

CSC 835 - Project Management - Summer 2023

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Assignment 4 - TDD with JUnit

Due Date: 08/06/2023

The purpose of this assignment is to practice Test-Driven Development with JUnit. To complete this assignment, you will implement the algorithm/function described below with the following procedure:

This Project will use the Maven Build Tool for testing the Java Program with JUnit in the Cygwin POSIX Development Environment where JDK 11+ among other CLTs are installed. No IDE will be utilized for Test Cases. With Apache Maven Version 3.9.4 installed, in the project root directory, the project archetype is generated using the following maven command :

```
mvn archetype:generate -DgroupId=edu.eku -DartifactId=csc835-assignment-4 -DarchetypeArtifactId=maven-archetype-quickstart -DinteractiveMode=false
```

With the project generated, modify the src files for both main and test to reflect the name of the project: SmallestAndLargest.java and SmallestAndLargestTest.java. Replace the source code with the code utilizing the straightforward algorithm for finding the smallest and largest values in an array. Modify the pom.xml (Project Object Model XML file) file and define the JUnit dependencies being used: JUnit Version 4.13.2. Confirm that each of the Maven Commands being used will execute without issue and the program runs: mvn compile, mvn test, mvn package, and java. Create 7 test cases for the new code being tested which is an improved processing algorithm for accomplishing the task of finding the smallest and largest values in an array. With each test case, modify the source code until it passes without fail. Once the code passes all test cases, refactor the code and comment where applicable.

Having used JUnit with the Maven Build tool via the command line for testing Java code for a given project, the value of TDD is demonstrated with respect to the development environment whether that is a custom environment like the one used in this report or an IDE such as Eclipse. Instead of running the program with hard coded values or passing in the same values again and again, the JUnit test case confirms if the expected output is achieved for a given test case. This is far more convenient and documented than trying different scenarios without recording results. These test cases can be used again and again throughout the development life cycle providing assurance to the project stakeholders and developers.

1. Generate a Java project using the Maven build tool via Cygwin

```
Cruz@DESKTOP-FS9D5BD ~/csc835
$ mvn archetype:generate -DgroupId=edu.eku -DartifactId=csc835-assignment-4 -DarchetypeArtifactId=maven-archetype-quickstart -DinteractiveMode=false
```

```
Cruz@DESKTOP-FS9D5BD ~/csc835
$ mvn archetype:generate -DgroupId=edu.eku -DartifactId=csc835-assignment-4 -DarchetypeArtifactId=maven-archetype-quickstart -DinteractiveMode=false
[INFO] Scanning for projects...
[INFO]
[INFO] -----< org.apache.maven:standalone-pom >-----
[INFO] Building Maven Stub Project (No POM) 1
[INFO] -----[ pom ]-----
[INFO]
[INFO] >>> archetype:3.2.1:generate (default-cli) > generate-sources @ standalone-pom >>>
[INFO]
[INFO] <<< archetype:3.2.1:generate (default-cli) < generate-sources @ standalone-pom <<<
[INFO]
[INFO] --- archetype:3.2.1:generate (default-cli) @ standalone-pom ---
[INFO] Generating project in Batch mode
[INFO]
[INFO] Using following parameters for creating project from old (1.x) Archetype: maven-archetype-quickstart:1.0
[INFO]
[INFO] -----
[INFO] Parameter: basedir, Value: C:\cygwin64\home\Cruz\csc835
[INFO] Parameter: package, Value: edu.eku
[INFO] Parameter: groupId, Value: edu.eku
[INFO] Parameter: artifactId, Value: csc835-assignment-4
[INFO] Parameter: packageName, Value: edu.eku
[INFO] Parameter: version, Value: 1.0-SNAPSHOT
[INFO] project created from old (1.x) Archetype in dir: C:\cygwin64\home\Cruz\csc835\csc835-assignment-4
[INFO]
[INFO] -----
[INFO] BUILD SUCCESS
[INFO]
[INFO] -----
[INFO] Total time: 3.311 s
[INFO] Finished at: 2023-08-05T11:35:45-04:00
[INFO]
[INFO] -----
Cruz@DESKTOP-FS9D5BD ~/csc835
$
```

Project Object Model

```
1 <project xmlns="http://maven.apache.org/POM/4.0.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
2   xsi:schemaLocation="http://maven.apache.org/POM/4.0.0 http://maven.apache.org/maven-v4_0_0.xsd">
3   <modelVersion>4.0.0</modelVersion>
4   <groupId>edu.eku</groupId>
5   <artifactId>csc835-assignment-4</artifactId>
6   <packaging>jar</packaging>
7   <version>1.0-SNAPSHOT</version>
8   <name>csc835-assignment-4</name>
9   <url>http://maven.apache.org</url>
10  <dependencies>
11    <dependency>
12      <groupId>junit</groupId>
13      <artifactId>junit</artifactId>
14      <version>4.13.2</version>
15      <scope>test</scope>
16    </dependency>
17  </dependencies>
18 </project>
19
```

Project Contents and Subdirectories

```
~/csc835/csc835-assignment-4
Cruz@DESKTOP-F59D5BD ~/csc835/csc835-assignment-4
$ ls . src/main/java/edu/eku/ src/test/java/edu/eku/ target target/classes/edu/eku/ target/test-classes/edu/eku/
.:
pom.xml runJava.sh src target

src/main/java/edu/eku/:
SmallestAndLargest.java

src/test/java/edu/eku/:
SmallestAndLargestTest.java

target:
classes csc835-assignment-4-1.0-SNAPSHOT.jar generated-sources generated-test-sources maven-archiver maven-status surefire-reports test-classes

target/classes/edu/eku/:
SmallestAndLargest.class

target/test-classes/edu/eku/:
SmallestAndLargestTest.class

Cruz@DESKTOP-F59D5BD ~/csc835/csc835-assignment-4
$
```

Project Initial Maven Compile

```
~/csc835/csc835-assignment-4
cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ mvn compile
[INFO] Scanning for projects...
[INFO]
[INFO] -----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO]
[INFO] --- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\resources
[INFO]
[INFO] --- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] changes detected - recompiling the module! :source
[WARNING] File encoding has not been set, using platform encoding UTF-8, i.e. build is platform dependent!
[INFO] Compiling 1 source file with javac [debug target 1.8] to target\classes
[WARNING] bootstrap class path not set in conjunction with -source 8
[WARNING] source value 8 is obsolete and will be removed in a future release
[WARNING] target value 8 is obsolete and will be removed in a future release
[WARNING] To suppress warnings about obsolete options, use -Xlint:-options.
[INFO]
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----
[INFO]
[INFO] Total time: 0.918 s
[INFO] Finished at: 2023-08-05T11:47:35-04:00
[INFO] -----
cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$
```

