Welcome

Java Fundamentals

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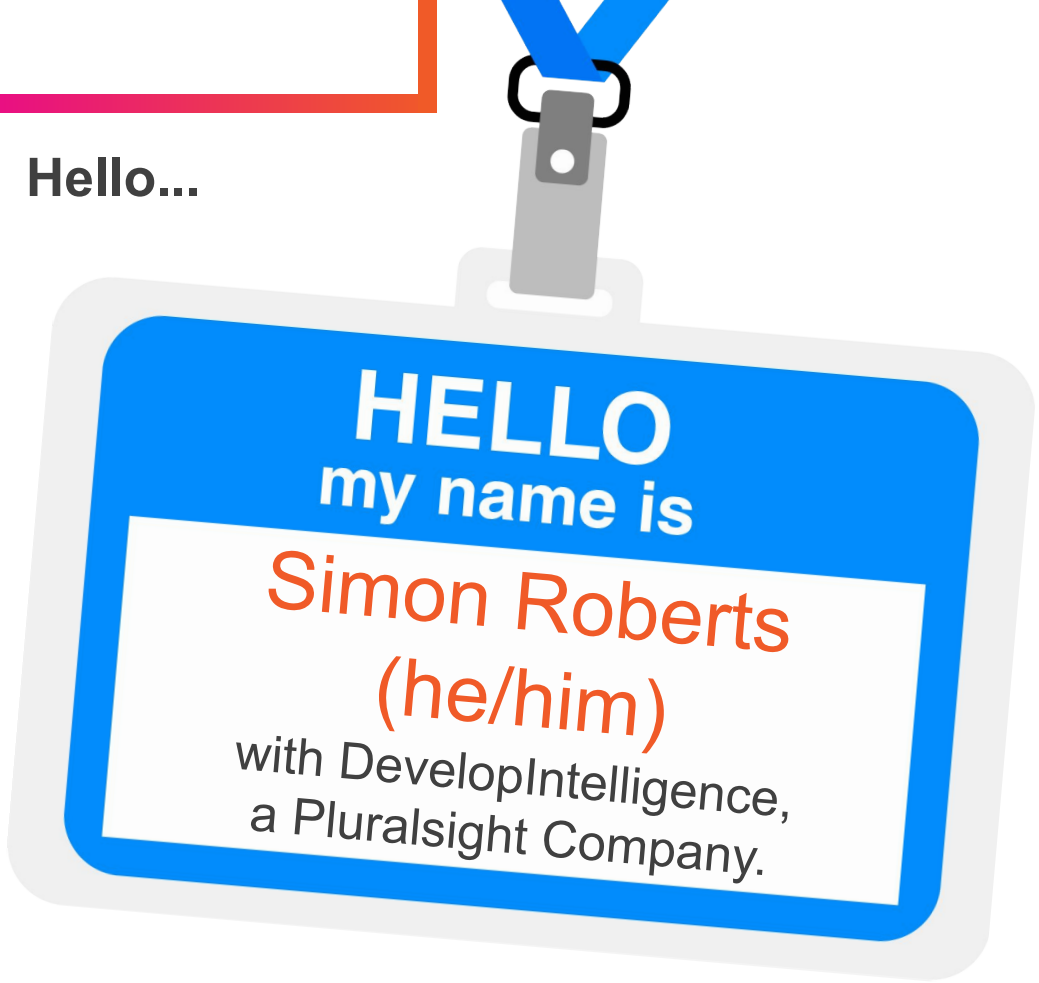
Hello...



About me...

We teach over 400 technology topics

You experience our impact on a daily basis!

Prerequisites

This course assumes you

- Know how to program in some other language
- Have never taken a formal course in Java and know little or nothing about the language

Please Note

If you have never programmed before or if you've only used Bash, Powershell, SQL or similar, this is probably not the right class for you.

Please chat me so we can get you to the right resource.

Why study this subject?

- Java is one of the main languages used in backend development today
- Many features of Java can be used in other languages too, so much of the learning either crosses into this language if you're already familiar, or supports learning those other languages if the concept is new to you.

My pledge to you

I will...

