Chapter 3: Decisions

CS 2070

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If Statements

If-Else Statements

If-Else-If Statements

Logical Operators

Comparison of String objects

Switch Statement

Formatting Values

If Statements

If Statements

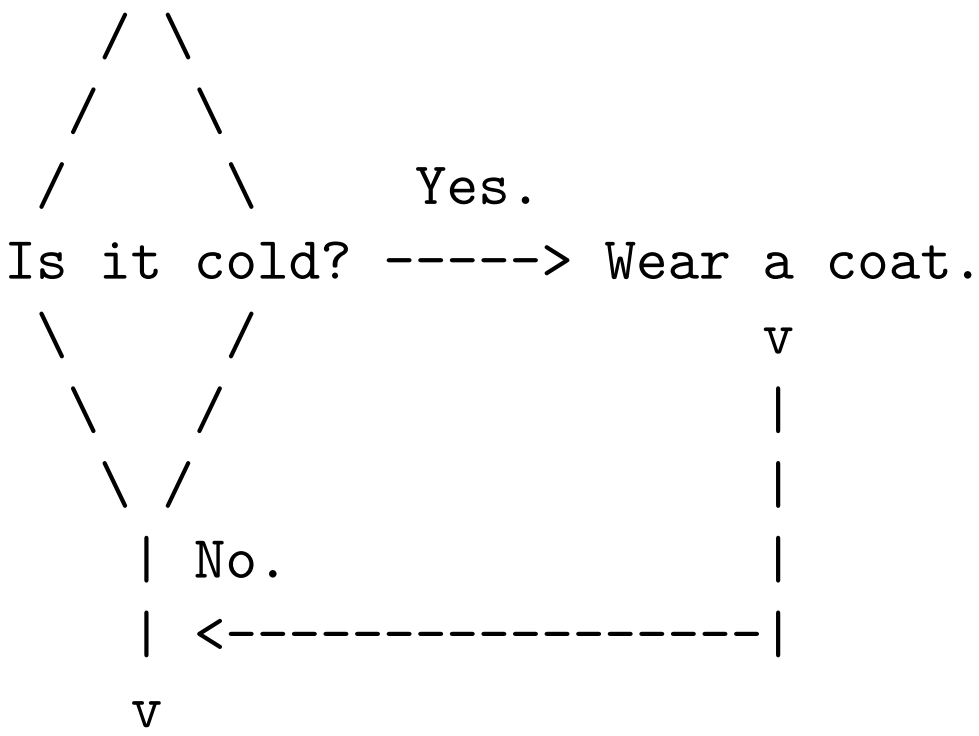
- An `if` statement will make a decision as to whether it should or should not execute a block of code.
- if statements look and behave almost identically to the same construct in C++

Code.

```
if (boolean expression is true) {
    execute these statements;
}
```

- If the boolean expression in the if condition is false, then the statements are never executed.

If Statements as a flowchart



Marvel at the beauty of my home made flow charts.

If Statements

There are two forms of the `if` statement:

```
if (boolean expression)
    statement;
```

Like C++, Java doesn't require curly brackets if you execute exactly one statement.

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

If you only need to execute a single statement, you don't need the curly brackets. However, I always recommend using curly brackets regardless of how many statements you need to execute.

Relational Operators

- Relational operators are used to compare numbers to determine relative order.
  - $a > b$ True if a is greater than b.
  - $a < b$ True if a is less than b.
  - $a >= b$ True if a is greater than or equal to b.
  - $a <= b$ True if a is less than or equal to b.
  - $a == b$ True if a is equal to b.
  - $a! = b$ True if a is not equal to b.
- Helpful to remember: There are 4 relational operators comprised of 2 characters. In each case, the = comes second.
- Also helpful: = means “assignment”, == means “equals”.
- Also, also helpful: This is identical in C++.

Examples

This came from the book slides. I disapprove of their lack of curly brackets.

```
if (x > y)
    System.out.println("X is greater than Y");

if (x == y)
    System.out.println("X is equal to Y");

if (x != y) {
    System.out.println("X is not equal to Y");
    x = y;
    System.out.println("However, now it is.");
}
```

Style

Each of these if statements are functionally the same, but only the last example is instructor approved.

```
if (score >= 90) grade = 'A';

if (score >= 90)
    grade = 'A';

if (score >= 90) { grade = 'A'; }

if (score >= 90) {
    grade = 'A';
}
```

Relational Operators and their opposites.