Project Initial Maven Test

```
~/csc835/csc835-assignment-4
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ mvn test
[INFO] Scanning for projects...
[INFO]
[INFO] -----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO]
[INFO] --- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\resources
[INFO]
[INFO] --- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO]
[INFO] --- resources:3.3.1:testResources (default-testResources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\resources
[INFO]
[INFO] --- compiler:3.11.0:testCompile (default-testCompile) @ csc835-assignment-4 ---
[INFO] Changes detected - recompiling the module! :source
[WARNING] File encoding has not been set, using platform encoding UTF-8, i.e. build is platform dependent!
[INFO] Compiling 1 source file with javac [debug target 1.8] to target\test-classes
[WARNING] bootstrap class path not set in conjunction with -source 8
[WARNING] source value 8 is obsolete and will be removed in a future release
[WARNING] target value 8 is obsolete and will be removed in a future release
[WARNING] To suppress warnings about obsolete options, use -Xlint:-options.
[INFO]
[INFO] --- surefire:3.1.2:test (default-test) @ csc835-assignment-4 ---
[INFO] Using auto detected provider org.apache.maven.surefire.junit.JUnit3Provider
[INFO]
[INFO] -----
[INFO] T E S T S
[INFO] -----
[INFO] Running edu.eku.SmallestAndLargestTest
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.015 s -- in edu.eku.SmallestAndLargestTest
[INFO]
[INFO] Results:
[INFO]
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----
[INFO] Total time: 1.591 s
[INFO] Finished at: 2023-08-05T11:49:53-04:00
[INFO]
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
```

Project Initial Maven Package

```
~/csc835/csc835-assignment-4
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ mvn package
[INFO] Scanning for projects...
[INFO]
[INFO] -----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO]
[INFO] --- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\resources
[INFO]
[INFO] --- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO]
[INFO] --- resources:3.3.1:testResources (default-testResources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\resources
[INFO]
[INFO] --- compiler:3.11.0:testCompile (default-testCompile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO]
[INFO] --- surefire:3.1.2:test (default-test) @ csc835-assignment-4 ---
[INFO] Using auto detected provider org.apache.maven.surefire.junit.JUnit3Provider
[INFO]
[INFO] -----
[INFO] T E S T S
[INFO] -----
[INFO] Running edu.eku.SmallestAndLargestTest
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.017 s -- in edu.eku.SmallestAndLargestTest
[INFO] Results:
[INFO]
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO] --- jar:3.3.0:jar (default-jar) @ csc835-assignment-4 ---
[INFO] Building jar: C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\target\csc835-assignment-4-1.0-SNAPSHOT.jar
[INFO]
[INFO] BUILD SUCCESS
[INFO]
[INFO] Total time: 1.478 s
[INFO] Finished at: 2023-08-05T11:50:46-04:00
[INFO]
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ |
```

Running the Java Program via CLTs – simple Hello World program

```
~/csc835/csc835-assignment-4
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ java -cp target/csc835-assignment-4-1.0-SNAPSHOT.jar edu.eku.SmallestAndLargest
Hello World!

Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ |
```

Main Java Program (SmallestAndLargest.java) and Build (Straightforward Algorithm) - **Design a function in Java to show the smallest and the largest numbers in an array of integers.**

```
C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\java\edu\eku\SmallestAndLargest.java - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
change.log App.java AppTest.java pom.xml runJava.sh SmallestAndLargestTest.java SmallestAndLargest.java Main.java runJava.sh pom.xml SmallestAndLargest.java Smal

1 package edu.eku;
2 /**
3  * COURSE: CSC 835 Project Management Summer 2023
4  * PROJECT: Assignment 4 - TDD with JUnit
5  * PROGRAMMER: Cruz Macias
6  * DESCRIPTION:
7  *
8  *
9  */
10 public class SmallestAndLargest {
11 {
12 //remove main once Test Cases are implemented
13 public static void main(String[] args) {
14 int[] nums = {5, 2, 9, 1, 7};
15 Pair result = findSmallestAndLargest(nums);
16 System.out.println("Smallest: " + result.getFirst());
17 System.out.println("Largest: " + result.getSecond());
18 }
19 }
20 /**
21 * FUNCTION: Pair
22 * DESCRIPTION: compare values in an array and return the smallest and largest as a pair
23 */
24 public static Pair findSmallestAndLargest(int[] nums) {
25 if (nums == null || nums.length == 0) {
26 return null;
27 }
28
29 int smallest = nums[0];
30 int largest = nums[0];
31
32 for (int i = 1; i < nums.length; i++) {
33 if (nums[i] < smallest) {
34 smallest = nums[i];
35 }
36 if (nums[i] > largest) {
37 largest = nums[i];
38 }
39 }
40
41 return new Pair(smallest, largest);
42 }
43 }
```

Pair Class Definition

```
C:\cygwin64\home\Cruz\csc835-assignment-4\src\main\java\edu\eku\SmallestAndLargest.java - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
change.log App.java AppTest.java pom.xml runJava.sh SmallestAndLargestTest.java SmallestAndLargest.java Main.java runJava.sh pom.xml SmallestAndLargest.java

44
45 /**
46  * CLASS: Pair
47  * DESCRIPTION: create a pair of two values
48  */
49 class Pair {
50     private int first;
51     private int second;
52
53     public Pair(int first, int second) {
54         this.first = first;
55         this.second = second;
56     }
57
58     public int getFirst() {
59         return first;
60     }
61
62     public int getSecond() {
63         return second;
64     }
65 }
```

Maven Compile Test and Build with new code


```

~/csc835/csc835-assignment-4
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ mvn compile
[INFO] Scanning for projects...
[INFO]
[INFO] -----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO]
[INFO] --- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\resources
[INFO]
[INFO] --- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] changes detected - recompiling the module! :source
[WARNING] File encoding has not been set, using platform encoding UTF-8, i.e. build is platform dependent!
[INFO] compiling 1 source file with javac [debug target 1.8] to target\classes
[WARNING] bootstrap class path not set in conjunction with -source 8
[WARNING] source value 8 is obsolete and will be removed in a future release
[WARNING] target value 8 is obsolete and will be removed in a future release
[WARNING] To suppress warnings about obsolete options, use -Xlint:-options.
[INFO]
[INFO] BUILD SUCCESS
[INFO]
[INFO] Total time: 0.805 s
[INFO] Finished at: 2023-08-05T12:25:44-04:00
[INFO]
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ mvn test
[INFO] Scanning for projects...
[INFO]
[INFO] -----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO]
[INFO] --- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\resources
[INFO]
[INFO] --- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO]
[INFO] --- resources:3.3.1:testResources (default-testResources) @ csc835-assignment-4 ---
[WARNING] using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\resources
[INFO]
[INFO] --- compiler:3.11.0:testCompile (default-testCompile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO]
[INFO] --- surefire:3.1.2:test (default-test) @ csc835-assignment-4 ---
[INFO] Using auto detected provider org.apache.maven.surefire.junit.JUnit3Provider
[INFO]
[INFO]
[INFO] T E S T S
[INFO]
[INFO] Running edu.eku.SmallestAndLargestTest
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.017 s -- in edu.eku.SmallestAndLargestTest
[INFO]
[INFO] Results:
[INFO]
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO]
[INFO] BUILD SUCCESS
[INFO]
[INFO] Total time: 1.146 s
[INFO] Finished at: 2023-08-05T12:25:52-04:00
[INFO]
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$

