

Selections

(a.k.a. “If Statements”)



EECS1021:
Object Oriented Programming:
from Sensors to Actuators
Winter 2020

Original slides: DR. CHEN-WEI “JACKIE” WANG
Updates: DR. JAMES ANDREW SMITH

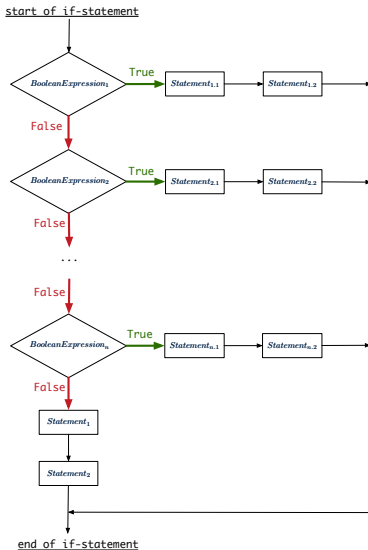
Topics in “Selections” series

- *Intro*
- If semantics
- One vs. multiple statements
- Scope of variables
- Primitive vs. Compound
- Logic: Intro
- Logic: Laws
- Operators
- Common Errors: 1, 2, 3, 4, 5, 6

References

- Chapter 4 (Operators) in Java 8 Fundamentals
<https://tinyurl.com/y8dpcskq> or
<https://bit.ly/3oaNAoZ>
 - Boolean Logical Operators
- Chapter 5 (Statements) in
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Visual of a typical `if` Statement



When might we encounter a selection statement?

- If the user enters a value to be used in a calculation (e.g. area of a circle) :

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

```
3
```

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

- what happens if the user enters a “weird” or wrong value?

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>

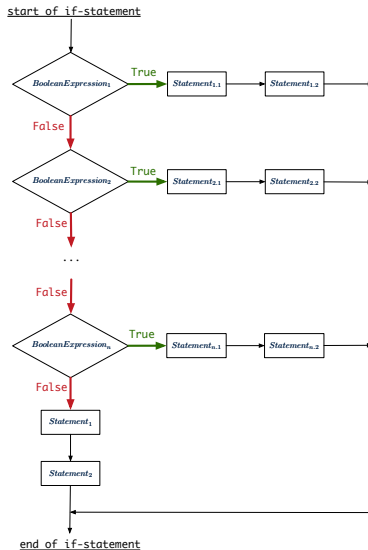
Note. Multiple ways of writing the same expression:

- `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)



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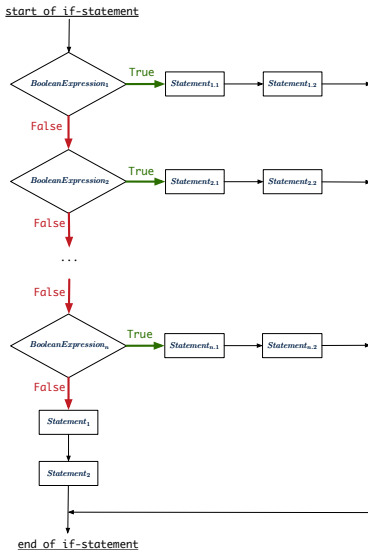
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```
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    Statement2.1; Statement2.2;  
}  
... /* as many else-if branches as you like */  
else if ( BooleanExpressionn ) { /* Optional */  
    Statementn.1; Statementn.2;  
}  
else { /* Optional */  
    /* 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 (2.1.1)

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

```
int i = -4;
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 negative

Semantics of `if` Statement (2.1.2)

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

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

```
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");  
        }  
    }  
}
```

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

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

Exercise: Draw the flow charts for both programs (previous slide)

```
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");  
}
```

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 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 92.

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Case Study: Error Handling of Input Radius (1)

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)

Question: Do these two programs behave same at runtime?

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

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

Question: Do these two programs behave same at runtime?

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

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


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

```
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 (3)

```
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.

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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) { ... }      x  
    }  
}
```


Scope of Variables (2.3)

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

```

1 public static void main(String[] args) {
2     int i = input.nextInt();
3     if (i > 0) {
4         int j = i * 3; /* a new variable j */
5         if (j > 10) { ... }
6     }
7     else {
8         int j = i * -3; /* a new variable also called j */
9         if (j < 10) { ... }
10    }
11    System.out.println("i * j is " + (i * j));    x
12 }

```

- A variable *cannot* be referred to outside its declared scope.
[e.g., illegal use of `j` at **L11**]
- A variable *can* be used:
 - within its declared scope [e.g., use of `i` at **L11**]
 - within sub-scopes of its declared scope [e.g., use of `i` at **L4, L8**]

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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 the flow chart.