- It's instinctive to think that the opposite of "less than" is "greater than", but this is not correct.
- The opposite of "less than" is "greater than or equal to".
- The opposite of "greater than" is "less than or equal to".
- The opposite of "equals" is "not equals".

Quick Example.

You should pay special attention to the next few examples. They represent simple uses or mistakes that new programmers will make. All four examples represent Java code which may or may not compile.

Quick Example.

What will this code print?

```
int x = 0;
int y = 1;
if (x == y) {
    System.out.println("1 is equal to 0!");
}
```

Quick Example.

What will this code print?

```
int x = 0;
int y = 1;
if (x == y) {
    System.out.println("1 is equal to 0!");
}
```

This code prints nothing to the screen because 1 is not 0.

Quick Example.

What will this code print?

```
int x = 0;
int y = 1;
if (x == 0) {
    System.out.println("x is equal to 0!");
}
```

Quick Example.

What will this code print?

```
int x = 0;
int y = 1;
if (x == 0) {
    System.out.println("x is equal to 0!");
}
```

This code prints “x is equal to 0!” because x does equal 0.

Quick Example.

What will this code print?

```
int x = 0;
int y = 1;
if (x = y) {
    System.out.println("1 is equal to 0!");
}
```

Quick Example.

What will this code print?

```
int x = 0;
int y = 1;
if (x = y) {
    System.out.println("1 is equal to 0!");
}
```

This code will not compile because "x = y" will not resolve to a boolean expression.

Quick Example.

What will this code print?

```
int x = 0;
int y = 1;
if (y) {
    System.out.println("y is equal to 1!");
}
```

Quick Example.

What will this code print?

```
int x = 0;
int y = 1;
if (y) {
    System.out.println("y is equal to 1!");
}
```

This code will not compile because “y” is not boolean.

Quick Example.

What will this code print?

```
int x = 0;
int y = 1;
if (x == 1); {
    System.out.println("x is equal to 1!");
}
```

Quick Example.

What will this code print?

```
int x = 0;
int y = 1;
if (x == 1); {
    System.out.println("x is equal to 1!");
}
```

This code prints “x is equal to 1!”. The semicolon represents a full statement. The following curly braces represent an unrelated code block. This is yet another easy mistake to make.

Quick Example.

What will this code print?

```
int x = 0;
int y = 1;
if (x == y)
    System.out.println("x is equal to y!");
    System.out.println("x is equal to 0!");
    System.out.println("y is equal to 1!");
```

Quick Example.

What will this code print?

```
int x = 0;
int y = 1;
if (x == y)
    System.out.println("x is equal to y!");
    System.out.println("x is equal to 0!");
    System.out.println("y is equal to 1!");
```

This code prints “x is equal to 0!” and “y is equal to 1!”. Since there is no use of curly brackets, the first statement under the if is associated with the if statement and the last two are not.

if Statement Notes

- Do not place ; after (expression).
- Be careful testing floats and doubles for equality
- Unlike C++, Java requires all conditional expressions to resolve to a boolean value of **true** or **false**.

Flags

- A flag is a boolean variable that is used to track for a change in the program.
- First, you set a boolean variable to default status (usually false).
- During the course of the program, you check for a condition, then update the flag to the new status (usually to true).
- Later on, you can then react to the status change.

Flags

```
boolean didAnyoneMakeAnA = false;
...
if (score >= 90) {
    didAnyoneMakeAnA = true;
}
...
if (didAnyoneMakeAnA) {
    System.out.println("Someone made an A!");
}
```

Comparing Characters

- Characters can be compared using the same relational operators used for numbers.
- The **char** data type is ordinal, which means every character has an order to it.
  - 'A' (65) comes before 'Z' (90).
  - 'a' (97) comes before 'z' (122).
  - 'Z' (90) comes before 'a' (97).
- Every character can be translated into a binary UTF-16 number which is used to determine order.
- If you aren't sure about the order of two characters, check the ASCII table (older standard), the UTF-16 table (modern standard), or the textbook.