```

Maven Package with new code

```

Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ mvn package
[INFO] Scanning for projects...
[INFO]
[INFO] -----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO]
[INFO] --- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\resources
[INFO]
[INFO] --- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO]
[INFO] --- resources:3.3.1:testResources (default-testResources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\resources
[INFO]
[INFO] --- compiler:3.11.0:testCompile (default-testCompile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO]
[INFO] --- surefire:3.1.2:test (default-test) @ csc835-assignment-4 ---
[INFO] Using auto detected provider org.apache.maven.surefire.junit3.JUnit3Provider
[INFO]
[INFO] -----
[INFO] T E S T S
[INFO] -----
[INFO] Running edu.eku.SmallestAndLargestTest
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.015 s -- in edu.eku.SmallestAndLargestTest
[INFO]
[INFO] Results:
[INFO]
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO] --- jar:3.3.0:jar (default-jar) @ csc835-assignment-4 ---
[INFO] Building jar: C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\target\csc835-assignment-4-1.0-SNAPSHOT.jar
[INFO]
[INFO] BUILD SUCCESS
[INFO]
[INFO] -----
[INFO] Total time: 1.420 s
[INFO] Finished at: 2023-08-05T12:27:09-04:00
[INFO] -----
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4

```

Running the Java Program via CLTs – Find Largest and Smallest values in an Array using Pair Class

```

Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ java -cp target/csc835-assignment-4-1.0-SNAPSHOT.jar edu.eku.SmallestAndLargest
Contents of the array: 5 2 9 1 7
Smallest: 1
Largest: 9

Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ |

```

2. Create a test file with all the test cases (AT LEAST 5 TEST CASES) you want to use to test your code (take a snapshot of your screen)

Test Cases 1 – 3 (SmallestAndLargestTest.java)

```
C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\java\edu\eku\SmallestAndLargestTest.java - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
change.log App.java AppTest.java pom.xml runJava.sh SmallestAndLargestTest.java SmallestAndLargest.java Main.java pom.xml SmallestAndLargestTest.java

1 package edu.eku;
2 import junit.framework.Test;
3 import junit.framework.TestCase;
4 import junit.framework.TestSuite;
5
6 /**
7  * .Unit.test.for.simple.App.
8  */
9 public class SmallestAndLargestTest
10     extends TestCase
11 {
12     /**
13      * .Test.Case.1
14      * .@Test:1
15      * .Test.for.empty.array
16      */
17     public void testSmallestAndLargest1() {
18         int[] inputArray = {};
19         assertNull(SmallestAndLargest.findSmallestAndLargest(inputArray));
20     }
21
22     /**
23      * .Test.Case.2
24      * .@Test:2
25      * .Test.for.smallest.and.largest.in.unordered.array.with.positive.integer.elements
26      */
27     public void testSmallestAndLargest2() {
28         int[] inputArray = {5, 2, 9, 1, 7};
29         Pair expectedPair = new Pair(1, 9);
30         Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
31         assertEquals(expectedPair.getFirst(), resultPair.getFirst());
32         assertEquals(expectedPair.getSecond(), resultPair.getSecond());
33     }
34
35     /**
36      * .Test.Case.3
37      * .@Test:3
38      * .Test.for.smallest.and.largest.in.unordered.array.with.negative.integer.elements
39      */
40     public void testSmallestAndLargest3() {
41         int[] inputArray = {-3, -8, -1, -5};
42         Pair expectedPair = new Pair(-8, -1);
43         Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
44         assertEquals(expectedPair.getFirst(), resultPair.getFirst());
45         assertEquals(expectedPair.getSecond(), resultPair.getSecond());
46     }
47 }
```

Test Cases 4 – 7 (SmallestAndLargestTest.java)

```
C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\java\edu\eku\SmallestAndLargestTest.java - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
change.log App.java AppTest.java pom.xml run.java.sh SmallestAndLargestTest.java SmallestAndLargest.java Main.java pom.xml SmallestAndLargest.java SmallestAndLargest

49 .....*/Test-Case-4
50 .....*/@Test-4
51 .....*/Test-for-smallest-and-largest-in-array-with-duplicate-elements
52 .....*/
53 .....public void testSmallestAndLargest4(){
54 .....int[] inputArray = {10, 10, 10, 10};
55 .....Pair expectedPair = new Pair(10, 10);
56 .....Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
57 .....assertEquals(expectedPair.getFirst(), resultPair.getFirst());
58 .....assertEquals(expectedPair.getSecond(), resultPair.getSecond());
59 .....}
60 .....
61 ...../**
62 .....*/Test-Case-5
63 .....*/@Test-5
64 .....*/Test-for-smallest-and-largest-in-unordered-array-with-less-than-5-elements
65 .....*/
66 .....public void testSmallestAndLargest5(){
67 .....int[] inputArray = {4, 2, 8, 6};
68 .....Pair expectedPair = new Pair(2, 8);
69 .....Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
70 .....assertEquals(expectedPair.getFirst(), resultPair.getFirst());
71 .....assertEquals(expectedPair.getSecond(), resultPair.getSecond());
72 .....}
73 .....
74 ...../**
75 .....*/Test-Case-6
76 .....*/@Test-6
77 .....*/Test-for-smallest-and-largest-in-unordered-array-where-the-last-element-is-the-largest-and-the-index-is-even
78 .....*/
79 .....public void testSmallestAndLargest6(){
80 .....int[] inputArray = {4, 2, 8, 6, 9};
81 .....Pair expectedPair = new Pair(2, 9);
82 .....Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
83 .....assertEquals(expectedPair.getFirst(), resultPair.getFirst());
84 .....assertEquals(expectedPair.getSecond(), resultPair.getSecond());
85 .....}
86 .....
87 ...../**
88 .....*/Test-Case-7
89 .....*/@Test-7
90 .....*/Test-for-smallest-and-largest-in-unordered-array-where-the-last-element-is-the-largest-and-the-index-is-odd
91 .....*/
92 .....public void testSmallestAndLargest7(){
93 .....int[] inputArray = {4, 2, 6, 8};
94 .....Pair expectedPair = new Pair(2, 8);
95 .....Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
96 .....assertEquals(expectedPair.getFirst(), resultPair.getFirst());
97 .....assertEquals(expectedPair.getSecond(), resultPair.getSecond());
98 .....}
99 .....}
100 .....
```

3. Select a test case (data). Do enough code that will pass the selected test case. **(take a snapshot to prove that you have done the code and passed the test case)**