- Make this interactive
- Ask you questions
- Ensure everyone can speak
- Create an inclusive learning environment
- Use an on-screen timer for breaks

…also, if you have an accessibility need, please let me know

Objectives

At the end of this course you will be able to:

- Explain what Java is and why it is used
- Create a stand-alone Java application
- Understand and use common Java Collection classes (List, Set, Map)
- Understand and use the JUnit testing framework

Agenda

- What is Java
- Basic Java Syntax
- Introduction to OO in Java
- Creating Enumerations
- Class design and Object inheritance in Java
- Working with Java Exceptions
- Working with Collections
- Unit Testing
- Using Lambdas

How we’re going to work together

- You'll have a copy of all the material I create after we're finished
  - These will be added to a git repository
  - THIS REPOSITORY WILL BE DELETED NEXT WEDNESDAY
  - Please be sure to take a copy before then if you want it
- You will work on practical exercises with my help as needed, so as to solidify your learning and discover anything I didn't explain clearly enough.

Student Introductions

- What you want to learn?
- What you want to do with Java?
- Experience with other programming languages?
- Fun fact?

Introduction to Java and OO

Java provides:

- Performance of compiled languages
- Platform independence
- Dynamic features usually reserved for interpreted languages
- Security (though it's not used as much as it should be)
- Familiar syntax and programming model
- Much like C, C++, Objective C, JavaScript, C#
- Object oriented with functional features too
- Carefully improving, backward compatible, development
- Huge library base
- Huge programmer skill base

Organizing source code

- Packages contain types (e.g. classes)
    - Types contain code and data models
        - Source code layout maps to the package and class structure
- Directory/folder ⇔ package
    - Source (dot-java) file ⇔ type (class)

- Finding where to look is an important problem when maintaining code in a large project

- Binary (classfile) layout parallels the source layout
- Binaries are searched for on "classpath" or "modulepath" depending on deployment model

Accessing code in other packages

- If using a class from another package it can be referred to "longhand"
  `java.util.List`
- Or the class can be imported
  Either: `import java.util.List;`
  Or: `import java.util.*;`

- Features of the package `java.lang` do not need to be imported, they are always in scope

- Importing is a "namespace" issue only
- Importing does not make any changes in the generated binary
- Importing does not change the size or speed of the running executable

Types, expressions, and computations

- Java has 8 "primitive" types:
  - `boolean`
  - `char`
  - `byte, short, int, long`
  - `float, double`
- Their behavior is predictable across platforms
- Variables must be declared, and have a single type throughout their lifetime
  <type> <varname> [= <expression>] ;
  `int x = 99;`
- Variables must be definitely assigned before reading / use
- Key binary arithmetic operators are:
  `+, -, *, /, %`
- Binary operators "promote" operands to at least int, and to at least the larger of the two operant types.

Core Java operators

- Conditional expressions produce boolean results:
  `<, <=, >=, >`
  `==, !=`
- Equals / not-equals works as expected for primitive types
  - but provides "object identity" test on non-primitive types

- Text may be represented using `String`:
  ```
  String s = "Hello";
  String t = s + " world!";
  ```
- String values are immutable, any operation that appears to change the string actually creates a new one
- Strings cannot safely be compared with `==`
- use dot-equals instead (helpful for many, but not all object types)
  ```
  boolean same = s.equals(t); // value is false
  ```

More Java operators

- Bitwise and logical operations:

	Bitwise	Logical
and	&	&&
or	|	||
not	~	!
exclusive-or	^ `	^

- && and || are "short-circuiting"; right hand operand is not evaluated if the left hand side defines the result

Declaring and using arrays

- Arrays create "many" variables accessed with a subscript

```
// ten numbers numbers[0] through numbers[9]
int [] numbers = new int[10];
System.out.println("count of numbers is "
  + numbers.length);

int [] num2 = {1, 3, 5, 7, 9};
```

- Arrays are of fixed length once created
- Lists, a library feature, are typically preferred

The `while` loop

- Java has four loop types: `while`, `do while`, C-style `for`, enhanced `for`

`while` loop

```
int count = 0;
while (count < 3) {
  System.out.println("count is " + count);
  count++;
}
```

- Java tests must be boolean expressions
    - Java avoids the notion of "truthiness"

The `do while` loop

- `do while` loop

```
int count = 0;
do {
  System.out.println("count is " + count);
  count++;
} while (count < 3);
```

The C-style `for` loop

- C-style for loop

```
for (int count = 0; while (count < 3); count++) {
  System.out.println("count is " + count);
}
```

The enhanced `for` loop

- Enhanced for loop works over arrays and collections

```
int [] numbers = {1, 3, 5, 7};
for (int n : numbers) {
  System.out.println("number is " + n);
}
```

