Intermediate Java

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Setup

Lab: Pre-Class Check

Before we begin it is assumed that all of you have the following tools installed:

- JDK 1.8 (latest java is 1.8.0_131)
- Maven 3.5.0

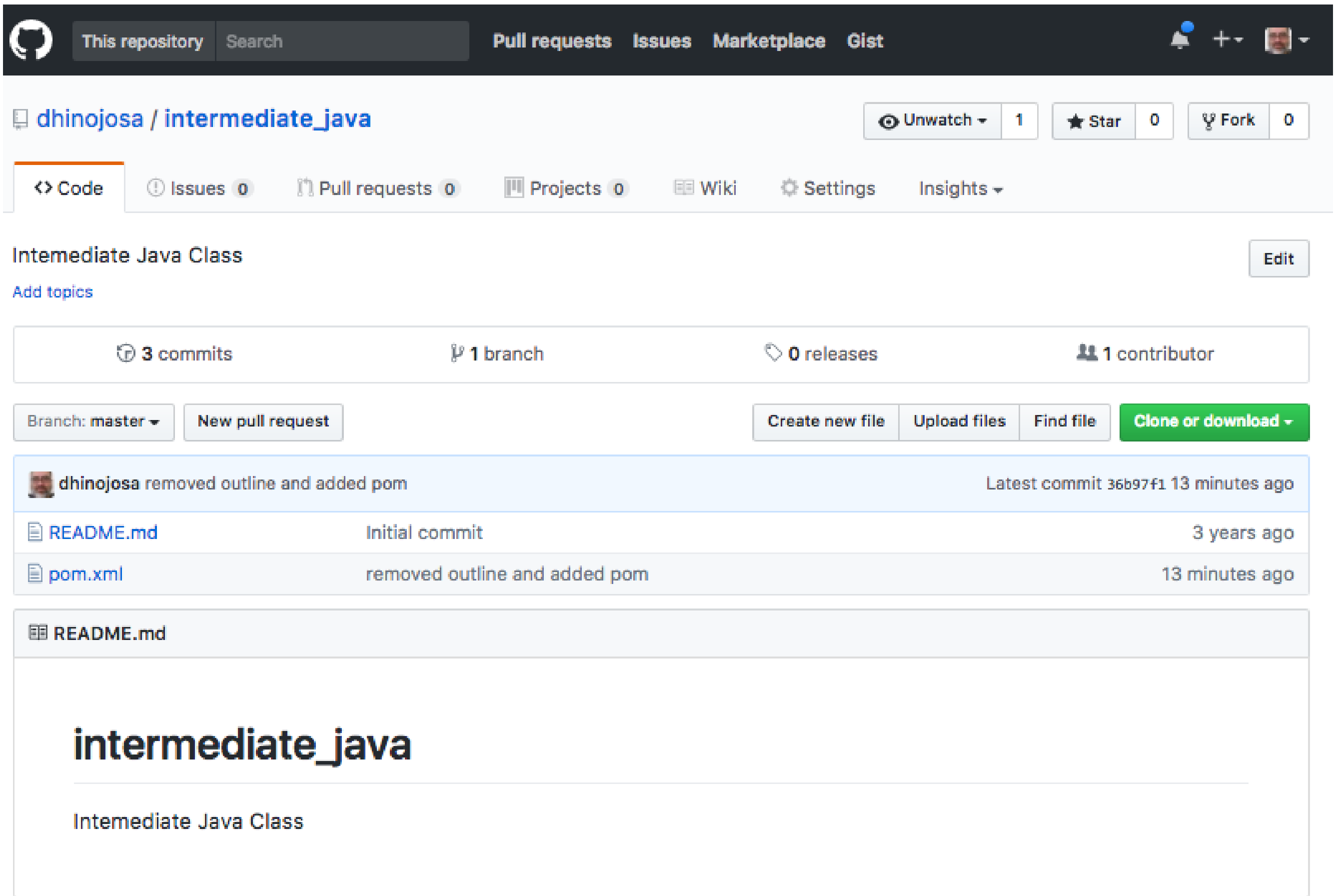
To verify that all your tools work as expected

```
% javac -version
javac 1.8.0_131

% java -version
java version "1.8.0_131"
Java(TM) SE Runtime Environment (build 1.8.0_1.8.0_131-b17)
Java HotSpot(TM) 64-Bit Server VM (build 25.65-b01, mixed mode)

% mvn -v
Apache Maven 3.5.0 (bb52d8502b132ec0a5a3f4c09453c07478323dc5; 2015-11-10T09:41:47
-07:00)
Maven home: /usr/lib/mvn/apache-maven-3.5.0
Java version: 1.8.0_131, vendor: Oracle Corporation
Java home: /usr/lib/jvm/jdk1.8.0_131/jre
Default locale: en_US, platform encoding: UTF-8
OS name: "linux", version: "4.4.0-34-generic", arch: "amd64", family: "unix"
```

The JDK 8 Version doesn't have to be exact as long as it is Java 8.