Test Case 1 (SmallestAndLargestTest.java) - Test for empty array

```
C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\java\edu\eku\SmallestAndLargestTest.java - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
change.log App.java AppTest.java pom.xml runJava.sh SmallestAndLargestTest.java SmallestAndLargest.java Main.java pom.xml SmallestAndLargest.java SmallestAndLargestTest.java

1 package edu.eku;
2 import junit.framework.Test;
3 import junit.framework.TestCase;
4 import junit.framework.TestSuite;
5
6 /**
7  * Unit test for simple App.
8  */
9 public class SmallestAndLargestTest
10     extends TestCase
11 {
12     /**
13      * Test Case 1
14      * @Test 1
15      * Test for empty array
16      */
17     public void testSmallestAndLargest1() {
18         int[] inputArray = {};
19         assertNull(SmallestAndLargest.findSmallestAndLargest(inputArray));
20     }
21
22     /**
23      * Test Case 2
24      * @Test 2
25      * Test for smallest and largest in unordered array with positive integer elements
26      */
27     public void testSmallestAndLargest2() {
28         int[] inputArray = {5, 2, 9, 1, 7};
29         Pair expectedPair = new Pair(1, 9);
30         Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
31         assertEquals(expectedPair.getFirst(), resultPair.getFirst());
32         assertEquals(expectedPair.getSecond(), resultPair.getSecond());
33     }
34     /**
35      * Test Case 3
36      */
37 }
```

Running Shell Script with Maven commands for compiling, testing, packing, and running the Java program.

```

Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ bash runJavaWithMaven.sh
[INFO] Scanning for projects...
[INFO]
[INFO] -----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO]
[INFO] --- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\resources
[INFO]
[INFO] --- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] changes detected - recompiling the module! :source
[WARNING] File encoding has not been set, using platform encoding UTF-8, i.e. build is platform dependent!
[INFO] Compiling 1 source file with javac [debug target 1.8] to target\classes
[WARNING] bootstrap class path not set in conjunction with -source 8
[WARNING] source value 8 is obsolete and will be removed in a future release
[WARNING] target value 8 is obsolete and will be removed in a future release
[WARNING] To suppress warnings about obsolete options, use -Xlint:-options.
[INFO]
[INFO] BUILD SUCCESS
[INFO]
[INFO] Total time: 0.851 s
[INFO] Finished at: 2023-08-05T18:12:16-04:00

```

```

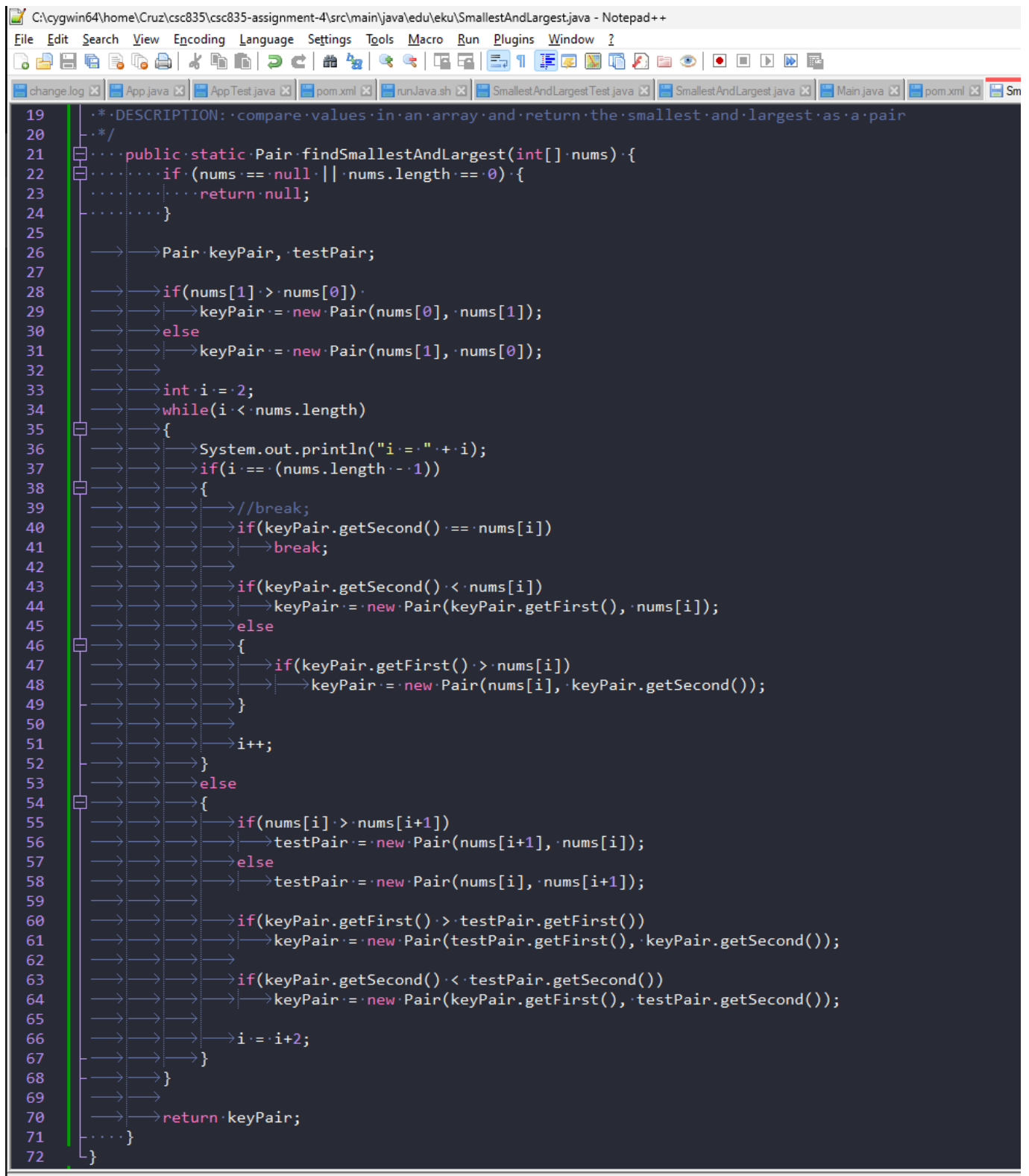
1  #!/bin/bash
2  # Run a Java Program in the current directory
3  # CSC 835 Assignment 4 Shell Script
4  # Programmer: Cruz Macias
5  # compile the java source code using the Maven Build Tool and place the class files containing the byte code in the maven-defined package
   and place it in the pwd
6  # copy MAVEN repos (third-party dependencies) into JUnit directory
7  # curl -s https://repo1.maven.org/maven2/junit/junit/4.13.2/junit-4.13.2.jar -o lib/Junit-4.12.jar
8  # curl -s https://repo1.maven.org/maven2/org/junit/jupiter/junit-jupiter-api/5.10.0/junit-jupiter-api-5.10.0.jar -o
   lib/junit-jupiter-api-5.10.0.jar
9  # curl -s https://repo1.maven.org/maven2/org/junit/jupiter/junit-jupiter-api/5.7.0/junit-jupiter-api-5.7.0.jar -o
   lib/junit-jupiter-api-5.7.0.jar
10 # curl -s https://repo1.maven.org/maven2/junit/junit/3.8.1/junit-3.8.1.jar -o lib/junit-3.8.1.jar
11 # generate the project using maven build tool (comment out after project files are generated)
12 # mvn archetype:generate -DgroupId=edu.eku -DartifactId=csc835-assignment-4 -DarchetypeArtifactId=maven-archetype-quickstart
   -DinteractiveMode=false
13 # compile the program using maven build tool
14 mvn compile
15 # compile the JUnit test program using maven build tool
16 mvn test
17 # create a jar file using the maven build tool
18 # place the class files containing the byte code in the maven-defined package
19 mvn package
20 # build dependency trees
21 # mvn dependency:tree -Dincludes=velocity:velocity
22 # run the compiled java program (specify the class path in the user-defined packages directory)
23 java -cp target/csc835-assignment-4-1.0-SNAPSHOT.jar edu.eku.SmallestAndLargest