- The enhanced for loop does not maintain a counter

The `if else` conditional structure

- Java has three conditional structures: `if`/`else`, `switch`/`case`, and the conditional expression

The `if` / `else` structure:

```
int x = 99;
if (x > 50) {
  System.out.println("x is large");
} else {
  System.out.println("x is not so big");
}
```

- Java does not need "elif", simply use `else if (...)`

The `switch case` structure

- The `switch` / `case` structure:

```
int x = 99;
String message;
switch (x) {
  case 99: case 100: case 101: message = "x is 100 ish";
  break;
  case 0: case 1: case 2: message = "x is small";
  break;
  default: message = "x is boring";
  break;
}
```

Behavior of `switch case`

- Switch is permitted on `int` (or smaller), `String`, and enumeration types
  - `case` values must be constants
  - `case` acts as a target for a "go-to" effect
  - Be sure to use `break` or execution flow will "fall through"
    - `return` from a method also avoids fall-through
- Falling through is helpful sometimes (but rarely) to allow the same path of execution for several conditions

The conditional expression ? :

- The conditional (aka "ternary") expression creates an if-else effect in a single expression:

```
boolean sometest = ???
String message =
  sometest ?
    "test value is true"
    : "test value is false";
```

- This code is typically laid out on a single line if space permits easy reading

Methods and method names

- Where code is repeated, or creates a meaningful "utility", it should be extracted into a method
- Sometimes called function, procedure, subroutine in other languages

```
<modifiers> <return type> <name> ( <formal parameter list> )
<body>
```

- For a `static` method `static` is one of the modifiers
- Other modifiers exist, `public` and `private` are common
- Name must be a legal Java "identifier"
    - Starts with letter, underscore (Unicode definitions)
    - Continues with letters, underscores, and digits
    - Avoid $, and single _
- Method body is enclosed in curly-braces

Static methods

- A `static` method is code that can be accessed in the context of the class as a whole
  - Static methods do not require an instance of their class to operate, but relate to the "concept as a whole"
  - E.g. determine if a year is a leap year
  - Static methods have the prefix `static`

```
public class MyDate {
  static boolean isLeapYear(int year) {
    return year % 4 == 0 && year % 100 != 0
      || year % 400 == 0;
  }
}
```

General method declaration

```
<modifiers> <return type> <name> ( <formal parameter list> )
<body>
```

- Formal parameters are local variable declarations in a comma separated list <type> <name>, <type> <name> …
  - e.g. `String s, int c`
- Their values are initialized for each method call by copying from the caller's values
- The enclosing parentheses are always required, even if no formal parameters exist for this method
- Return value, matching the declared type must be supplied by a return statement in the body
- A method with return type void must not return a value, but may run off the end of the method, or use return; (without an expression)

Method examples

```
public static int addUp(int a, int b) {
  System.out.println("Adding numbers");
  return a + b;
}

public static void show(String s, long l) {
  System.out.println("String is " + s);
  System.out.println("long is " + l);
  return; // optional, can run off end
}

public static void hello() {
  System.out.println("Hello!");
}
```

Declaring `enum` types

- For situations where a specific, known, and never-changing set of values exist, an enumeration is appropriate:

```
public enum DayName {
  MONDAY, TUESDAY, WEDNESDAY, THURSDAY,
  FRIDAY, SATURDAY, SUNDAY;
}

DayName dn = DayName.WEDNESDAY;
```

- Enumeration types can reduce the potential errors of using simple `int` values (how will code respond to day number -17, for example?)

Throwing exceptions

- If something goes wrong and it's necessary to abandon some operation as a result, an exception might be appropriate.
- When identifying the bad situation, throw an exception:

```
if (dayNumber < 1 || dayNumber > 7) {
  throw new IllegalArgumentException(
    "Bad day number " + dayNumber);
}
```

Exception concepts

- If an exception is thrown by code, it can be "caught"
    - This gives a chance to recover
    - Catching it, even if nothing is done, is considered to have handled the problem and execution flow returns to normal
- Use a `try`/`catch` or `try`/`catch`/`finally` construction
- "Happy path" goes in the `try` block
- Multiple `catch` blocks can be provided to handle different potential problems
- If no `catch` block matches the exception, then the exception has not been recovered and propagates out of this method
- A `finally` block can be used for code that must be run in success, recovered-failure, and unrecovered failure
    - This is less common in modern Java