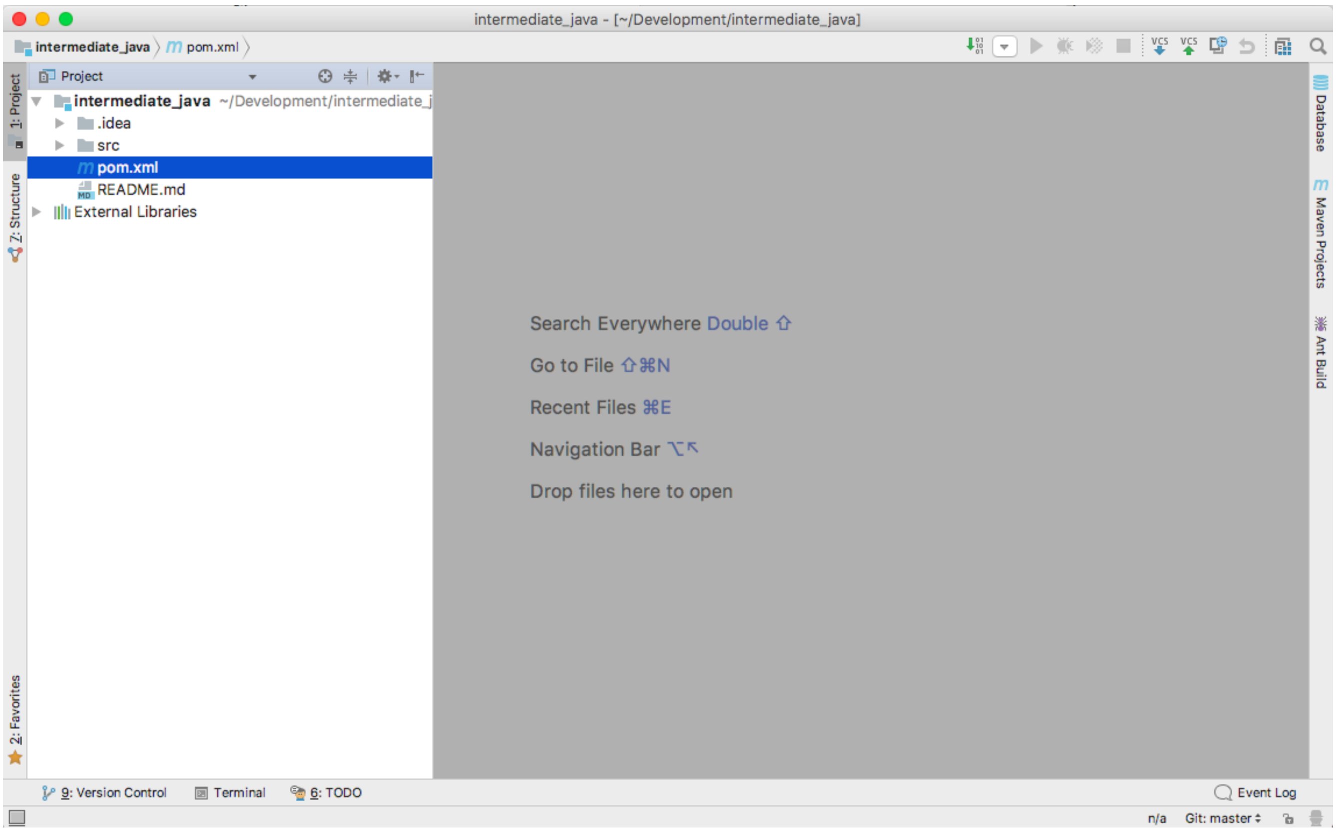
Lab: Download the Project

From https://github.com/dhinojosa/intermediate_java download the project .zip file and extract it into your favorite location or if you know how to use git, then clone the project into your favorite location.



Optional Lab: Open Project in IntelliJ

Once intermediate_java is downloaded and extracted or cloned to your favorite location, In IntelliJ Open The Project, IntelliJ will recognize it as a Maven project and you are good to go.

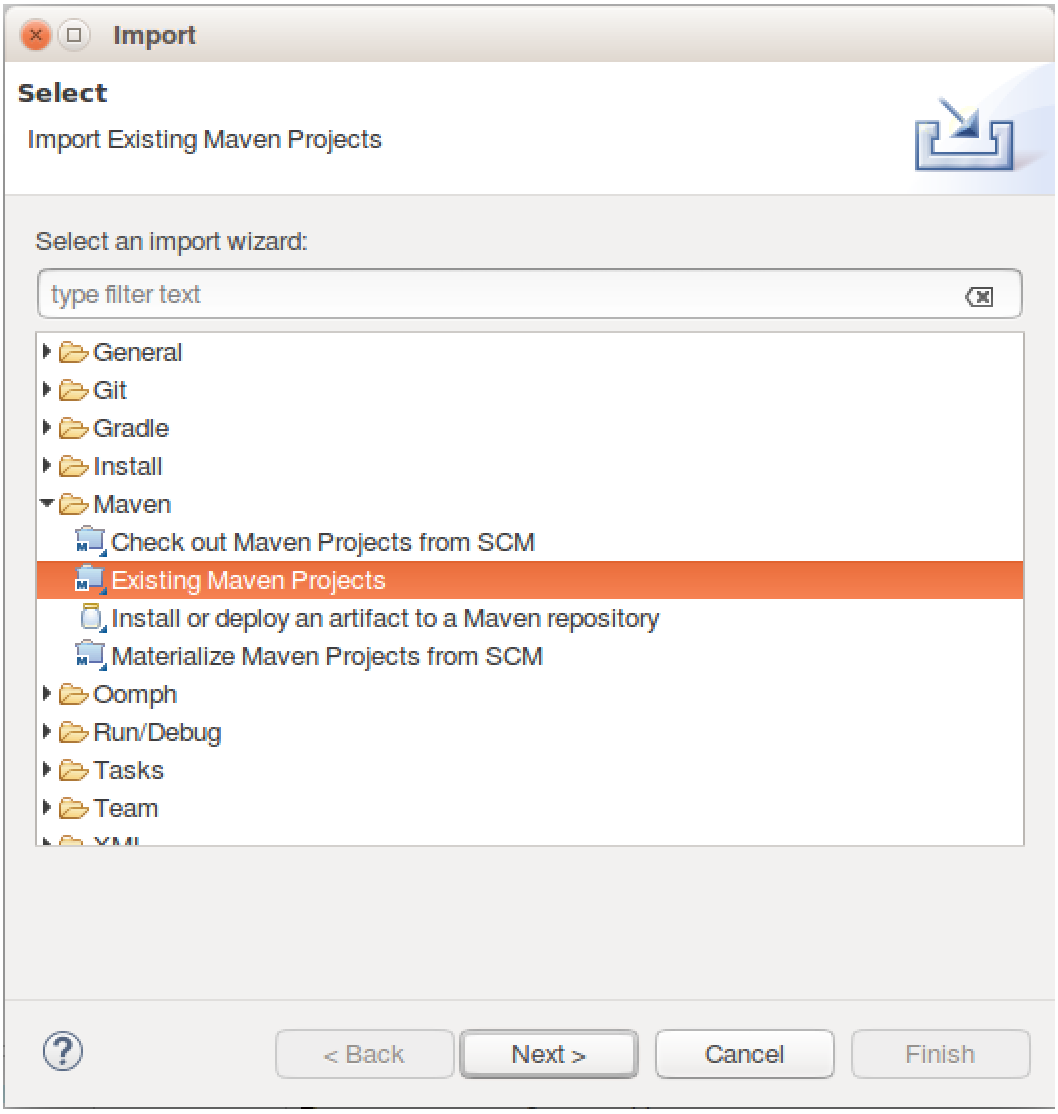


Optional Lab: Open Project in Eclipse

Once downloaded and extracted:

Step 1: Select *File* > *Import Project* in the menu.