```

mvn test results for Test Case 1 (Test Cases 2-7 shown in step 4 below)

```
cruz@DESKTOP-PS9058D ~/csc835/csc835-assignment-4
$ mvn test
[INFO] Scanning for projects...
[INFO] -----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO] --- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\resources
[INFO] --- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO] --- resources:3.3.1:testResources (default-testResources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\resources
[INFO] --- compiler:3.11.0:testCompile (default-testCompile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO] --- surefire:3.1.2:test (default-test) @ csc835-assignment-4 ---
[INFO] Using auto detected provider org.apache.maven.surefire.junit4.JUnit4Provider
[INFO] -----
[INFO] T E S T S
[INFO] -----
[INFO] Running edu.eku.SmallestAndLargestTest
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.030 s -- in edu.eku.SmallestAndLargestTest
[INFO] Results:
[INFO] Tests run: 1, Failures: 0, Errors: 0, Skipped: 0
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----
[INFO] Total time: 1.198 s
[INFO] Finished at: 2023-08-05T18:14:36-04:00
[INFO] -----
cruz@DESKTOP-PS9058D ~/csc835/csc835-assignment-4
$
```

Main Java Program (SmallestAndLargest.java) and Build (Improved Performance Algorithm)



```
19  /*-DESCRIPTION: compare values in an array and return the smallest and largest as a pair
20  */
21  ...public static Pair findSmallestAndLargest(int[] nums){
22  ...if(nums == null || nums.length == 0){
23  ...return null;
24  ...}
25
26  ...Pair keyPair, testPair;
27
28  ...if(nums[1] > nums[0]){
29  ...keyPair = new Pair(nums[0], nums[1]);
30  ...else
31  ...keyPair = new Pair(nums[1], nums[0]);
32
33  ...int i = 2;
34  ...while(i < nums.length)
35  ...{
36  ...System.out.println("i = " + i);
37  ...if(i == (nums.length - 1))
38  ...{
39  ...//break;
40  ...if(keyPair.getSecond() == nums[i])
41  ...break;
42  ...if(keyPair.getSecond() < nums[i])
43  ...keyPair = new Pair(keyPair.getFirst(), nums[i]);
44  ...else
45  ...{
46  ...if(keyPair.getFirst() > nums[i])
47  ...keyPair = new Pair(nums[i], keyPair.getSecond());
48  ...}
49  ...i++;
50  ...}
51  ...else
52  ...{
53  ...if(nums[i] > nums[i+1])
54  ...testPair = new Pair(nums[i+1], nums[i]);
55  ...else
56  ...testPair = new Pair(nums[i], nums[i+1]);
57  ...if(keyPair.getFirst() > testPair.getFirst())
58  ...keyPair = new Pair(testPair.getFirst(), keyPair.getSecond());
59  ...if(keyPair.getSecond() < testPair.getSecond())
60  ...keyPair = new Pair(keyPair.getFirst(), testPair.getSecond());
61  ...i = i+2;
62  ...}
63  ...}
64  ...return keyPair;
65  ...}
66  ...}
67  ...}
68  ...}
69  ...}
70  ...}
71  ...}
72  ...}
```

4. Repeat Step 3 until your code has passed all the test cases.

Test Case 2 (SmallestAndLargestTest.java) - Test for smallest and largest in unordered array with positive integer elements

```
C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\java\edu\eku\SmallestAndLargestTest.java - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window Help
change.log App.java AppTest.java pom.xml run.java.sh SmallestAndLargestTest.java SmallestAndLargest.java Main.java pom.xml SmallestAndLargest.java SmallestAndLargestTest.java run.javaWh

7  /**.Unit.test.for.simple.App.
8  */
9  public class SmallestAndLargestTest {
10     extends TestCase
11 {
12     /**
13      * .Test.Case.1
14      * .@Test.1
15      * -> .Test.for.empty.array
16      */
17     public void testSmallestAndLargest1() {
18         int[] inputArray = {};
19         assertNull(SmallestAndLargest.findSmallestAndLargest(inputArray));
20     }
21
22     /**
23      * .Test.Case.2
24      * .@Test.2
25      * -> .Test.for.smallest.and.largest.in.unordered.array.with.positive.integer.elements
26      */
27     public void testSmallestAndLargest2() {
28         int[] inputArray = {5, 2, 9, 1, 7};
29         Pair expectedPair = new Pair(1, 9);
30         Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
31         assertEquals(expectedPair.getFirst(), resultPair.getFirst());
32         assertEquals(expectedPair.getSecond(), resultPair.getSecond());
33     }
34     /**
35      * .Test.Case.3
36      * .@Test.3
37      * -> .Test.for.smallest.and.largest.in.unordered.array.with.negative.integer.elements
38      */
39     public void testSmallestAndLargest3() {
40         int[] inputArray = {-3, -8, -1, -5};
41     }
```

mvn test results for Test Case 2

```

Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ mvn test
[INFO] Scanning for projects...
[INFO]
-----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO]
--- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\resources
[INFO]
--- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO]
--- resources:3.3.1:testResources (default-testResources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\resources
[INFO]
--- compiler:3.11.0:testCompile (default-testCompile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO]
--- surefire:3.1.2:test (default-test) @ csc835-assignment-4 ---
[INFO] Using auto detected provider org.apache.maven.surefire.junit4.JUnit4Provider
[INFO]
-----
[INFO] T E S T S
[INFO] -----
[INFO] Running edu.eku.SmallestAndLargestTest
[INFO]
[INFO] Tests run: 2, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.031 s -- in edu.eku.SmallestAndLargestTest
[INFO]
Results:
[INFO]
[INFO] Tests run: 2, Failures: 0, Errors: 0, Skipped: 0
[INFO]
-----
[INFO] BUILD SUCCESS
[INFO] -----
[INFO] Total time: 1.281 s
[INFO] Finished at: 2023-08-05T18:18:29-04:00
[INFO]
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$