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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: radius value must be positive.");
}
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>

```

int 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>

```

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

```

Selections

(a.k.a. "If Statements")



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- *Logic: Laws*
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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 { /* !(i > j) */
    /* Action 2 */
}

```

equivalent to

```

if( i <= j ) {
    /* Action 2 */
}
else { /* !(i <= j) */
    /* Action 1 */
}

```

- 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?

$i < 0 \mid\mid i > 10$

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

- When is *Action 1* executed?

false

- When is *Action 2* executed? *true* (i.e., $i \geq 0 \mid\mid \text{true}$)

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

- When is *Action 1* executed?

false

- When is *Action 2* executed? *true* (i.e., $i \geq 0 \mid\mid i \leq 10$)

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?

$0 \leq i \text{ \&\& } i \leq 10$

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

- When is **Action 1** executed? **true**
- When is **Action 2** executed? **false** (i.e., $i \geq 0 \text{ \&\& } \text{false}$)

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

- When is **Action 1** executed? **true**
- When is **Action 2** executed? **false** (i.e., $i \geq 10 \text{ \&\& } i < 10$)

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

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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., `true || 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)`

Short-Circuit Evaluation (1)

- Both *Logical 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 */ }
```

Short-Circuit Evaluation (2)

- Both *Logical operators* `&&` and `||` evaluate from left to right.
- Short-Circuit Evaluation is not exploited: crash when `x == 0`

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

- Short-Circuit Evaluation is not exploited: crash when `x == 0`

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

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Common Error 1: 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.

Overlapping Conditions: Exercise (1)

- Does this program always print exactly one line?

```
if(x < 0) { println("x < 0"); }  
if(0 <= x && x < 10) { println("0 <= x < 10"); }  
if(10 <= x && x < 20) { println("10 <= x < 20"); }  
if(x >= 20) { println("x >= 20"); }
```

- Yes**, because the branching conditions for the **four** if-statements are all **non-overlapping**.
- That is, any two of these conditions **cannot be satisfied simultaneously**:
 - $x < 0$
 - $0 \leq x \text{ \&\& } x < 10$
 - $10 \leq x \text{ \&\& } x < 20$
 - $x \geq 20$

Overlapping Conditions: Exercise (2)

- Does this program always print exactly one line?

```
if(x < 0) { println("x < 0"); }  
else if(0 <= x && x < 10) { println("0 <= x < 10"); }  
else if(10 <= x && x < 20) { println("10 <= x < 20"); }  
else if(x >= 20) { println("x >= 20"); }
```

- Yes**, because it's a **single** if-statement:

Only **the first satisfying branch** is executed.

- But, can it be simplified?

Hint: In a single if-statement, a branch is executed only if **all earlier branching conditions** fail.

Overlapping Conditions: Exercise (3)

- This simplified version is equivalent:

```
1  if(x < 0) { println("x < 0"); }  
2  else if(x < 10) { println("0 <= x < 10"); }  
3  else if(x < 20) { println("10 <= x < 20"); }  
4  else { println("x >= 20"); }
```

- At runtime, the 2nd condition `x < 10` at **L2** is checked only when the 1st condition at **L1** *fails* (i.e., $!(x < 0)$, or equivalently, $x \geq 0$).
- At runtime, the 3rd condition `x < 20` at **L3** is checked only when the 2nd condition at **L2** *fails* (i.e., $!(x < 10)$, or equivalently, $x \geq 10$).
- At runtime, the else (default) branch at **L4** is reached only when the 3rd condition at **L3** *fails* (i.e., $!(x < 20)$, or equivalently, $x \geq 20$).

General vs. Specific 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`

General vs. Specific 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 ($x \geq 0$).

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Common Error 2: `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 2: 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"; }
```

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Common Error 3: 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 3: 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);  
}
```

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Common Error 4: 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);  
}
```

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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 26.

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?
 \therefore else clause matches the *most recent* unmatched if clause.
 \therefore 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`

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Visual of a typical `if` Statement

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

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

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General vs. Specific Boolean Conditions (1)

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Common Error 2: `if-elseif` Statement with Most General Condition First (1)

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

Common Error 3: Missing Braces (1)

Common Error 3: Missing Braces (2)

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Common Error 4: Misplaced Semicolon

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Common Error 5:

Variable Not Properly Re-Assigned

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Common Error 6: Ambiguous `else` (1)

Common Error 6: Ambiguous `else` (2)

Common Pitfall 1: Updating Boolean Variable