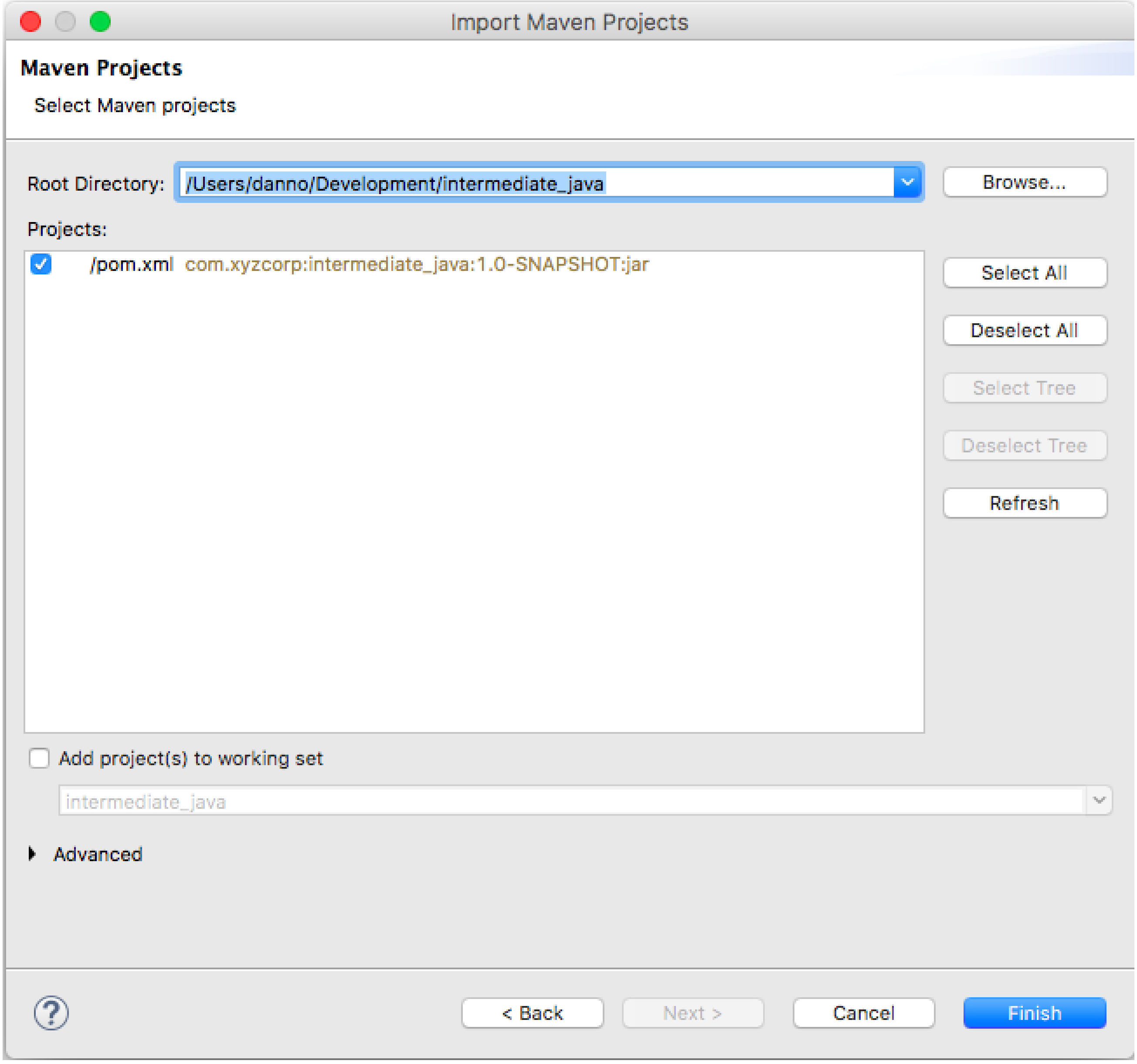
Step 2: In the following dialog box:



- Open the *Maven* category
- Select *Import Existing Maven Projects*

Optional Lab: Open Project in Eclipse (Continued)

Step 3:



- Click the *Browse:* button next to *Root Directory*
- Select the location of your ***intermediate_java*** directory.

Step 4: Click *Finish*

Lambdas

About Java 8 Lambdas

Functional Interface Definition

> A functional interface is any interface that contains only one abstract method. (A functional interface may contain one or more default methods or static methods.) Because a functional interface contains only one abstract method, you can omit the name of that method when you implement it.

(`equals` is an explicit declaration of a concrete method inherited from `Object` that, without this declaration, would otherwise be implicitly declared.)

Default Methods

- Enable you to add new functionality to the `interface` of your libraries
- Ensure binary compatibility with code written for older versions of those `interface`.
- Comes closer to have "concrete" method in an "interface" by composing other `abstract` methods.

Default Method Arbitrary Example

```java
public interface Human {
   public String getFirstName();
   public String getLastName();
   default public String getFullName() {
     return String.format("%s %s",
        getFirstName(), getLastName());
   }
}
```

Lab: Create `MyPredicate`

Step 1: Ensure you have a `src/main/java` directory in the `intermediate_java` module

Step 2: Ensure that the folders are seen as a build path (Eclipse only)

Step 3: Create a package called `com.xyzcorp` in `src/main/java`

Step 4: Create an interface in `com.xyzcorp` called `MyPredicate`

```java
package com.xyzcorp;

public interface MyPredicate<T> {
      public boolean test(T item);
}
```

About `MyPredicate`

- It's an interface
- One `abstract` method: `test`
- `default` methods don't count (More on that later)
- `static` methods don't count
- Any methods inherited from `Object` don't count either.

```java
package com.xyzcorp;

public interface MyPredicate<T> {
      public boolean test(T item);
}
```

Conclusion: We can omit the name when we implement it.

Functional `filter`

> Filter is a higher-order function that processes a data structure (usually a list) in some order to produce a new data structure containing exactly those elements of the original data structure for which a given predicate returns the boolean value true.

[Wikipedia: Map (higher-order function)]

Functional `filter` by example

1. Given List of `list`: `[1,2,3,4]`
2. Given a function `f`: `x → x % 2 == 0`
3. When calling `filter` on a `list` with `f`: `[1,2,3,4].filter(f)`
4. Then a copy of the `list` should return: `[2,4]`

Lab: Using `MyPredicate`

Step 1: Create a File in the `com.xyzcorp` package called ***Functions.java***

Step 2: Create an method called `myFilter` as seen below.

```
package com.xyzcorp;

import java.util.ArrayList;
import java.util.Arrays;
import java.util.List;

public class Functions {

    public static <T> List<T> myFilter (List<T> list, MyPredicate<T> predicate) {
        ArrayList<T> result = new ArrayList<T>();
        for (T item : list) {
            if (predicate.test(item)) {
                result.add(item);
            }
        }
        return result;
    }
```

This is the functional `filter`

Lab: Test Method in *LambdasTest.java*

Step 1: Ensure you have a `src/test/java` directory in the `intermediate_java` module

Step 2: Ensure that the folders are seen as a build path (Eclipse only)

Step 3: Create a package called `com.xyzcorp` in `src/test/java`

Step 4: Create a class called `LambdasTest` in the `com.xyzcorp` package with the following test:

```java
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    @Test
    public void testMyFilter() {
        List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15,
                                              19, 21, 33, 78, 93, 10);
        List<Integer> filtered = Functions.myFilter(numbers,
           new MyPredicate<Integer>() {
               @Override
               public boolean test(Integer item) {
                   return item % 2 == 0;
               }
           });
        System.out.println(filtered);
    }
}
```

Here we are defining what the predicate will do when sent into `filter`.