The `try catch finally` structure

```
try {
  // something that might throw and exception
} catch (SomeException e1) {
  // recover from Some problem
} catch (OtherException e2) {
  // recover from Other problem
} finally {
  // do something in all situations
}
```

- In this structure a `try` cannot exist unless at least one `catch` or a `finally` exists
  - It would be pointless

The try-with-resources structure

- Exceptions are very common with IO operations
    - Closing files is important whether the operation succeeds or fails
    - Try-with-resources is the right way to handle this (since Java 7)

```
try (
    FileReader fr = new FileReader("data.txt");
    BufferedReader br = new BufferedReader(fr);
) {
  System.out.println(br.readLine());
} catch (IOException ioe) {
  System.out.println("That broke: " + ioe);
}
```

- "Resources" (`AutoCloseable`) opened in `try (...)` are closed

Checked exceptions

- Some exceptions are "checked"
- These are normal problems in the environment
    - A quality program should include code for recovery, rather than simply crashing
    - Java identifies these exceptions (not always perfectly) and requires some code to address the problem
- Either surround the source of the problem with a try/catch
- Or declare that the method containing the problem "throws" the exception(s) with a comma separated list of their types:

```
public static void mightBreak()
    throws IOException, SQLException {
  // method code that might break
}
```

Classes

- Classes are the "home" of code that provides the behavior (code) that implements a single concept that is being modeled in a software system
- Classes also act as a template for how to build the data model for that same concept, e.g. for a calendar date:
- int day, month, year;
- The code in the class might act on the data representation as a whole, or on other data that relate, e.g. in modeling a date:
    - find the name of day number 3
    - find the number of days in March 2020
    - find the day of the week of July 4th, 1776
    - find the date four years, 2 months, and 13 days after this date

Declaring a classe

- Define a class with this syntax:

```
<modifiers> class <name> [ <parent information> ] <class body>
```

- Modifiers often include `public`, and might be `abstract` or `final` in special cases
- The name is any valid identifier, but stylistically should start uppercase
- Class body is enclosed in curly-braces
- Optional parent information describes superclasses or interfaces E.g.:

```
public class MyDate
    extends CalendarItem implements Printable {
  // class body code
}
```

More about classes

- The class body can declare fields, methods, and other classes
- An instance "field" becomes a variable that is a part of an object when a class is instantiated.
    - E.g. day would be a field in a date.
    - Create ten date objects, get ten day fields, one in each
- Instance field accessibility can be `private`, <default>, `protected`, or `public`
    - Omitting the keyword gives <default> access
    - `private` is "normal"
- Define instance fields in classes as for simple variables:

```
public class MyDate {
  private int day;
  private int month;
  private int year;
}
```

Accessibility of classes and their members

- Accessibility governs what other code can see and use an element
- This concept relates to all field types, and method types
- Some accessibilities may be used on classes too, depending on circumstances
- `private` means "visible withing the enclosing top-level curly braces surrounding this declaration
- <default> means visible anywhere within the same package
- `protected` means visible anywhere <default> is visible plus in sub-classes (with some constraints)
- `public` means visible anywhere in this module, or anywhere within the JVM if non-modular
    - `public` elements of exported packages may be visible in other modules if the containing package is exported by the owning module, and read by the other

Defining `static` fields

- A "static field" is a variable that is a part of the class.
  - One variable exists in the class, and may be accessed from any instance
    - The value is effectively "shared'
  - E.g. `daysInJanuary` could be a `static` field in the `MyDate` class.
  - Create zero or ten date objects, always have one daysInJanuary value
- Define `static` fields in classes as for simple variables with the prefix `static`:

```
public class MyDate {
  static int daysInJanuary = 31;
}
```

Defining `static` methods

- Static methods define behavior that relates to the concept modeled by the class, but that do not relate specifically to an individual instance
  - find the name of day number 3
  - find the number of days in March 2020

```
public class MyDate {
  static String dayName(int dayNum) {
    // body of method
  }
  static int numberOfDays(int monthNum) {
    // body of method
  }
}
```

Instance methods

- Instance methods define behavior that relates to the concept modeled by the class, and specifically act on an individual instance, e.g.:
    - find the day of the week of July 4th, 1776
    - find the date four years, 2 months, and 13 days after this date
- Instance methods:
    - *Omit* the word `static`
- The first formal parameter of an instance method:
    - Is of exactly the enclosing class type
    - Has/must have the special/reserved name `this`
    - May optionally be omitted from the parameter list, in which case it is implicit
- Instance methods must be invoked using a subject-verb grammar rather than a verb-object grammar