Comparing Characters

Try it.

```
System.out.print("Enter a character: ");
String line = keyboard.nextLine();
char first = line.charAt(0);
System.out.print("Enter a second character: ");
line = keyboard.nextLine();
char second = line.charAt(0);
if (first < second) {
    System.out.println(first + " comes before " + second);
}
```

Char: Java and C++

- The difference between Java's char and C++'s char is...
  - Java's char is 2 bytes (and uses UTF-16).
  - C++'s char is 1 byte (and uses ASCII).
- The first 128 characters in UTF-16 are identical in ASCII (except being 16 bit instead of 8 bit).

If-Else Statements

If-Else Statements

- The `else` clause to an `if` statement adds the ability to conditionally execute code when a condition is false.
- Thank the developers of Java: This is again identical to C++.

Code.

```
if (boolean expression is true) {
    // These Statements are executed.
}
else {
    // These Statements are executed
    // only if the boolean expression is false.
}
```

Nested If Statements

- Nested if statements are when an if-statement or an if-else-statement appears fully inside of another if-statement.
- The inner if-statement will only be evaluated if the outer if-statement condition is true. Otherwise it will be ignored completely.
- In the opinion of your instructor, code which uses nested if-statements are harder to read and understand than code which uses our next construct, so the use of nested-if statements are discouraged.
- This is like your English teacher telling you about long sentences: Yes, you can write a perfectly valid long sentence, but they are often hard to understand.

Nested If Statements

```
char first = line.charAt(0);
if ('a' <= first) {
  if ('z' >= first) {
     System.out.println("This is a lower case letter.");
  }
  else {
     System.out.println("This is not a lower case letter.");
  }
}
else {
 System.out.println("This is not a lower case letter.");
}
```

This example requires two identical else clauses to check for lower case letters. I think this difficult to read. I did not enjoy typing this example.

If-Else-If Statements

If-Else-If Statements

- Because nested if-statements can become complex, I recommend using if-else-if statements as an alternative.
- After every `else`, continue with another `if` to create chains of if-statements.
- The last `else` does not require another `if` statement, thus creating a default case.
- See next slide.

If-Else-If Example

```
int score = keyboard.nextInt();
code grade = 'F';
if (score >= 90)      { grade = 'A'; }
else if (score >= 80) { grade = 'B'; }
else if (score >= 70) { grade = 'C'; }
else if (score >= 60) { grade = 'D'; }
System.out.println("Your grade based on this score is "
                   +grade);
```

After every else, there's another if-statement. This example does not contain a default case.

Logical Operators

Logical Operators

- **Relational operators** are used to compare numbers.
- **Logical operators** are used to compare boolean expressions or boolean variables.
- Once again, the common logical operators that you remember from C++ appear in the same form in Java.

Logical Operators

- AND (&&): Binary. Evaluates as true if two boolean expressions are both true. False otherwise.
- OR (||): Binary. Evaluates as true if either two boolean expressions are true or both are true. False otherwise.
- NOT (!): Unary. Evaluates as true if an expression is false. Evaluates as false if an expression is true.

AND Truth Table (&&)

- AND (&&): Binary. Evaluates as true if two boolean expressions are both true. False otherwise.
- true && true is true
- false && true is false
- true && false is false
- false && false is false

OR Truth Table (||)

- OR (||): Binary. Evaluates as true if either two boolean expressions are true or both are true. False otherwise.
- true || true is true
- false || true is true
- true || false is true
- false || false is false

NOT Truth Table (!)

- NOT (!): Unary. Evaluates as true if an expression is false. Evaluates as false if an expression is true.
- !true is false
- !false is true

Exclusive Or Truth Table

- "Exclusive OR" is similar to regular OR (||) except that if two boolean expressions are true, the result is false.
- There is no "exclusive or" operator in Java.
  - We can still make our own using a combination of AND, OR, and NOT.
- p is a boolean expression
- q is a boolean expression
- Exclusive OR can be created using this: (p && !q) || (!p && q)

Short Circuiting.

