Selections

EECS2030 B & E: Advanced Object Oriented Programming
Fall 2021

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Learning Outcomes

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

Extra Practice?

- Java project archive: `Lecture_02_Selections.zip`
  contains some of the lecture examples.
  Expanded it: *remaining examples* and *your own examples*!
- *Optional (but recommended)*: **Videos 10 – 17** from W19 Java tutorial:
  `https://www.eecs.yorku.ca/~jackie/teaching/tutorials/index.html#java_from_scratch`

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      System.out.println("Enter the radius of a circle:");
6      double radiusFromUser = input.nextDouble();
7      final double PI = 3.14;
8      double area = radiusFromUser * radiusFromUser * PI;
9      System.out.print("Circle with radius " + radiusFromUser);
10     System.out.println(" has an area of " + area);
11     input.close();
12   }
13 }
```

- 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 11**.
- In **Line 6**, 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 top to bottom, line by line, without ever ***branching***.
- 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
$\leq$	`<=`	`r <= 5`	*true*
$\geq$	`>=`	`r >= 5`	*true*
$=$	`==`	`r == 5`	*true*
$<$	`<`	`r < 5`	*false*
$>$	`>`	`r > 5`	*false*
$\neq$	`!=`	`r != 5`	*false*

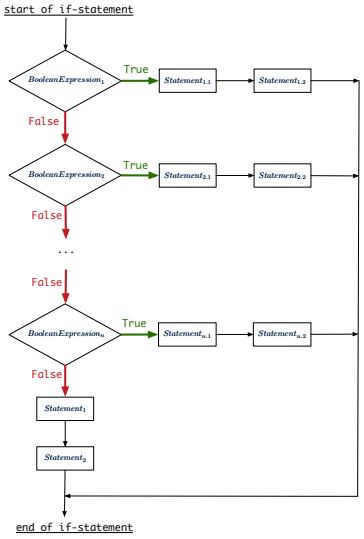
Note. You may do the following rewritings:

- `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;
}
```


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: Case 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: Case 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: Case 3

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

```
int i = 10;
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 equal to 10
```


Semantics of `if` Statement: Case 4

No satisfying branches, and an `else` part is present, then the *default action* 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
```


Semantics of `if` Statement: Case 5

No satisfying branches, and an `else` part is absent, 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");
}
```

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();
final double PI = 3.14;
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`
true	*true*	*true*
true	*false*	*false*
false	*true*	*false*
false	*false*	*false*

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

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

Logical Laws: Negation

- 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 {  /* !(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 $i <= j$.

Case Study: Error Handling of Input Radius (1)

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

```
public class ComputeArea {
  public static void main(String[] args) {
    Scanner input = new Scanner(System.in);
    System.out.println("Enter a radius value:");
    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);
    }
    input.close();
  }
}
```


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) {
    Scanner input = new Scanner(System.in);
    System.out.println("Enter a radius value:");
    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!");
    }
    input.close();
  }
}
```


Logical Laws: DeMorgan for Conjunction

Say we have two Boolean expressions B_1 and B_2:

- What does `!(B1 && B2)` mean?
  It is **not** the case that both B_1 and B_2 are *true*.
- What does `!B1 || !B2` 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	`!(B1 && B2)`	`!B1 || !B2`
true	true	false	false
true	false	true	true
false	true	true	true
false	false	true	true

Logical Laws: DeMorgan for Disjunction

Say we have two Boolean expressions B_1 and B_2:

- What does `!(B1 || B2)` mean?
  It is **not** the case that either 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	`!(B1 || B2)`	`!B1 && !B2`
true	*true*	*false*	*false*
true	*false*	*false*	*false*
false	*true*	*false*	*false*
false	*false*	*true*	*true*

Example: DeMorgan for Conjunction

```
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* (i.e., `i >= 0 || 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 >= 0 || i <= 10`)

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

Example: DeMorgan for Disjunction

```
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* (i.e., `i >= 0 && 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 >= 10 && i < 10`)

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

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)`

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. */
}
```


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.

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 without `else` Part

```
String letterGrade = "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 56.

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

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 <= x && x < 10`
  - `10 <= x && x < 20`
  - `x >= 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 >= 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 >= 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 >= 20`).

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, `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));    ×
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**]

Scope of Variables (2.4)

How about **input** parameters and **return** value?

```
1  public class SumApp {
2    public static void main(String[] args) {
3      Scanner input = new Scanner(System.in);
4      int i = input.nextInt();
5      int j = input.nextInt();
6      int k = Utilities.getSum(i, j);
7      System.out.println(k);
8    } }
```

```
public class Utilities {
  public static int getSum(int x, int y) {
    int result = x + y;
    return result;
  } }
```

  - Scope of `i`, `j`, `k`? [`SumApp.main`]
  - Scope of `x`, `y`, `result`? [`Utilities.getSum`]
  - **L5** is as if we wrote: `int k = result;` where `result` stores the value computed by executing `getSum`

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 >= 5` and `x >= 0`:

- What values make both conditions *true*? [5, 6, 7, ...]
- Which condition is more *general*? [`x >= 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 >= 5`]
  - What output from the second program? [`x >= 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 >= 5`) before checking the more *general* condition (`x >= 0`).

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"; }
```


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 */ }
```

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);
}
```


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);
}
```


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 34.

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`

Beyond this lecture. . .

- Create a *console tester* in Eclipse.
  Try out the examples given in the slides.
- Solve the motivating example in **Slide 5**.
- *Optional (but recommended)*: **Videos 10 – 17** from W19 Java tutorial:
  `https://www.eecs.yorku.ca/~jackie/teaching/tutorials/index.html#java_from_scratch`

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