Declaring an instance method with explicit `this` argument

- Instance method declaration example using explicit this:

```
public class MyDate {
  int day, month, year;

  void setDayOfMonth(MyDate this, int day) {
    this.day = day;
  }
}
```

Declaring an instance method with implicit `this` argument

- Instance method declaration example using implicit this:

```
public class MyDate {
  int day, month, year;

  void setDayOfMonth(int day) { // no "MyDate this,"
    this.day = day;
  }
}
```

- Note that this example is *identical in effect to the preceding one.*

Invoking an instance method

- Instance method invocation:

```
MyDate md … // initialized in some way
md.setDayOfMonth(3);
```

- Note that the prefix value **`md`** is assigned to the value **`this`** inside the invoked method body
- The prefix is mandatory for an instance method and *must not be* **`null`**

Intializing an object using a constructor

- To initialize the fields of a new object, provide initialization behavior in a special behavior called a "constructor"

```
public class MyDate {
  private int day, month, year;
  public MyDate(int day, int month, int year) {
    this.day = day;
    this.month = month;
    this.year = year;
  }
}
```

Inheritance in Java

- A subclass creates a variation on the parent class
  - Additional features can be added
  - Implementation details may be changed
  - Instances of the subclass may be substituted where instances of the parent class are expected (the "is a" relationship)
  - All the features of the parent class will exist in the subclass by default
- To define a subclass, specify the parent in the `extends` clause of the subclass' declaration:

```
public class MyHoliday extends MyDate {
  private String name;
}
```

Initializing subclasses

- Subclass constructors must make their first action to properly initialize the parent features:

```
public class MyHoliday extends MyDate {
  private String name;
  public MyHoliday(String name,
      int day, int month, int year) {
    super(day, month, year);
    this.name = name;
  }
}
```

Overriding methods in subclasses

- Subclasses can modify the definition of parent instance methods.
  - This is called "overriding"
  - Define an instance method with identical name and argument type sequence as that of the parent method
  - Return type must be "compatible"
- Objects are converted to text using the method `toString`, defined in the base class `java.lang.Object` in this manner:

```
public class Object {
  public String toString(Object this) {
    return <textual representation>;
  }
}
```

The `@Override` annotation

- User defined types can redefine the behavior of text conversion by overriding the default/inherited behavior like this:

```
public class MyDate {
  @Override // optional, but advised
  public String toString() { // implicit this (either form is OK)
    return "My Date, day is " + this.day +
      " month is " + this.month;
  }
}
```

Liskov substitution, the "is a" relationship

- An instance of a subclass can be used anywhere an instance of the parent class is expected "Liskov Substitution"
    - Therefore a declaration of this kind is legal:

```
MyDate md = new Holiday("New Years", 1, 1, 2022);
```

- And given a method of this form `doStuff(Date d)` and an instance of `Holiday` called `myHoliday`, a call of this form is also legal:

```
doStuff(myHoliday);
```

Dynamic binding in overriding methods

- Given the example:

```
MyDate md = new Holiday("New Years", 1, 1, 2022);
```

- An invocation like the following will invoke the toString behavior of the Holiday class (if overridden) rather than that of the MyDate class

```
String text = md.toString();
```

- This is known as:
    - Dynamic method invocation
    - Virtual method invocation
    - Late binding

The Collections API

- The package `java.util` defines several useful "collection" types:
  - `Iterable`
  - `List`
  - `Set`
  - `Map`
- These are ***interfaces***, which describe the methods available separately from the implementation by some other class
- Differing implementations are available for several of these
  - The implementations have differing performance characteristics depending on usage patterns
- These types are "generic", which refers to a language mechanism that allows indicating the type of data that should be contained and provides compile-time verification that the usages made are correct

The `List` interface

- The `java.util.List` interface:
  - Provides an array-like storage for multiple items
  - The items have a user-controlled order
  - Items can be added to the list at any given position
  - The length grows and shrinks automatically as needed
  - Items can be changed, or removed
  - Items can be retrieved by index
  - Items can be searched (provided the items implement equals properly)

```
List<String> names = new ArrayList<>();
names.add("Fred");
System.out.println(names.get(0));
boolean found = names.contains("Fred");
names.set(0, "Frederick");
```