- Java doesn't do any work that it doesn't have to do.
- In an `if` statement, when the boolean expression is false, statements associated with the true branch are not evaluated.
- Likewise, if Java can determine the results of a binary logical expression by looking at only the first boolean expression, it will not evaluate the second boolean expression.
  - This is called "short circuiting".

Short Circuiting.

- The only two binary logical operators are AND (&&) and OR (||).
- If the first expression of AND (&&) is false, the entire expression is false. The second expression isn't touched.
- If the first expression of OR (||) is true, then entire expression is true. The second expression isn't touched.

Short Circuiting: Why?

Look at this example. Assume that `doUnsafeOperation` will return a boolean expression of `true` when it is successful.

```
boolean itIsSafeToDoOperation = ...

if (itIsSafeToDoOperation && doUnsafeOperation()) {
    System.out.println("The unsafe operation was successful
}
```

- Under what circumstance will `doUnsafeOperation` be called?
- Under what circumstance will "The unsafe operation was successful." be displayed?

Short Circuiting: Why?

Look at this example. Assume that `doUnsafeOperation` will return a boolean expression.

- Under what circumstance will `doUnsafeOperation` be called?
  - When `itIsSafeToDoOperation` is true. Otherwise it is never called. This is an example of short circuiting.
- Under what circumstance will "The unsafe operation was successful." be displayed?
  - When `itIsSafeToDoOperation` is true AND `doUnsafeOperation()` returns true.

Comparison of String objects

Comparison of String objects

Quick: is `String` a primitive type or a class?

Comparison of String objects

Quick: is `String` a primitive type or a class?

- It's a class because `String` begins with an upper case letter.
- All variables which store objects are created dynamically.
  - The variable reference is placed on the memory stack.
  - The string data is placed on the memory heap.
  - The variable reference on the stack points to the data in the memory heap.

Comparison of String : What is happening here?

```
String password = "popcorn";
System.out.print("What is the password? ");
String guess = keyboard.nextLine();

if (password == guess) {
    System.out.println("The passwords match!");
}
```

- This is comparing the reference variables `password` and `guess` and not the actual data.
- In other words, **this code is incorrect**.
- If you test this code, you may find that it still works because of the way Java optimizes String memory.

Comparison of String

- C++ has a feature called **operator overloading**.
  - If a type (such as **string**) cannot be easily compared, then we can overload the operator "==" method with completely new code to compare two **string** objects.
  - Hopefully you had such an assignment in your CS 2000 or 2010 class. This is an important topic to learn about.
- Java lacks **operator overloading**.
  - This means that Java's "==" has a fixed meaning which cannot be changed anywhere, even if you think it is a good idea to change it.
  - This means also that you should not use "==" to compare two **String** objects.
  - Intelligent minds can differ on this, but I think it is good that "==" can never be redefined.
  - So how do we compare **String** objects?

Comparison of String : Right Way

```
String password = "popcorn";
System.out.print("What is the password? ");
String guess = keyboard.nextLine();

if (password.equals(guess)) {
    System.out.println("The passwords match!");
}
```

- We use a special method built into the **String** class called **equals**.
- This method is called from one string and requires a second string as a passed parameter. It will return `true` if two **String** objects match.
- **You will see this on the midterm.**

The Ternary Operator

- The ternary operator is an operator which takes three expressions.
  - The first expression must be a boolean.
- This is a glorified short version of an if-else statement.
- The ternary operator exists in C++ and it acts the same.

The Ternary Operator

Format:

```
condition ? true expression : false expression;
```

- The condition is evaluated first.
- The true expression is evaluated if the condition is true.
- The false expression is evaluated if the condition is false.

The Ternary Operator

Example:

```
z = x > y ? 10 : 5;
```

This line is functionally equivalent to:

```
if (x > y) {
    z = 10;
}
else {
    z = 5;
}
```

The Ternary Operator

Overtime pay example. Suppose you work for $7.50 per hour for 43 hours in the United States. Overtime pay law says that you get your wages plus another half of your wages for every hour worked in a week after the first 40 hours.

```
double wages = 7.50;
int hoursWorked = 43;
double grossPay = hoursWorked > 40
                  ? 40*wages + (hoursWorked-40)*(wages*1.5)
                  : hoursWorked * wages;
```

Some programmers believe that the ternary operator is difficult to read and should be avoided. I think it is okay in some circumstances.