```

Test Case 3 (SmallestAndLargestTest.java) - Test for smallest and largest in unordered array with negative integer elements

```
C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\java\edu\eku\SmallestAndLargestTest.java - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
change.log App.java AppTest.java pom.xml run.java.sh SmallestAndLargestTest.java SmallestAndLargest.java Main.java pom.xml SmallestAndLargest.java SmallestAndLargestTest.java ru
19 .....assertNull(SmallestAndLargest.findSmallestAndLargest(inputArray));
20 .....}
21 .....
22 ...../**
23 ..... * Test Case 2
24 ..... * @Test
25 ..... * Test for smallest and largest in unordered array with positive integer elements
26 ..... */
27 .....public void testSmallestAndLargest2() {
28 .....    int[] inputArray = {5, 2, 9, 1, 7};
29 .....    Pair expectedPair = new Pair(1, 9);
30 .....    Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
31 .....    assertEquals(expectedPair.getFirst(), resultPair.getFirst());
32 .....    assertEquals(expectedPair.getSecond(), resultPair.getSecond());
33 .....}
34 ...../**
35 ..... * Test Case 3
36 ..... * @Test
37 ..... * Test for smallest and largest in unordered array with negative integer elements
38 ..... */
39 .....public void testSmallestAndLargest3() {
40 .....    int[] inputArray = {-3, -8, -1, -5};
41 .....    Pair expectedPair = new Pair(-8, -1);
42 .....    Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
43 .....    assertEquals(expectedPair.getFirst(), resultPair.getFirst());
44 .....    assertEquals(expectedPair.getSecond(), resultPair.getSecond());
45 .....}
46 .....
47 ...../**
48 ..... * Test Case 4
49 ..... * @Test
50 ..... * Test for smallest and largest in array with duplicate elements
51 ..... */
52 ...../*
53 .....public void testSmallestAndLargest4() {
```

mvn test results for Test Case 3

```
~/csc835/csc835-assignment-4
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ mvn test
[INFO] Scanning for projects...
[INFO] -----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO] --- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\resources
[INFO] --- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO] --- resources:3.3.1:testResources (default-testResources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\resources
[INFO] --- compiler:3.11.0:testCompile (default-testCompile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO] --- surefire:3.1.2:test (default-test) @ csc835-assignment-4 ---
[INFO] Using auto detected provider org.apache.maven.surefire.junit4.JUnit4Provider
[INFO] -----
[INFO] T E S T S
[INFO] -----
[INFO] Running edu.eku.SmallestAndLargestTest
[INFO] Tests run: 3, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.029 s -- in edu.eku.SmallestAndLargestTest
[INFO] Results:
[INFO] Tests run: 3, Failures: 0, Errors: 0, Skipped: 0
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----
[INFO] Total time: 1.261 s
[INFO] Finished at: 2023-08-05T18:22:23-04:00
[INFO] -----
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ |
```

Test Case 4 (SmallestAndLargestTest.java) - Test for smallest and largest in array with duplicate elements

```
C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\java\edu\yeku\SmallestAndLargestTest.java - Notepad ++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
change.log App.java AppTest.java pom.xml runJava.sh SmallestAndLargestTest.java SmallestAndLargest.java Main.java pom.xml SmallestAndLargest.java SmallestAndLargestTest.java runJ...

31     assertEquals(expectedPair.getFirst(), resultPair.getFirst());
32     assertEquals(expectedPair.getSecond(), resultPair.getSecond());
33 }
34 /**
35  * Test Case 3
36  * @Test
37  * Test for smallest and largest in unordered array with negative integer elements
38  */
39 public void testSmallestAndLargest3() {
40     int[] inputArray = {-3, -8, -1, -5};
41     Pair expectedPair = new Pair(-8, -1);
42     Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
43     assertEquals(expectedPair.getFirst(), resultPair.getFirst());
44     assertEquals(expectedPair.getSecond(), resultPair.getSecond());
45 }
46
47 /**
48  * Test Case 4
49  * @Test
50  * Test for smallest and largest in array with duplicate elements
51  */
52 public void testSmallestAndLargest4() {
53     int[] inputArray = {10, 10, 10, 10};
54     Pair expectedPair = new Pair(10, 10);
55     Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
56     assertEquals(expectedPair.getFirst(), resultPair.getFirst());
57     assertEquals(expectedPair.getSecond(), resultPair.getSecond());
58 }
59
60 /**
61  * Test Case 5
62  * @Test
63  * Test for smallest and largest in unordered array with less than 5 elements
64  */
65
66 public void testSmallestAndLargest5() {
67     int[] inputArray = {4, -2, -8, -6};
```

mvn test results for Test Case 4

```
~/csc835/csc835-assignment-4
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ mvn test
[INFO] Scanning for projects...
[INFO] -----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO] --- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\resources
[INFO] --- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO] --- resources:3.3.1:testResources (default-testResources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\resources
[INFO] --- compiler:3.11.0:testCompile (default-testCompile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO] --- surefire:3.1.2:test (default-test) @ csc835-assignment-4 ---
[INFO] Using auto detected provider org.apache.maven.surefire.junit4.JUnit4Provider
[INFO]
[INFO] T E S T S
[INFO] -----
[INFO] Running edu.eku.SmallestAndLargestTest
[INFO] Tests run: 4, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.029 s -- in edu.eku.SmallestAndLargestTest
[INFO] Results:
[INFO] Tests run: 4, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO] BUILD SUCCESS
[INFO]
[INFO] Total time: 1.222 s
[INFO] Finished at: 2023-08-05T18:23:04-04:00
[INFO]
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$
```

Test Case 5 (SmallestAndLargestTest.java) - Test for smallest and largest in unordered array with less than 5 elements

```
46
47  ..../**
48  ....*Test-Case-4
49  ....*@Test-4
50  ->*.Test-for-smallest-and-largest-in-array-with-duplicate-elements
51  ....*/
52  ....public void testSmallestAndLargest4() {
53  ->int[] inputArray = {10, 10, 10, 10};
54  ->Pair expectedPair = new Pair(10, 10);
55  ->Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
56  ->assertEquals(expectedPair.getFirst(), resultPair.getFirst());
57  ->assertEquals(expectedPair.getSecond(), resultPair.getSecond());
58  ....}
59
60  ..../**
61  ....*Test-Case-5
62  ....*@Test-5
63  ->*.Test-for-smallest-and-largest-in-unordered-array-with-less-than-5-elements
64  ....*/
65  ....public void testSmallestAndLargest5() {
66  ....int[] inputArray = {4, 2, 8, 6};
67  ->Pair expectedPair = new Pair(2, 8);
68  ->Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
69  ->assertEquals(expectedPair.getFirst(), resultPair.getFirst());
70  ->assertEquals(expectedPair.getSecond(), resultPair.getSecond());
71  ....}
72
73  ..../**
74  ....*Test-Case-6
75  ....*@Test-6
76  ->*.Test-for-smallest-and-largest-in-unordered-array-where-the-last-element-is-the-largest-and-the-index-is-even
77  ....*/
78  ....*/
79  ....public void testSmallestAndLargest6() {
80  ....int[] inputArray = {4, 2, 8, 6, 9};
```

mvn test results for Test Case 5

```
~/csc835/csc835-assignment-4
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ mvn test
[INFO] Scanning for projects...
[INFO] -----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO] --- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\resources
[INFO] --- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO] --- resources:3.3.1:testResources (default-testResources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\resources
[INFO] --- compiler:3.11.0:testCompile (default-testCompile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO] --- surefire:3.1.2:test (default-test) @ csc835-assignment-4 ---
[INFO] Using auto detected provider org.apache.maven.surefire.junit4.JUnit4Provider
[INFO] -----
[INFO] T E S T S
[INFO] -----
[INFO] Running edu.eku.SmallestAndLargestTest
[INFO] Tests run: 5, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.030 s -- in edu.eku.SmallestAndLargestTest
[INFO] Results:
[INFO] Tests run: 5, Failures: 0, Errors: 0, Skipped: 0
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----
[INFO] Total time: 1.247 s
[INFO] Finished at: 2023-08-05T18:25:42-04:00
[INFO] -----
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ |
```


