IT314 - Software Engineering

Lab - 7

Name: Hiten Mistry

Student Id: 202001182

Section A

Q1: Consider a program for determining the previous date. Its input is triple of day, month and year with the following ranges

1 <= month <= 12,

1 <= day <= 31,

1900 <= year <= 2015.

The possible output dates would be the previous date or invalid date. Design the equivalence class test cases?

Ans:

1. **Equivalence Classes for the Day parameter:**

    a. Valid classes: 1 <= day <= 31
    b. Invalid classes: day < 1, day > 31

2. **Equivalence Classes for the Month parameter:**

    a. Valid classes: 1 <= month <= 12
    b. Invalid classes: month < 1, month > 12

3. **Equivalence Classes for the Year parameter:**

a. Valid classes: 1900 <= year <= 2015
b. Invalid classes: year < 1900, year > 2015

Some Test Cases:

1. **Valid test cases:**

    a. (1, 1, 1900) - the minimum valid date
    b. (15, 7, 2005) - a random valid date
    c. (31, 12, 2015) - the maximum valid date

2. **Invalid test cases:**

    a. (0, 7, 1999) - day is less than 1
    b. (32, 1, 2008) - day is greater than 31
    c. (29, 2, 1900) - the year is not a leap year, but the day is 29
    d. (31, 4, 2016) - the year is greater than 2015
    e. (15, 13, 1998) - month is greater than 12
    f. (-10, -5, 2022) - all parameters are invalid

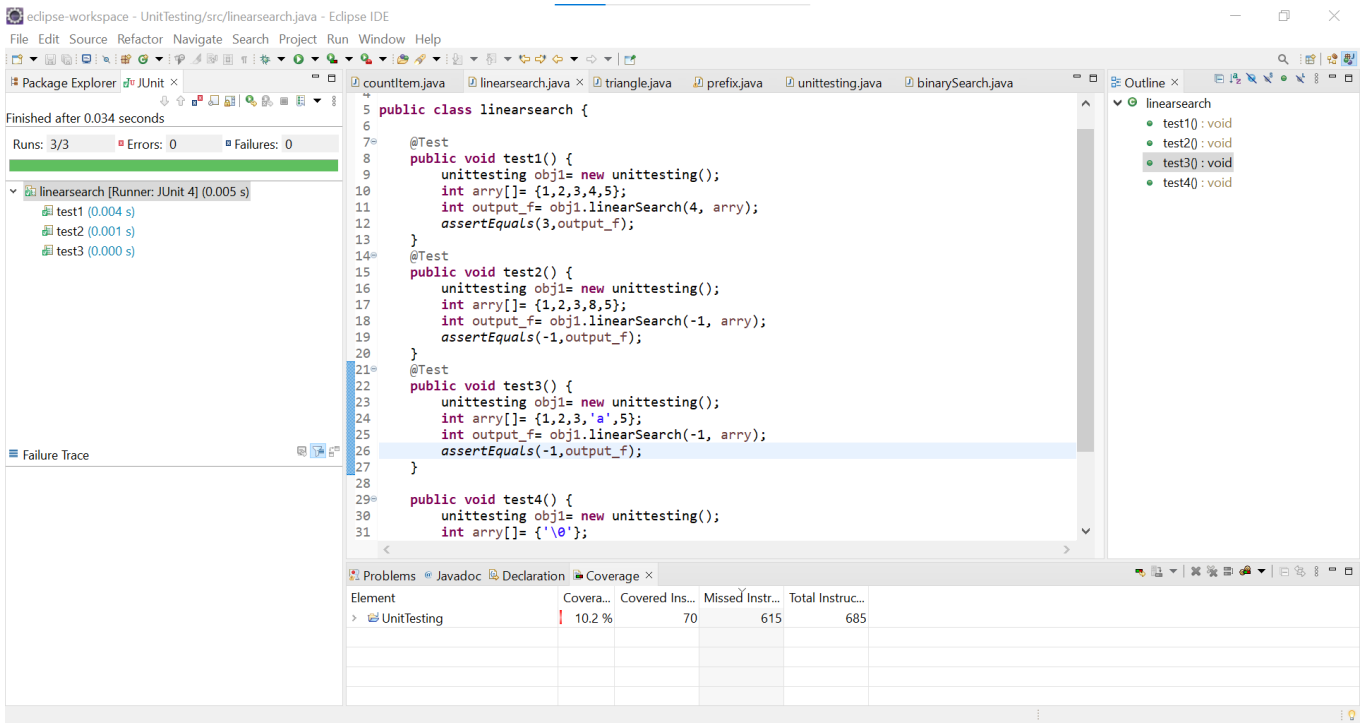
These test cases represent the equivalence classes and should cover all possible scenarios.