The `Set` interface

- The `java.util.Set` interface:
  - Provides storage for multiple items
    - Duplicates are not added
  - The order of items is not under user control and might change
    - Items can be searched for efficiently
  - Some Set implementations require items implement equals properly, others expect the items to have an ordering

```
Set<String> names = new HashList<>();
names.add("Fred"); // succeeds, returns true
names.add("Fred"); // fails, returns false
boolean found = names.contains("Fred"); // true
```

The `Iterable` interface

- The `java.util.Iterable` interface:
  - Provides for taking items one at a time from some source
    - Order might or might not be significant
  - Any `Iterable` implementation can be used in the enhanced-for loop
  - An `Iterable` is usually used to obtain an Iterator, which performs, and maintains the progress of, the iteration process
  - Iterator provides `hasNext()` and `next()` methods for the iteration
  - Both `List` and `Set` implement `Iterable` (but `Map` does not)

```
List<String> aList = List.of("Fred", "Jim", "Sheila");
Iterator<String> it = aList.iterator();
while (it.hasNext()) {
  System.out.println(it.next());
}
```

The `Map` interface

- The `java.util.Map` interface:
  - Provides storage for multiple key-value pairs
  - Storing against a duplicate key overwrites the previous value
  - Keys can be searched for efficiently, yielding the associated value

```
Map<String, String> names = new HashMap<>();
names.put("Fred", "Jones");
String name = names.get("Fred"); // returns "Jones"
name = names.get("Alan"); // returns null
```

Lambda expressions

- A lambda expression in Java defines an object in a context.
- The context must require an implementation of an interface
- The interface must declare ***exactly one*** abstract method
- We must only want to implement ***that one abstract method***
- We provide a modified method argument list and body with an "arrow" between them:

```
(Student s) -> {
  // function body
}
```

- The argument list and return type must conform to the abstract method's signature

Requirements for lambda expressions

- Argument types can be omitted if they're unambiguous
  - This is "all or nothing"
- Since Java 10, argument types can be replaced with **`var`** if they're unambiguous
  - This is also "all or nothing"
- If a single argument carries zero type information the parentheses can be omitted
- If the method body consists of a single return statement, the entire body can be replaced with the expression that is to be returned.

The functional interface concept

- If an interface is intended for use with lambdas, it must define exactly one abstract method.
- The `@FunctionalInterface` annotation asks the compiler to verify this and create an error if this is not the case.

Key predefined functional interfaces

- Due to Java's strong static typing, and the restrictions preventing generics being used with primitives, different interfaces must be provided for a variety of different situations.
- Key interface categories are:
  - `Function` - takes argument, produces result
  - `Supplier` - zero argument, produces result
  - `Consumer` - takes argument, returns void
  - `Predicate` - takes argument, returns boolean
  - `Unary/Binary Operator` - Function variants that lock arguments and returns to identical type

Variations of functional interfaces

- For two arguments, expect a "`Bi`" prefix
- For primitives:
- `Int`, `Long`, `Double` prefix usually means "primitive argument"
    - Note for `Supplier`, this prefix refers to return type (there are zero arguments.)
- `ToInt`, `ToLong`, `ToDouble` prefix means "primitive return"

Unit testing concepts

- The `main` method is the traditional entry point to an entire program
- Testing usually involves an entry point per test
    - I.e. a great many entry points
- JUnit and TestNG are common test frameworks that provide for executing many tests as separate operations
    - Each test is annotated with `@Test` and becomes an entry point
    - Tests should be zero argument instance methods in classes dedicated to testing
    - Test classes are placed in a different directory structure from code implementing the main project (this allows separating the tests from the deliverable binaries)

Unit testing

- Tests should be written in three parts:
    - Configuration of the conditions of the test
    - The action to be tested
    - The expected results described using "assertions"
- The test system is implemented in libraries that must be made available
- For example, if using maven, add this to the project's `pom.xml`:

```
<dependencies>
    <dependency>
        <groupId>junit</groupId>
        <artifactId>junit</artifactId>
        <version>RELEASE</version>
        <scope>test</scope>
    </dependency>
</dependencies>
```

Unit testing example

```
import org.junit.Assert;
import org.junit.Test;

public class SimpleTest {
  @Test
  public void testTwoPlusThree() {
    int two = 2;
    int three = 3;
    int result = two + three;
    Assert.assertEquals("2 + 3 should be 5", 5, result);
  }
}
```

- Many tests, and many test classes, can be added

Thank you!

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