Switch Statement

Switch Statement

- The switch statement is used to replace if-else-if statements with shorter code.
- Switch statements are in C++ and they act the same.
- The switch statement can evaluate an integer type or character type variable and make decisions based on the value.
  - I think you can also use **String** objects in newer versions of Java.
- The switch statement allows you to use an ordinal value to determine how a program will branch.

The switch Statement

The switch statement takes the form:

```
switch (SwitchExpression) {
  case CaseExpression:
    // place one or more statements here
    break;
  case CaseExpression:
    // place one or more statements here
    break;
  default:
    // place one or more statements here
}
```

The switch Statement

The switch statement takes an ordinal value (byte, short, int, long, or char) as the SwitchExpression.

```
switch (SwitchExpression) {
    ...
}
```

The switch Statement

- If there is an associated case statement that matches that value, program execution will be transferred to that case statement.
- Each case statement will have a corresponding CaseExpression that must be unique.

Code.

```
case CaseExpression:
    // place one or more statements here
    break;
```

If the SwitchExpression matches the CaseExpression, the Java statements between the colon and the break statement will be executed, even through other case statements.

The case Statement

- The break statement ends the case statement.
- The break statement is optional.
- If a case does not contain a break, then program execution continues into the next case.
- The default section is optional and will be executed if no CaseExpression matches the SwitchExpression.

Formatting Values

The printf Method

- printf is a special method that can be used to print formatted values to the screen.
- This doesn't exist in C++, but is instead taken from the C programming language (1973), which borrowed a similar feature from BCPL (1966).
- This is my preferred way to format variables.
  - Also, I don't care for C++'s **iomanip** library.

The printf method

- The first argument to `printf` is the **format** argument. This is a string containing the format information of all of the text and variables to be displayed.
- Every argument after the first is a variable to display. If you have no arguments, then this is the same as the `print` method.
  - `print` and `printf` will not display a newline character for you.
  - The variables to be displayed must be in the same order as they appear in the format string.

`printf` format codes.

Every format code in `printf` begins with a percent sign (%). While there are many codes that you could learn using `printf`, here are the most important.

- %d: print an integer (the type does not matter)
- %f: print a float (the type does not matter)
- %s: print a String object
- %n: print a new line (you should use this instead of "\n")

Note: The book uses "\n" incorrectly in `printf` statements. It should use "%n" instead.

Example

These two examples will print the same content. The first uses `println` and the second uses `printf`.

```
int age = 103;
System.out.println("My age is "+age+" years old.");
System.out.printf("My age is %d years old.%n", age);
```

Cats and Dogs Example

These two examples will print the same content. The first uses `println` and the second uses `printf`.

```
int dogs = 2;
int cats = 4;
System.out.println("We have "+dogs+" dogs and "+cats+" cats
System.out.printf("We have %d dogs and %d cats.%n",dogs,cat
```

Floating point output.

The floating point format code can specify how a value will be rounded.

```
double grossPay = 874.12;
System.out.printf("Your pay is %.2f.%n", grossPay);
```

Here, the ".2" in "%.2f" means that we wish to round the value to 2 decimal places.

Number formatting

The first number (if any) after the "%" represents the width in spaces to format the value.

```
int age = 103;
double grossPay = 874.12;
String name = "Ringo";
System.out.printf("%5d %7.2f %10s%n", age, grossPay, name);
```

Here, the age will be displayed using 5 spaces, grossPay with 7 spaces and rounded to 2 decimal places, and the name with 10 spaces. The numbers are always right justified.

Printf is a minilanguage

- Minilanguages are languages which exist inside of other languages.
- Regular expressions is another example of a minilanguage.
- Several programming languages will embed minilanguages from other programming languages in their internals.
- Learning these minilanguages is fun because you can see them reappear in other languages.
- I think this is easier to use than C++'s **iomanip**.