Step 5: Run the test in your IDE to verify that it works as expected

Lab: `MyPredicate` is "Lambdaized"

Step 1: In the test you just wrote, convert `MyPredicate` into a lambda and use your IDE's faculties to do so.

```java
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

   @Test
    public void testMyFilter() {
        List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15,
                                               19, 21, 33, 78, 93, 10);
        List<Integer> filtered = Functions.myFilter(numbers, item -> item % 2 == 0);
        System.out.println(filtered);
    }
}
```

Functional `map`

> Applies a given function to each element of a list, returning a list of results in the same order. It is often called apply-to-all when considered in functional form.

Wikipedia: Map (higher-order function)

Functional `map` by example

1. Given List of `list`: `[1,2,3,4]`
2. Given a function `f`: `x → x + 1`
3. When calling `map` on a `list` with `f`: `[1,2,3,4].map(f)`
4. Then a copy of the `list` should return: `[2,3,4,5]`

Lab: Create a `MyFunction`

Step 1: Create an `interface` for `MyFunction`

- In `src/main/java` and in the package `com.xyzcorp` create an `interface` called `MyFunction`
- The interface should have a method called `apply`
- The `MyFunction` interface should have two parameterized types `T1` and `R`
- The `apply` method have one parameter `(T1 in)`
- The `apply` method should have one return type: `R`

Lab: Create a `myMap` in *Functions.java*

Step 1: Create `static` method called `myMap` in ***Functions.java*** with the following method header:

```
public static <T, R> List<R> myMap(List<T> list, MyFunction<T, R> function) { }
```

Step 2: Fill in the method with what you believe a `map` should look like given the previous description.

Lab: Use `myMap` in *LambdasTest.java*

Step 1: Add the following test to your ***LambdasTest.java*** file:

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testMyMap() {
        List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
                                              21, 33, 78, 93, 10);
        List<Integer> mapped = Functions.myMap(numbers,
          new MyFunction<Integer, Integer>() {
            @Override
            public Integer apply(Integer item) {
                return item + 2;
            }
        });
        System.out.println(mapped);
    }
}
```

Step 2: Convert the `new MyFunction` anonymous instantiation into a lambda using your IDE's faculties

Step 3: Run to verify it all works!

Functional `forEach`

> Performs an action on each element returning nothing or `void`, a sink

Functional `forEach` by example

1. Given List of `list`: `[1,2,3,4]`
2. Given a function `f`: `x → System.out.println(x)`
3. When calling `forEach` on a `list` with `f`: `[1,2,3,4].forEach(f)`
4. Then `void` is returned. This is called a side effect.

Lab: Create `MyConsumer`

Step 1: Under `src/main/java`, and inside the `com.xyzcorp` package, create an `interface` called `MyConsumer` with the following content:

```
package com.xyzcorp;

public interface MyConsumer<T> {
   public void accept(T item);
}
```

Notice that it does not return anything

Lab: Create a `forEach` in *ListOps.java*

Step 1: Create `static` method called `myForEach` in ***Functions.java*** with the following method header:

```
public static <T, R> void myForEach(List<T> list, MyConsumer<T> consumer) {}
```

Step 2: Fill in the method with what you believe a `forEach` should look like

Lab: Use `myForEach` in *LambdasTest.java*

Step 1: Add the following test to your ***LambdasTest.java*** file:

```
package com.xyzcorp;

import java.util.ArrayList;
import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testForEach() {
        List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
                                               21, 33, 78, 93, 10);
        Functions.myForEach(numbers, new MyConsumer<Integer>() {
            @Override
            public void consume(Integer item) {
                System.out.println(item);
            }
        });
    }
}
```

Step 4: Convert the `new MyConsumer` anonymous instantiation into a lambda using your IDE's faculties

Step 5: Run to verify it all works!

A Detour with Method References

- When a lambda expression does nothing but call an existing method
- It's often clearer to refer to the existing method by name.
- Works with lambda expressions for methods that already have a name.

Types of Method References

Table 1. Types of Method References

Kind	Example
Reference to a static method	`ContainingClass::staticMethodName`
Reference to an instance method of a particular object	`containingObject::instanceMethodName`
Reference to an instance method of an arbitrary object of a particular type	`ContainingType::methodName`
Reference to a constructor	`ClassName::new`

Lab: `forEach` with a method reference

Step 1: Convert `x → System.out.println(x)` from the `testForEach` exercise in ***LambdasTest.java*** into a method reference.

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testForEach() {
        List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
                                              21, 33, 78, 93, 10);
        Functions.myForEach(numbers, System.out::println);
    }
}
```

Although confusing, in `System.out`, `out` is a `public final static` variable. Therefore, `println` is a non-static method of `java.io.PrintStream`. This is an instance method of an object.

Lab: Method Reference to a static method

Step 1: Enter the following in the test method, `testMethodReferenceAStaticMethod` into ***LambdasTests.java*** and convert it using a method reference.

```java
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testMethodReferenceAStaticMethod() {
        List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
                                              21, 33, 78, 93, 10);
        System.out.println(Functions.myMap(numbers, a -> Math.abs(a)));
    }
}
```

Use your IDE to guide you. It's easier that way.

Step 2: Run to verify it all works!

Lab: Method Reference with a Containing Type

Step 1: Enter the following test method `testMethodReferenceAContainingType` in ***LambdasTest.java*** and convert it using a method reference.

```java
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testMethodReferenceAContainingType() {
        List<String> words = Arrays.asList("One", "Two", "Three", "Four");
        System.out.println(Functions.myMap(words, s -> s.length()));
    }
}
```

Use your IDE to guide you. It's easier that way.

Step 2: Run to verify it all works!

Lab: Method Reference with a Containing Type Trick Question

Step 1: Enter the following test method `testMethodReferenceAContainingTypeTrickQuestion` in ***LambdasTest.java*** and convert it using a method reference.

