

## Common Error 2: Misplaced Semicolon

Semicolon (;) in Java marks *the end of a statement* (e.g., assignment, if statement).

```
if (radius >= 0); {
 area = radius * radius * PI;
 System.out.println("Area is " + area);
}
```

This program will calculate and output the area even when the input radius is *negative*, why? Fix?

```
if (radius >= 0) {
 area = radius * radius * PI;
 System.out.println("Area is " + area);
}
```

# Overlapping Boolean Conditions (1)

Two or more conditions **overlap** if they can evaluate to *true* simultaneously.

e.g., Say `marks` is declared as an integer variable:

- `marks >= 80` and `marks >= 70` overlap. [why?]
  - Values 80, 81, 82, ... make both conditions *true*
  - `marks >= 80` has **fewer** satisfying values than `marks >= 70`
  - We say `marks >= 80` is more *specific* than `marks >= 70`
  - Or, we say `marks >= 70` is more *general* than `marks >= 80`
- `marks <= 65` and `marks <= 75` overlap. [why?]
  - Values 65, 64, 63, ... make both conditions *true*
  - `marks <= 65` has **fewer** satisfying values than `marks <= 75`
  - We say `marks <= 65` is more *specific* than `marks <= 75`
  - Or, we say `marks <= 75` is more *general* than `marks <= 65`

## Overlapping Boolean Conditions (2)

Say we have two overlapping conditions  $x \geq 5$  and  $x \geq 0$ :

- What values make both conditions *true*? [5, 6, 7, ...]
- Which condition is more *general*? [ $x \geq 0$ ]
- If we have a single if statement, then having this order

```
if(x >= 5) { System.out.println("x >= 5"); }
else if(x >= 0) { System.out.println("x >= 0"); }
```

is different from having this order

```
if(x >= 0) { System.out.println("x >= 0"); }
else if(x >= 5) { System.out.println("x >= 5"); }
```

- Say  $x$  is 5, then we have
  - What output from the first program? [ $x \geq 5$ ]
  - What output from the second program? [ $x \geq 0$ , not *specific* enough!]
- The cause of the “*not-specific-enough*” problem of the second program is that we did not check the more *specific* condition ( $x \geq 5$ ) before checking the more *general* condition ( $x \geq 0$ ).

## Common Error 3: Independent `if` Statements with Overlapping Conditions

```
if (marks >= 80) {
 System.out.println("A");
}
if (marks >= 70) {
 System.out.println("B");
}
if (marks >= 60) {
 System.out.println("C");
}
else {
 System.out.println("F");
}
/* Consider marks = 84 */
```

```
if (marks >= 80) {
 System.out.println("A");
}
else if (marks >= 70) {
 System.out.println("B");
}
else if (marks >= 60) {
 System.out.println("C");
}
else {
 System.out.println("F");
}
/* Consider marks = 84 */
```

- **Conditions** in a list of `if` statements are checked **independently**.
- In a single `if` statement, **only** the **first satisfying branch** is executed.

## Common Error 4: `if-elseif` Statement with Most General Condition First (1)

---

```
if (gpa >= 2.5) {
 graduateWith = "Pass";
}
else if (gpa >= 3.5) {
 graduateWith = "Credit";
}
else if (gpa >= 4) {
 graduateWith = "Distinction";
}
else if (gpa >= 4.5) {
 graduateWith = "High Distinction" ;
}
```

The above program will:

- Not award a “High Distinction” to `gpa == 4.8`.
- Why?

## Common Error 4: `if-elseif` Statement with Most General Condition First (2)

- Always “*sort*” the branching conditions s.t. the more *specific* conditions are checked before the more *general* conditions.

```
if (gpa >= 4.5) {
 graduateWith = "High Distinction" ;
}
else if (gpa >= 4) {
 graduateWith = "Distinction";
}
else if (gpa >= 3.5) {
 graduateWith = "Credit";
}
else if (gpa >= 2.5) {
 graduateWith = "Pass";
}
else { graduateWith = "Fail"; }
```

## Common Error 5: Variable Not Properly Re-Assigned

---

```
1 String graduateWith = "";
2 if (gpa >= 4.5) {
3 graduateWith = "High Distinction" ; }
4 else if (gpa >= 4) {
5 graduateWith = "Distinction"; }
6 else if (gpa >= 3.5) {
7 graduateWith = "Credit"; }
8 else if (gpa >= 2.5) {
9 graduateWith = "Pass"; }
```

The above program will award "" to  $gpa == 1.5$ . Why?

Possible Fix 1: Change the *initial value* in Line 1 to "Fail".

Possible Fix 2: Add an *else* branch after Line 9:

```
else { graduateWith = "fail" }
```

Compare this example with the example in slide 20.

## Common Errors 6: Ambiguous else (1)

```
if (x >= 0)
 if (x > 100) {
 System.out.println("x is larger than 100");
 }
else {
 System.out.println("x is negative");
}
```

- When  $x$  is 20, this program considers it as negative. Why?  
∴ else clause matches the *most recent* unmatched if clause.  
∴ The above is as if we wrote:

```
if (x >= 0) {
 if (x > 100) {
 System.out.println("x is larger than 100");
 }
else {
 System.out.println("x is negative");
}
```

## Common Errors 6: Ambiguous else (2)

- Fix?