Test Case 6 (SmallestAndLargestTest.java) - Test for smallest and largest in unordered array where the last element is the largest and the index is even

```

61 | .....*.Test·Case·5
62 | .....*.Test·5
63 | →*.Test·for·smallest·and·largest·in·unordered·array·with·less·than·5·elements
64 | .....*/
65 | public·void·testSmallestAndLargest5()·{
66 |     int[]·inputArray·=·{4,·2,·8,·6};
67 |     Pair·expectedPair·=·new·Pair(2,·8);
68 |     Pair·resultPair·=·SmallestAndLargest.findSmallestAndLargest(inputArray);
69 |     assertEquals(expectedPair.getFirst(),·resultPair.getFirst());
70 |     assertEquals(expectedPair.getSecond(),·resultPair.getSecond());
71 | }
72 |
73 | ...../**
74 | .....*.Test·Case·6
75 | .....*.Test·6
76 | →*.Test·for·smallest·and·largest·in·unordered·array·where·the·last·element·is·the·largest·and·the·index·is·even
77 | .....*/
78 | public·void·testSmallestAndLargest6()·{
79 |     int[]·inputArray·=·{4,·2,·8,·6,·9};
80 |     Pair·expectedPair·=·new·Pair(2,·9);
81 |     Pair·resultPair·=·SmallestAndLargest.findSmallestAndLargest(inputArray);
82 |     assertEquals(expectedPair.getFirst(),·resultPair.getFirst());
83 |     assertEquals(expectedPair.getSecond(),·resultPair.getSecond());
84 | }
85 |
86 | ...../**
87 | .....*.Test·Case·7
88 | .....*.Test·7
89 | →*.Test·for·smallest·and·largest·in·unordered·array·where·the·last·element·is·the·largest·and·the·index·is·odd
90 | .....*/
91 | .....*/
92 | public·void·testSmallestAndLargest7()·{
93 |     int[]·inputArray·=·{4,·2,·6,·8};
94 |     Pair·expectedPair·=·new·Pair(2,·8);
95 |     Pair·resultPair·=·SmallestAndLargest.findSmallestAndLargest(inputArray);
96 |     assertEquals(expectedPair.getFirst(),·resultPair.getFirst());
97 |     assertEquals(expectedPair.getSecond(),·resultPair.getSecond());

```

mvn test results for Test Case 6

```
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ mvn test
[INFO] Scanning for projects...
[INFO]
[INFO] -----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO]
[INFO] --- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\resources
[INFO]
[INFO] --- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO]
[INFO] --- resources:3.3.1:testResources (default-testResources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\test\resources
[INFO]
[INFO] --- compiler:3.11.0:testCompile (default-testCompile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO]
[INFO] --- surefire:3.1.2:test (default-test) @ csc835-assignment-4 ---
[INFO] Using auto detected provider org.apache.maven.surefire.junit4.JUnit4Provider
[INFO]
[INFO] -----
[INFO] T E S T S
[INFO] -----
[INFO] Running edu.eku.SmallestAndLargestTest
[INFO] Tests run: 6, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.034 s -- in edu.eku.SmallestAndLargestTest
[INFO]
[INFO] Results:
[INFO]
[INFO] Tests run: 6, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----
[INFO] Total time: 1.199 s
[INFO] Finished at: 2023-08-05T18:27:06-04:00
[INFO] -----
Cruz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
```

Test Case 7 (SmallestAndLargestTest.java) - Test for smallest and largest in unordered array where the last element is the largest and the index is odd

```

70  →      assertEquals(expectedPair.getSecond(), resultPair.getSecond());
71  →    }
72
73  →    /**
74  →    ... * Test Case 6
75  →    ... * @Test 6
76  →    ... * Test for smallest and largest in unordered array where the last element is the largest and the index is even
77  →    ... */
78  →    public void testSmallestAndLargest6() {
79  →    ... int[] inputArray = {4, 2, 8, 6, 9};
80  →    ... Pair expectedPair = new Pair(2, 9);
81  →    ... Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
82  →    ... assertEquals(expectedPair.getFirst(), resultPair.getFirst());
83  →    ... assertEquals(expectedPair.getSecond(), resultPair.getSecond());
84  →    }
85
86  →    /**
87  →    ... * Test Case 7
88  →    ... * @Test 7
89  →    ... * Test for smallest and largest in unordered array where the last element is the largest and the index is odd
90  →    ... */
91  →    public void testSmallestAndLargest7() {
92  →    ... int[] inputArray = {4, 2, 6, 8};
93  →    ... Pair expectedPair = new Pair(2, 8);
94  →    ... Pair resultPair = SmallestAndLargest.findSmallestAndLargest(inputArray);
95  →    ... assertEquals(expectedPair.getFirst(), resultPair.getFirst());
96  →    ... assertEquals(expectedPair.getSecond(), resultPair.getSecond());
97  →    }
98
99  }
```

mvn test results for Test Case 7

```
Crüz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$ mvn test
[INFO] Scanning for projects...
[INFO]
[INFO] -----< edu.eku:csc835-assignment-4 >-----
[INFO] Building csc835-assignment-4 1.0-SNAPSHOT
[INFO] from pom.xml
[INFO] -----[ jar ]-----
[INFO]
[INFO] --- resources:3.3.1:resources (default-resources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Crüz\csc835\csc835-assignment-4\src\main\resources
[INFO]
[INFO] --- compiler:3.11.0:compile (default-compile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO]
[INFO] --- resources:3.3.1:testResources (default-testResources) @ csc835-assignment-4 ---
[WARNING] Using platform encoding (UTF-8 actually) to copy filtered resources, i.e. build is platform dependent!
[INFO] skip non existing resourceDirectory C:\cygwin64\home\Crüz\csc835\csc835-assignment-4\src\test\resources
[INFO]
[INFO] --- compiler:3.11.0:testCompile (default-testCompile) @ csc835-assignment-4 ---
[INFO] Nothing to compile - all classes are up to date
[INFO]
[INFO] --- surefire:3.1.2:test (default-test) @ csc835-assignment-4 ---
[INFO] Using auto detected provider org.apache.maven.surefire.junit4.JUnit4Provider
[INFO]
[INFO] -----
[INFO] T E S T S
[INFO] -----
[INFO] Running edu.eku.SmallestAndLargestTest
[INFO] Tests run: 7, Failures: 0, Errors: 0, Skipped: 0, Time elapsed: 0.033 s -- in edu.eku.SmallestAndLargestTest
[INFO]
[INFO] Results:
[INFO]
[INFO] Tests run: 7, Failures: 0, Errors: 0, Skipped: 0
[INFO]
[INFO] -----
[INFO] BUILD SUCCESS
[INFO] -----
[INFO] Total time: 1.213 s
[INFO] Finished at: 2023-08-05T18:31:07-04:00
[INFO] -----
Crüz@DESKTOP-FS9D5BD ~/csc835/csc835-assignment-4
$
```