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testMethodReferenceAContainingTypeTrickQuestion() {
        List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
                                              21, 33, 78, 93, 10);
        System.out.println(Functions.myMap(numbers, number -> number.toString()));
    }
}
```

Use your IDE to guide you. It's easier that way.

Step 2: Run to verify it all works!

Lab: Create a `Tax Rate` class:

Step 1: In `src/main/java`, create a file called ***TaxRate.java*** in the `com.xyzcorp` package with the following content:

```java
package com.xyzcorp;

public class TaxRate {
    private final int year;
    private final double taxRate;

    public TaxRate(int year, double taxRate) {
        this.year = year;
        this.taxRate = taxRate;
    }

    public double apply(int subtotal) {
        return (subtotal * taxRate) + subtotal;
    }
}
```

Step 2: Ensure it compiles.

Lab: Method Reference with an Instance

Step 1: Enter the following test method `testMethodReferenceAnInstance` in ***LambdasTest.java*** and convert it using a method reference.

```java
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testMethodReferenceAnInstance() {
        List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
                                              21, 33, 78, 93, 10);
        TaxRate taxRate2016 = new TaxRate(2016, .085);
        System.out.println(Functions.myMap(numbers, subtotal -> taxRate2016.apply
(subtotal)));
    }
}
```

Use your IDE to guide you. It's easier that way.

Step 2: Run to verify it all works!

Lab: Method Reference with an New Type

Step 1: Enter the following test method `testMethodReferenceANewType` in ***LambdasTest.java*** and convert it using a method reference.

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testMethodReferenceANewType() {
        List<Integer> numbers = Arrays.asList(2, 4, 5, 1, 9, 15, 19,
                                              21, 33, 78, 93, 10);
        System.out.println(Functions.myMap(numbers, value -> new Double(value)));
    }
}
```

Use your IDE to guide you. It's easier that way.

Step 2: Run to verify it all works!

Lab: Create `MySupplier`

Step 1: In `src/main/java`, create an `interface` in the `com.xyzcorp` package called `MySupplier`

```
package com.xyzcorp;

public interface MySupplier<T> {
   public T get();
}
```

Compare the difference to `MyConsumer`

Lab: Create a `myGenerate` in *Functions.java*

Step 1: Create `static` method called `myGenerate` with the following method header which takes a `MySupplier`, and a count, and returns a `List` with `count` number of items where each element is derived from invoking the `Supplier`

```java
public static <T> List<T> myGenerate(MySupplier<T> supplier, int count) {}
```

Step 2: Fill in the method with what you believe a `myGenerate` should look like

Lab: Use `myGenerate` in *LambdasTest.java*

Step 1: Add the following test, `testMyGenerate` to the `LambdasTests` class:

```java
package com.xyzcorp;

import org.junit.Test;

import java.time.LocalDateTime;
import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testMyGenerate() {
        List<LocalDateTime> localDateTimes =
          Functions.myGenerate(new MySupplier<LocalDateTime>() {
              @Override
              public LocalDateTime get() {
                  return LocalDateTime.now();
              }
          }, 10);
        System.out.println(localDateTimes);
    }
}
```

`LocalDateTime.now()` is from the new Java Date/Time API from Java 8.

Step 2: Convert the `new MySupplier` anonymous instantiation into a lambda using your IDE's faculties

Step 3: Run to verify it all works!

Lab: Viewing Consumer, Supplier, Predicate, Function, in the official Javadoc.

https://docs.oracle.com/javase/8/docs/api/java/util/function/package-summary.html

Lab: Multi-line Lambdas

Step 1: In ***LambdasTest.java*** create the following test, `testLambdasWithRunnable` where a `java.lang.Runnable` and `java.lang.Thread` is being created.

```
package com.xyzcorp;

import org.junit.Test;

import java.time.LocalDateTime;
import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testLambdasWithRunnable() {
        Thread t = new Thread(new Runnable() {
            @Override
            public void run() {
                String threadName =
                        Thread.currentThread().getName();
                System.out.format("%s: %s%n",
                        threadName,
                        "Hello from another thread");
            }
        });
        t.start();
    }
}
```

`Runnable` is an `interface` with one `abstract` method.

Step 2: Convert the `Runnable` into a lambda.

Step 3: Notice how the lambda is created, this is a multi-line lambda.

Closure

- *Lexical scoping* caches values provided in one context for use later in another context.
- If lambda expression closes over the scope of its definition, it is a *closure*.

```java
public static Integer foo
        (Function<Integer, Integer> f) {
    return f.apply(5);
}

public void otherMethod() {
    Integer x = 3;
    Function<Integer, Integer> add3 = z -> x + z;
    System.out.println(foo(add3));
}
```

Lexical Scoping Restrictions

- To avoid any race conditions:
  - The variable that is being in enclosed must either be:
    - `final`
    - *Effectively final*. No change can be made after used in a closure.

Closure Error

The following will not work...

```java
public static Integer foo
        (Function<Integer, Integer> f) {
    return f.apply(5);
}

public void otherMethod() {
    Integer x = 3;
    Function<Integer, Integer> add3 = z -> x + z;
    x = 10;
    System.out.println(foo(add3));
}
```

Lab: Create Duplicated Code

An application for a closure is to avoid repetition.

Step 1: In ***LambdasTest.java*** create the following test, `testClosuresAvoidRepeats`

```java
package com.xyzcorp;

import org.junit.Test;

import java.time.LocalDateTime;
import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    @Test
    public void testClosuresAvoidRepeats() {
        MyPredicate<String> stringHasSizeOf4 =
                str -> str.length() == 4;

        MyPredicate<String> stringHasSizeOf2 =
                str -> str.length() == 2;

        List<String> names = Arrays.asList("Foo", "Ramen", "Naan", "Ravioli");
        System.out.println(Functions.myFilter(names, stringHasSizeOf4));
        System.out.println(Functions.myFilter(names, stringHasSizeOf2));
    }
}
```

Step 2: Notice that `stringHasSize4` and `stringHasSize2` are duplicated.

Lab: Refactor Duplicated Code with a Closure

An application for a closure is to avoid repetition.

Step 1: In ***LambdasTest.java*** change `testClosuresAvoidRepeats` to avoid repeats to look like the following:

```java
package com.xyzcorp;

import org.junit.Test;

import java.time.LocalDateTime;
import java.util.Arrays;
import java.util.List;

public class LambdasTest {

    ...

    public MyPredicate<String> stringHasSizeOf(final int length) {
        return null; //Create your closure here
    }

    @Test
    public void testClosuresAvoidRepeats() {
        List<String> names = Arrays.asList("Foo", "Ramen", "Naan", "Ravioli");
        System.out.println(Functions.myFilter(names, stringHasSizeOf(4)));
        System.out.println(Functions.myFilter(names, stringHasSizeOf(2)));
    }
}
```

Step 2: Inside of `stringHasSizeOf(final int length)` return a `MyPredicate` that *closes* around the length.

