Selections

EECS2030: Advanced
Object Oriented Programming
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CHEN-WEI WANG

Learning Outcomes

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

```
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!

- 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 (*r* is 5)	Result
≤	<=	r <= 5	*true*
≥	>=	r >= 5	*true*
=	==	r == 5	*true*
<	<	r < 5	*false*
>	>	r > 5	*false*
≠	!=	r != 5	*false*

Note. You may do the following rewritings:

○ x <= y   x > y   x != y   x == y

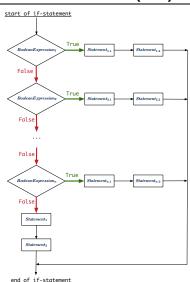○ !(x > y)   !(x <= y)   !(x == y)   !(x != y)

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;
}
```

start of if-statement

end of if-statement

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*.

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

```java
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
```

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");
}
```

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
```

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.

```java
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.

```java
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)

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```
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 $i >= 3$ and $i <= 8$ *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 $i <= 3$
and $i >= 8$ *cannot* be satisfied simultaneously.

```
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. */
}
```

```
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.

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```java
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 an 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.

- 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
true	*false*
false	*true*

```
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
true	*true*	*true*
true	*false*	*false*
false	*true*	*false*
false	*false*	*false*

```
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
false	*false*	*false*
true	*false*	*true*
false	*true*	*true*
true	*true*	*true*

-
```java
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 <= j
i >= j	!(i >= j)	i < j
i < j	!(i < j)	i >= j
i <= j	!(i <= j)	i > j

- e.g.,

```
if( i > j ) {
  /* Action 1 */
}
else {  /* implicit: !(i > j) , equivalent to i <= j */
  /* Action 2 */
}
```

  ○ Action 1 is executed when $i > j$
  ○ Action 2 is executed when $i <= j$.

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 <u>both</u> B_1 and B_2 are *true*.

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

  It is <u>either</u> 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	$!(B_1 \;\&\&\; B_2)$	$!B_1 \;||\; !B_2$
true	*true*	*false*	*false*
true	*false*	*true*	*true*
false	*true*	*true*	*true*
false	*false*	*true*	*true*

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?   *false*
• **When** is *Action 2* executed?   *true*

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

• **When** is *Action 1* executed?   *false*
• **When** is *Action 2* executed?   *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 `! (B₁ || B₂)` mean?

  It is **not** the case that <u>either</u> B_1 is *true*, B_2 is *true*, or both are *true*.

- What does `!B₁ && !B₂` 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
true	*true*	*false*	*false*
true	*false*	*false*	*false*
false	*true*	*false*	*false*
false	*false*	*true*	*true*

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 */ }
```

- 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.

- 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);
}
```

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

```java
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?

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

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`

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

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

is different from having this order

```java
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

```java
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 */
```

```java
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.

```
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?

- Always *"sort"* the branching conditions s.t. the more *specific* conditions are checked <u>before</u> 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");
   }
}
```

• 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");
}
```

```java
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?

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

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

```
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!

```
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.

```java
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.

```java
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.

```java
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) { ... }      ×
  }
}
```

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

```java
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 );    ×
}
```

Index (2)

Index (3)

Index (4)