Use pairs of curly braces ({} ) to force what you really mean to specify!

```
if (x >= 0) {
 if (x > 100) {
 System.out.println("x is larger than 100");
 }
}
else {
 System.out.println("x is negative");
}
```

# Common Pitfall 1: Updating Boolean Variable

```
boolean isEven;
if (number % 2 == 0) {
 isEven = true;
}
else {
 isEven = false;
}
```

**Correct**, but **simplifiable**: `boolean isEven = (number%2 == 0);`  
Similarly, how would you simply the following?

```
if (isEven == false) {
 System.out.println("Odd Number");
}
else {
 System.out.println("Even Number");
}
```

**Simplify** `isEven == false` to `!isEven`

## Common Pitfall 2: Repeated Code (1)

```
if (status == 1) { /* single filing mechanism for tax */
 if (income <= 8350) {
 double part1 = income * 0.10;
 double tax = part1;
 System.out.println("Tax amount: " + tax); }
 else if (income <= 33950) {
 double part1 = 8350 * 0.1;
 double part2 = (income - 8350) * 0.15;
 double tax = part1 + part2;
 System.out.println("Tax amount: " + tax); }
 else {
 double part1 = 8350 * 0.1;
 double part2 = (33950 - 8350) * 0.15;
 double part3 = (income - 33950) * 0.25;
 double tax = part1 + part2 + part3;
 System.out.println("Tax amount: " + tax); }
}
```

This code is *correct*, but it **smells** due to lots of code repetition!

## Common Pitfall 2: Repeated Code (2)

```
if (status == 1) { /* single filing mechanism for tax */
 double part1 = 0;
 double part2 = 0;
 double part3 = 0;
 double tax = 0;
 if (income <= 8350) {
 part1 = income * 0.10; }
 else if (income <= 33950) {
 part1 = 8350 * 0.1;
 part2 = (income - 8350) * 0.15; }
 else {
 part1 = 8350 * 0.1;
 part2 = (33950 - 8350) * 0.15;
 part3 = (income - 33950) * 0.25;
 }
 tax = part1 + part2 + part3;
 System.out.println("Tax amount: " + tax);
}
```

# Scope of Variables (1)

When you declare a variable, there is a limited **scope** where the variable can be used.

- If the variable is declared directly under the `main` method, then all lines of code (including branches of `if` statements) may either *re-assign* a new value to it or *use* its value.

```
public static void main(String[] args) {
 int i = input.nextInt();
 System.out.println("i is " + i);
 if (i > 0) {
 i = i * 3; /* both use and re-assignment, why? */
 }
 else {
 i = i * -3; /* both use and re-assignment, why? */
 }
 System.out.println("3 * |i| is " + i);
}
```

## Scope of Variables (2.1)

- If the variable is declared under an `if` branch, an `else if` branch, or an `else` branch, then only lines of code appearing within that branch (i.e., its body) may either *re-assign* a new value to it or *use* its value.

```
public static void main(String[] args) {
 int i = input.nextInt();
 if (i > 0) {
 int j = i * 3; /* a new variable j */
 if (j > 10) { ... }
 }
 else {
 int j = i * -3; /* a new variable also called j */
 if (j < 10) { ... }
 }
}
```

## Scope of Variables (2.2)

- A variable declared under an `if` branch, an `else if` branch, or an `else` branch, cannot be *re-assigned* or *used* outside its scope.

```
public static void main(String[] args) {
 int i = input.nextInt();
 if (i > 0) {
 int j = i * 3; /* a new variable j */
 if (j > 10) { ... }
 }
 else {
 int k = i * -3; /* a new variable also called j */
 if (j < k) { ... } ×
 }
}
```

## Scope of Variables (2.3)

- A variable declared under an `if` branch, an `else if` branch, or an `else` branch, cannot be *re-assigned* or *used* outside its scope.

```
public static void main(String[] args) {
 int i = input.nextInt();
 if (i > 0) {
 int j = i * 3; /* a new variable j */
 if (j > 10) { ... }
 }
 else {
 int j = i * -3; /* a new variable also called j */
 if (j < 10) { ... }
 }
 System.out.println("j is " + j); ×
}
```

## Beyond this lecture...

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- Read Chapter 3 of the textbook and complete as many exercises as possible.
- Study the usage of `switch` statement and conditional statement.

# Index (1)

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## Learning Outcomes

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Motivating Examples (1.2)

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Semantics of `if` Statement (1.2)

Semantics of `if` Statement (2.1)

Semantics of `if` Statement (2.2)

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Common Pitfall 1: Updating Boolean Variable

Common Pitfall 2: Repeated Code (1)

Common Pitfall 2: Repeated Code (2)

Scope of Variables (1)

Scope of Variables (2.1)

Scope of Variables (2.2)

Scope of Variables (2.3)

Beyond this lecture...