`Optional`

> I call it my billion-dollar mistake. It was the invention of the null reference in 1965. At that time, I was designing the first comprehensive type system for references in an object oriented language (ALGOL W). My goal was to ensure that all use of references should be absolutely safe, with checking performed automatically by the compiler. But I couldn't resist the temptation to put in a null reference, simply because it was so easy to implement. This has led to innumerable errors, vulnerabilities, and system crashes, which have probably caused a billion dollars of pain and damage in the last forty years.

`Optional` Defined in Java 8

> A **container object** which may or may not contain a non-null value. If a value is present, `isPresent()` will return `true` and `get()` will return the value.

Optional is **not** `Serializable`

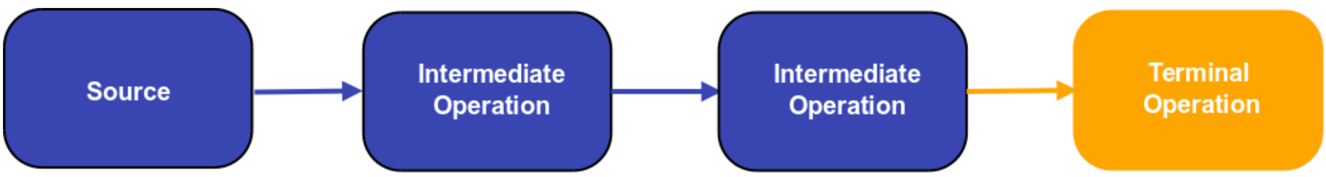
This is a value-based class; use of identity-sensitive operations (including reference equality (`==`), identity hash code, or synchronization) on instances of `Optional` may have unpredictable results and should be avoided.

Streams

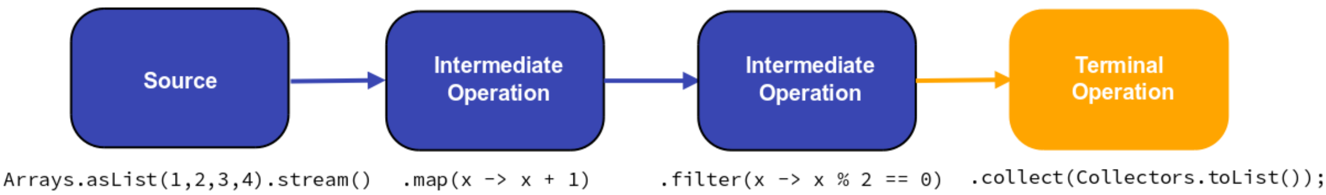
`Streams` differ from Collections in the following ways:

- No storage. A stream is not a data structure that stores elements; instead
- It conveys elements from a source through a pipeline of computational operations
- Sources can include.
  - Data structure
  - An array
  - Generator function
  - I/O channel
- Functional in nature. An operation on a stream produces a result, **but does not modify its source**.
- Intermediate operations are laziness-seeking exposing opportunities for optimization.
- Possibly unbounded. While collections have a finite size, streams need not.
- Short-circuiting operations such as `limit(n)` or `findFirst()` can allow computations on infinite streams to complete in finite time.
- Consumable, The elements of a stream are only visited once during the life of a stream.
- Like an `java.util.Iterator`, a new `Stream` must be generated to revisit the same elements of the source.

Streams Overview



Streams Overview With Code



Lab: Create a Basic Stream

Step 1: Create a class called StreamsTest in the `com.xyzcorp` package with the following test:

Step 2: Run the test

```
package com.xyzcorp;

import org.junit.Test;

import java.util.Arrays;
import java.util.List;
import java.util.stream.Collectors;

public class StreamsTest {

    @Test
    public void testBasicStream() {
        List<Integer> strings = Arrays.asList(1, 4, 5, 10, 11, 12, 40, 50);
        strings.stream().map(x -> x + 1).collect(Collectors.toList());
    }
}
```

- The `stream()` call converts the string `List` into a stream
- The stream becomes a pipeline that functional operations can be completed.
- `map` is an intermediate operation
- `collect` is an terminal operation
- The terminal operation will convert the `stream` into a list`
- `Collectors` offers a wide range of different terminal operations

Doing your own collecting

- When calling `collect`, you can specify your own functions

Java API for the `Stream` method `collect`:

```
<R> R collect(Supplier<R> supplier,
              BiConsumer<R, ? super T> accumulator,
              BiConsumer<R, R> combiner);
```

The `Supplier` in `collect`

- `Function` that creates a new result container.
- In a parallel execution:
  - May be called multiple times
  - Must return a fresh value each time.

Java API for the `Stream` method `collect`:

```
<R> R collect(Supplier<R> supplier,
              BiConsumer<R, ? super T> accumulator,
              BiConsumer<R, R> combiner);
```

The `Accumulator` in `collect`

- `Function` for incorporating an additional element into a result

Java API for the `Stream` method `collect`:

```
<R> R collect(Supplier<R> supplier,
              BiConsumer<R, ? super T> accumulator,
              BiConsumer<R, R> combiner);
```

The `Combiner` in `collect`

- `Function` for combining two values
- Must be compatible with the `accumulator` function

Java API for the `Stream` method `collect`:

```
<R> R collect(Supplier<R> supplier,
              BiConsumer<R, ? super T> accumulator,
              BiConsumer<R, R> combiner);
```

Lab: Create your own `collect`

Step 1: In `StreamsTest` in create the following test, `testCompleteCollector` (Yes, it's a bit long)

```
@Test
public void testCompleteCollector() {
   List<Integer> numbers = Arrays.asList(0, 1, 2, 3, 4, 5, 6, 7, 8, 9);
   List<Integer> result = numbers.stream()
                       .map(x -> x + 1)
                       .collect(
   new Supplier<List<Integer>>() {
       @Override
       public List<Integer> get() {
           return new ArrayList<Integer>();
       }
   }, new BiConsumer<List<Integer>, Integer>() {
       @Override
       public void accept(List<Integer> integers, Integer integer) {
           System.out.println("adding integer: " + integer);
           integers.add(integer);
       }
   }, new BiConsumer<List<Integer>, List<Integer>>() {
       @Override
       public void accept(List<Integer> left, List<Integer> right) {
           synchronized (numbers) {
               System.out.println("left = " + left);
               System.out.println("right = " + right);
               left.addAll(right);
               System.out.println("combined = " + left);
           }
       }
   });
   System.out.println("Ending with the result = " + result);
}
```

Step 2: Run the test

Step 3: Discuss what we are looking at.

Step 4: Using your IDEs convert these functions to lambdas or method references.