5. Refactor your code (with comments and meaningful names)

Main Java Program (SmallestAndLargest.java) and Build (Improved Performance Algorithm)

```
C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\java\edu\eku\SmallestAndLargest.java - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
change.log App.java AppTest.java pom.xml runJava.sh SmallestAndLargestTest.java SmallestAndLargest.java Main.java pom.xml SmallestAndLargest.java

16  /**
17  * FUNCTION: Pair
18  * DESCRIPTION: compare values in an array and return the smallest and largest as a pair
19  */
20  ...
21  public static Pair findSmallestAndLargest(int[] nums) {
22      //return if array is empty
23      if (nums == null || nums.length == 0) {
24          return null;
25      }
26
27      //declare new Pairs for comparison
28      Pair keyPair, testPair;
29
30      //assign a largest and smallest key value
31      if (nums[1] > nums[0]) {
32          keyPair = new Pair(nums[0], nums[1]);
33      } else {
34          keyPair = new Pair(nums[1], nums[0]);
35      }
36
37      int i = 2;
38      while (i < nums.length) {
39          if (i == (nums.length - 1)) {
40              //if the last index is even and the value is equal to the largest key value, exit the loop
41              if (keyPair.getSecond() == nums[i]) {
42                  break;
43              }
44              //if the last element value is larger than the largest key value, update the key pair
45              if (keyPair.getSecond() < nums[i]) {
46                  keyPair = new Pair(keyPair.getFirst(), nums[i]);
47              } else {
48                  //if the last element is smaller than the smallest key value, update the key pair
49                  if (keyPair.getFirst() > nums[i]) {
50                      keyPair = new Pair(nums[i], keyPair.getSecond());
51                  }
52              }
53              i++; //exit
54          } else {
55              //assign the largest and smallest values of the test pair
56              if (nums[i] > nums[i+1]) {
57                  testPair = new Pair(nums[i+1], nums[i]);
58              } else {
59                  testPair = new Pair(nums[i], nums[i+1]);
60              }
61              //if the smallest element of the test pair is smaller than the smallest key value, update the key pair
62              if (keyPair.getFirst() > testPair.getFirst()) {
63                  keyPair = new Pair(testPair.getFirst(), keyPair.getSecond());
64              }
65              //if the largest element of the test pair is larger than the largest key value, update the key pair
66              if (keyPair.getSecond() < testPair.getSecond()) {
67                  keyPair = new Pair(keyPair.getFirst(), testPair.getSecond());
68              }
69              i = i+2; //exit
70          }
71      }
72
73      return keyPair; //return the key pair
74  }
75
76
77
78
79
80
```

Pair Class Definition

```
C:\cygwin64\home\Cruz\csc835\csc835-assignment-4\src\main\java\edu\eku\SmallestAndLargest.java - Notepad++
File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?
change.log App.java AppTest.java pom.xml runJava.sh SmallestAndLargestTest.java SmallestAndLargest.java Main.java pom.xml SmallestAndLargest.java SmallestAndLargestTest.java runJavaWithMaven.sh new 1

79 }
80
81 /**
82  * CLASS: Pair
83  * DESCRIPTION: create a pair of two values
84  */
85 class Pair {
86     //data members of the class
87     private int first; //the smaller value
88     private int second; //the larger value
89
90     /**
91      * method: constructor
92      * DESCRIPTION: assign values to the data members if values are passed to the class object declaration
93      */
94     public Pair(int first, int second) {
95         this.first = first;
96         this.second = second;
97     }
98
99     /**
100      * method: getFirst
101      * DESCRIPTION: return the first data member
102      */
103     public int getFirst() {
104         return first;
105     }
106
107     /**
108      * method: getSecond
109      * DESCRIPTION: return the second data member
110      */
111     public int getSecond() {
112         return second;
113     }
114 }
```

6. Write a report to summarize all the steps from 1 to 5, including the snapshots. The report should include a whole page that indicates your opinions about TDD and JUnit.

This Project will use the Maven Build Tool for testing the Java Program with JUnit in the Cygwin POSIX Development Environment where JDK 11+ among other CLTs are installed. No IDE will be utilized for Test Cases. With Apache Maven Version 3.9.4 installed, in the project root directory, the project archetype is generated using the following maven command :

```
mvn archetype:generate -DgroupId=edu.eku -DartifactId=csc835-assignment-4 -  
DarchetypeArtifactId=maven-archetype-quickstart -DinteractiveMode=false
```

With the project generated, modify the src files for both main and test to reflect the name of the project: SmallestAndLargest.java and SmallestAndLargestTest.java. Replace the source code with the code utilizing the straightforward algorithm for finding the smallest and largest values in an array. Modify the pom.xml (Project Object Model XML file) file and define the JUnit dependencies being used: JUnit Version 4.13.2. Confirm that each of the Maven Commands being used will execute without issue and the program runs: mvn compile, mvn test, mvn package, and java. Create 7 test cases for the new code being tested which is an improved processing algorithm for accomplishing the task of finding the smallest and largest values in an array. With each test case, modify the source code until it passes without fail. Once the code passes all test cases, refactor the code and comment where applicable.

Having used JUnit with the Maven Build tool via the command line for testing Java code for a given project, the value of TDD is demonstrated with respect to the development environment whether that is a custom environment like the one used in this report or an IDE such as Eclipse. Instead of running the program with hard coded values or passing in the same values again and again, the JUnit test case confirms if the expected output is achieved for a given test case. This is far more convenient and documented than trying different scenarios without recording results. These test cases can be used again and again throughout the development life cycle providing assurance to the project stakeholders and developers.

7. Submit the report **AND** your Java project to EKU Blackboard.

Function to be implemented:

In the PowerPoint file, Pair Programming and Test Driven Development--for students, check slides #13, 14, and 15. On Slide #14, it shows a straightforward method for finding the smallest and the largest numbers in an array of integers. Slide #15 shows another method to find the two numbers. The method suggests that the numbers in an array should be paired and compared first. Then the smaller numbers from each pair will compare with each other, and so will the larger numbers. The time complexity of the method will be the same as the straight method, but the actual number of comparisons could be lower. This assignment needs you to implement the second method with TDD techniques.

Design a function in Java to show the smallest and the largest numbers in an array of integers.