Parallelizing Streams

- We can call `parallel()` anywhere in our pipeline when needed.
- This is will cause the rest of that pipeline to be executed on a different thread.
- Aggregate operations and parallel streams enable you to implement parallelism with non-thread-safe collections, provided that you ***do not modify the collection*** while you are operating on it.
- Parallelism is not automatically faster than performing operations serially, although it can be if you have enough data and processor cores

Lab: Parallelizing `collect`

Step 1: In `StreamsTest`, and in the `testCompleteCollector` add a `parallel` to the stream pipeline.

```
@Test
public void testCompleteCollector() {
    List<Integer> numbers = Arrays.asList(0, 1, 2, 3, 4, 5, 6, 7, 8, 9);
    List<Integer> result = numbers.stream().map(x -> x + 1).parallel().collect(
            ArrayList::new,
            (integers, integer) -> {
                System.out.println("adding integer: " + integer);
                integers.add(integer);
            }, (left, right) -> {
                synchronized (numbers) {
                    System.out.println("left = " + left);
                    System.out.println("right = " + right);
                    left.addAll(right);
                    System.out.println("combined = " + left);
                }
            });
    System.out.println("Ending with the result = " + result);
}
```

Step 2: Run the test

Step 3: Discuss what we are looking at and how it is different without `parallel`

Lab: Testing a Summation Terminal Operation

Step 1: In `StreamsTest`, create a `testSum` test with the following content

```
@Test
  public void testSum() {
      List<Integer> numbers = Arrays.asList(0, 1, 2, 3, 4, 5, 6, 7, 8, 9);
      Integer result = numbers.stream().map(x -> x + 1)
                       .collect(Collectors.summingInt(x -> x));
      System.out.println(result);
  }
}
```

Step 2: Run the test

Specialized Streams

- There are a collection of primitive based `Stream` that support sequential and parralel aggregate operations.
- These operations are specialized for those primitives and they include
  - `IntStream`
    - To convert from a `Stream<Integer>` to a `IntStream` used `mapToInt`
    - To convert from a `IntStream` to a `Stream<Integer>` use `boxed()`
  - `DoubleStream`
    - To convert from a `Stream<Double>` to a `DoubleStream` used `mapToDouble`
    - To convert from a `DoubleStream` to a `Stream<Double>` use `boxed()`
  - `LongStream`
    - To convert from a `Stream<Long>` to a `LongStream` used `mapToLong`
    - To convert from a `LongStream` to a `Stream<Double>` use `boxed()`

Lab: In `StreamsTest` using `of`:

Step 1: In `StreamsTest` create a test called `testUsingStreamsOf` with the following content:

```
@Test
public void testCreateStreamsUsingOf() {
    Stream<Integer> streamOfInteger = Stream.of(1, 2, 3, 4, 5);
    //int primitive specialization of a stream
    IntStream intStream = IntStream.of(1, 2, 3, 4, 5);
}
```

Using your IDE check the differences between `streamOfInteger` and `intStream`

Step 2: Run the test

Lab: Choosing Between an `IntStream` and a `Stream<Integer>`

Step 1: Create one test in `StreamsTest` called `testStreamGetAverageGradesUsingCollector` with the following content:

```
@Test
public void testStreamGetAverageGradesUsingStream() {
    Stream<Integer> grades = Stream.of(100, 99, 95, 88, 100, 90, 85);
    Double collect = grades.collect(Collectors.averagingInt(x -> x));
    System.out.println(collect);
}
```

Step 2: Create another test in `StreamsTest` called `testStreamGetAverageGradeUsingIntStream()` with the following content:

```
public void testStreamGetAverageGradesUsingIntStream() {
   IntStream grades = IntStream.of(100, 99, 95, 88, 100, 90, 85);
   OptionalDouble optionalDouble = grades.average();
   System.out.println(optionalDouble);
}
```

Step 2: Run both tests and compare and contrast API calls using IDE and Javadoc.

Lab: Converting from `IntStream` to `Stream<Integer>`

Step 1: Create a test in `StreamsTest` called `testConvertToStream()` with the following content:

```
@Test
public void testConvertToStream() {
    Set<Integer> set = IntStream.range(5, 10)
                                .filter(x -> x % 2 == 0)
                                .boxed()
                                .collect(Collectors.toSet());
    System.out.println(set);
}
```

The issue with `IntRange` is that you are left to do you own collect.

Step 2: Run the test.

Lab: Converting from `Stream<Integer>` to `IntStream`

Step 1: Create a test in `StreamsTest` called `testConvertToStream()` with the following content:

```java
@Test
public void testConvertToIntStream() {
  Stream<Integer> numbers = Stream.of(100, 33, 22, 400, 30);
  IntStream intStream = numbers.mapToInt(x -> x);
  System.out.println(intStream.sum());
}
```

Step 2: Run the test.

Lab: Having more choice with `IntStream` vs. `Stream<Integer>`

`IntStream` has some really nice methods, that you would like to use that aren't a part of `Stream<Integer>`

Step 1 In `StreamsTest`, create a test called `testIntStreamSummaryStatistics` with the following content:

```java
@Test
public void testIntStreamSummaryStatistics() {
    Stream<Integer> numbers = Stream.of(100, 33, 22, 400, 30);
    IntStream intStream = numbers.mapToInt(x -> x);
    System.out.println(intStream.summaryStatistics());
}
```

Step 2: Run the test

Step 3: Using your IDE discover some of the other options available to `IntStream`

Lab: Peeking into what is going on…

`peek` is a functional method on a `Stream` that allow you to peer into what is going on. You can plug a `peek` at any part.

Step 1: Create a test in `StreamsTest` called `testStreamWithPeek()` with the following content:

```java
@Test
public void testStreamWithPeek() {
    List<Integer> result = Stream.of(1, 2, 3, 4, 5)
            .map(x -> x + 1)
            .peek(System.out::println)
            .filter(x -> x % 2 == 0)
            .collect(Collectors.toList());
    System.out.println(result);
}
```

Peek is a side effect intermediate calculation to view the state of the the chain.

Step 2: Run the test

Getting `distinct` values from the `Stream`

Now that you understand more of the basic concepts here is another one, `distinct` that filters out all the distinct values of the `Stream`

```
List<Integer> result = Stream.of(1, 2, 3, 4, 5, 4, 3, 2, 1)
  .distinct()
  .peek(System.out::println)
  .collect(Collectors.toList());
  System.out.println(result);
```

Lab: Laziness and the `limit`

One of the most important things about `Stream` is that it is lazily evaluated. Consider the following lab.

Step 1: Create a test in `StreamsTest` called `testLimit` with the following content:

```
@Test
public void testLimit() {
    Stream<Integer> integerStream = Stream.iterate(0, x -> x + 1); //Goes on forever!
    List<Integer> result = integerStream.map(x -> x + 4)
                               .peek(System.out::println)
                               .limit(10)
                               .collect(Collectors.toList());
    System.out.println(result);
}
```

`Stream` can be programmed to be infinite!

Step 2: Decide, will this run forever, or stop at 10 iterations?

Step 3: Run the test

Lab: Essence of `flatMap`

This is one of the hardest topics in all of functional programming, but one of the most essential. `flatMap` is the combination of `flatten` and `map`, but there is more to it.

Step 1: Create a test called `testFlatMap` in `StreamsTest` with the following content.

```java
@Test
public void testFlatMap() {
    Stream<Integer> streamStream = Stream.of(1, 2, 3, 4)
                                        .flatMap(x -> Stream.of(-x, x, x + 2));
    List<Integer> list = streamStream.collect(
                                Collectors.toCollection(ArrayList::new));
    System.out.println(list);
}
```

Step 2: Run the test and consider what `streamStream` type would be without `flatMap`

Step 3: Have a further discussion on `flatMap`

Reductions

Reduction is taking streams of data, and whittling it down to some smaller answer. With `Stream` there are two variants:

- One with a seed
- One that will take the first element of the `Stream`

Lab: Reductions with a seed

Step 1: In `StreamsTest` create a new test called `testReduceWithASeed()` with the following content:

```java
@Test
public void testReduceWithASeed() {
    Stream<Integer> stream = Stream.of(1, 2, 3, 4, 5, 6);
    Integer reduction = stream.reduce(0, (total, next) -> {
        System.out.format("total: %d, next: %d\n", total, next);
        return total + next;
    });
    System.out.println(reduction);
}
```

Step 2: Run the test, evaluate the output to see how all of this works.

Lab: Reductions without a seed

Step 1: In `StreamsTest` create a new test called `testReduce()` with the following content:

```java
@Test
public void testReduceWithASeed() {
    Stream<Integer> stream = Stream.of(1, 2, 3, 4, 5, 6);
    Integer reduction = stream.reduce(0, (total, next) -> {
        System.out.format("total: %d, next: %d\n", total, next);
        return total + next;
    });
    System.out.println(reduction);
}
```

Step 2: Run the test, evaluate the output to see how all of this works.

Bonus: What would if be called if we used `*` instead of `+`?

Lab: Sorting a `Stream`

Sort a `Stream` anywhere needed:

- With `sorted()` to use the natural `Comparable<T>`
- With `sorted(BiFunction)` to use the natural `Comparable<T>`
- With `sorted(Comparator)` to use your own algorithm

Let's first use the natural sorting.

Step 1: In `StreamsTest` create a new test called `testSorted()` with the following content:

```java
@Test
public void testSorted() {
    Stream<String> stream =
        Stream.of("Apple", "Orange", "Banana", "Tomato", "Grapes");
    System.out.println(stream.sorted().collect(Collectors.toList()));
}
```

Step 2: Run the test to evaluate

Lab: Sorting a `Stream` with what looks like a `BiFunction`

Step 1: In `StreamsTest` create a new test called `testWithComparator()` with the following content which will sort the `Stream` of `String` by their size.

```
@Test
public void testSortedWithComparator() {
    Stream<String> stream =
       Stream.of("Apple", "Orange", "Banana", "Tomato", "Grapes");
    System.out.println(stream
            .sorted((string1, string2) -> string1.length() - string2.length())
            .collect(Collectors.toList()));
}
```

Step 2: Run the test to evaluate

Step 3: It's not really a `BiFunction` is it? What is it?

Lab: Sorting a `Stream` with a compound `Comparator`

Step 1: In `StreamsTest` create a new test called `testWithComparatorLevels` with the following content:

```
@Test
public void testSortedWithComparatorLevels() {
    Stream<String> stream =
         Stream.of("Apple", "Orange", "Banana", "Tomato", "Grapes");
    Comparator<String> stringComparator = Comparator.comparing(String::length)
            .thenComparing(x -> x);
    System.out.println(stream)
            .sorted(stringComparator)
            .collect(Collectors.toList()));
}
```

Step 2: Run the test, but keep in mind what is going on with `stringComparator` and discuss.

Identity Function Defined

$f(x) = x$

> In mathematics, an identity function, also called an identity relation or identity map or identity transformation, is a function that always returns the same value that was used as its argument.

Source: [Wikipedia]

Inside of `java.util.Function`

```
static <T> Function<T, T> identity() {
        return t -> t;
}
```

Lab: Replace `x → x` with `Function.identity`

Step 1: In the last example, replace `x → x` with `Function.identity`

Lab: Grouping

We saw that `Stream` can be reduced, but they can also be grouped and partitioned. Grouping allows you to group data by category.

Step 1: In `StreamsTest` create a test called `testGrouping` with the following content.

```
@Test
public void testGrouping() {
    Stream<String> stream =
       Stream.of("Apple", "Orange", "Banana", "Tomato", "Grapes");
    Map<Character, List<String>> groups = stream
             .collect(Collectors.groupingBy(s -> s.charAt(0)));
    System.out.println(groups);
}
```

Step 2: Run the test. Were they the results that you expected?

Lab: Partitioning

Partitioning will split based on a `boolean`.

Step 1: In `StreamsTest` create a test called `testPartitioning` with the following content.

```
@Test
public void testPartitioning() {
    Stream<String> stream =
       Stream.of("Apple", "Orange", "Banana", "Tomato", "Grapes");
    Map<Boolean, List<String>> partition = stream.collect
            (Collectors.partitioningBy(s -> "AEIOU"
                    .indexOf(s.toUpperCase().charAt(0)) > 0));
    System.out.println(partition);
}
```

Step 2: Run the test

Lab: Joining

Finally, `joining` is a reducer that will format `Streams` into a well formatted `String`

Step 1: In our old friend `StreamsTest` create `testJoining` test with the following:

```
@Test
public void testJoining() {
    Stream<String> stream =
       Stream.of("Apple", "Orange", "Banana", "Tomato", "Grapes");
    System.out.println(stream.collect(Collectors.joining(", ")));
}
```

Step 2: Run the test.

Step 3: Replace with last line with a different variant.

```
System.out.println(stream.collect(Collectors.joining(", ", "{", "}")));
```

If time allows, *Discovering America*

Step 1: `java.time.ZoneId` has a method called `getAvailableZoneIds` that returns a `Set<String>`, convert the `Set<String>` to a `Stream<String>`

Step 2: Next find all the distinct time zones in the Americas.

Step 3: Only return the name of the time zone not the prefix of `America/`. If the time zone was `America/New_York`, make sure that it is only `New_York`.

Step 4: Use `sorted()` which uses the natural `Comparable` of the object

Step 5: Recollect the stream back into a `Set` or `List`