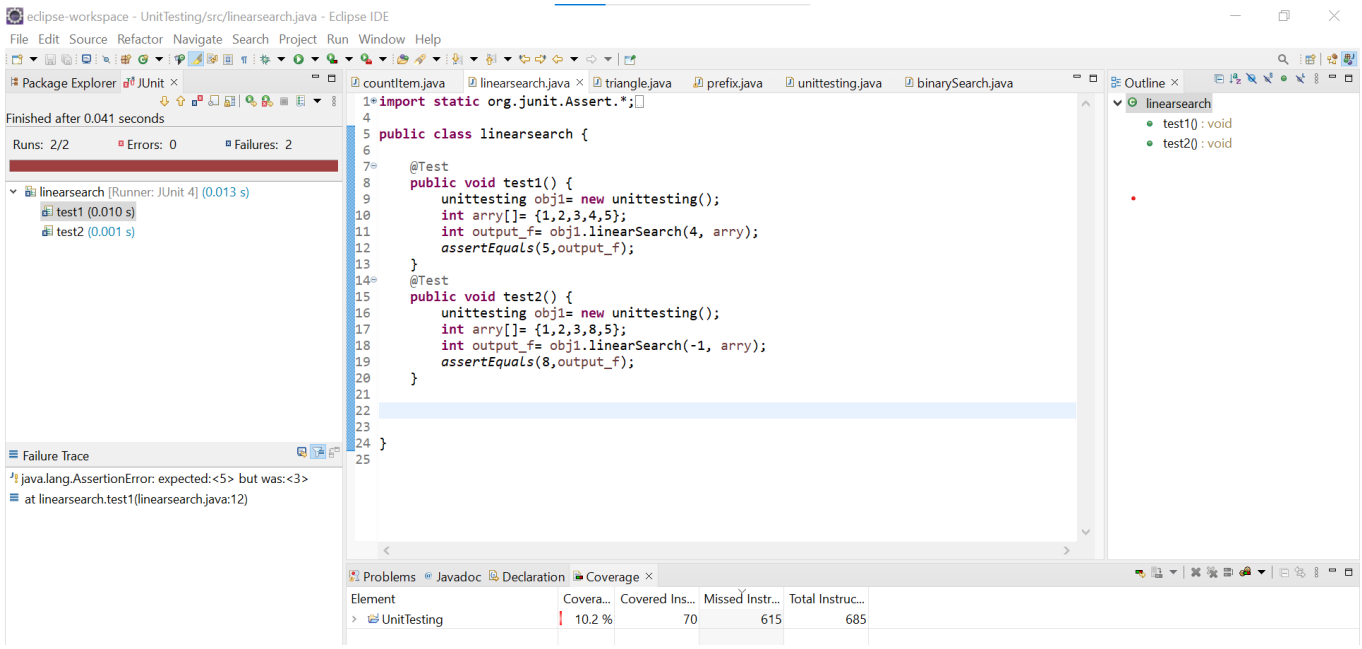
Programs:

P1. The function linearSearch searches for a value v in an array of integers a. If v appears in the array a, then the function returns the first index i, such that a[i] == v; otherwise, -1 is returned.

```
int linearSearch(int v, int a[])
{
        int i = 0;
        while (i < a.length)
        {
                if (a[i] == v)
                        return(i);
                i++;
        }
        return (-1);
}
```

Test Case in Eclipse





Equivalence Partitioning:

Tester Action and Input Data	Expected Outcome
Test with v as a non-existent value and an empty array a[]	-1
Test with v as a non-existent value and a non-empty array a[]	-1
Test with v as an existent value and an empty array a[]	-1
Test with v as an existent value and a non-empty array a[] where v exists	the index of v in a[]
Test with v as an existent value and a non-empty array a[] where v does not exist	-1

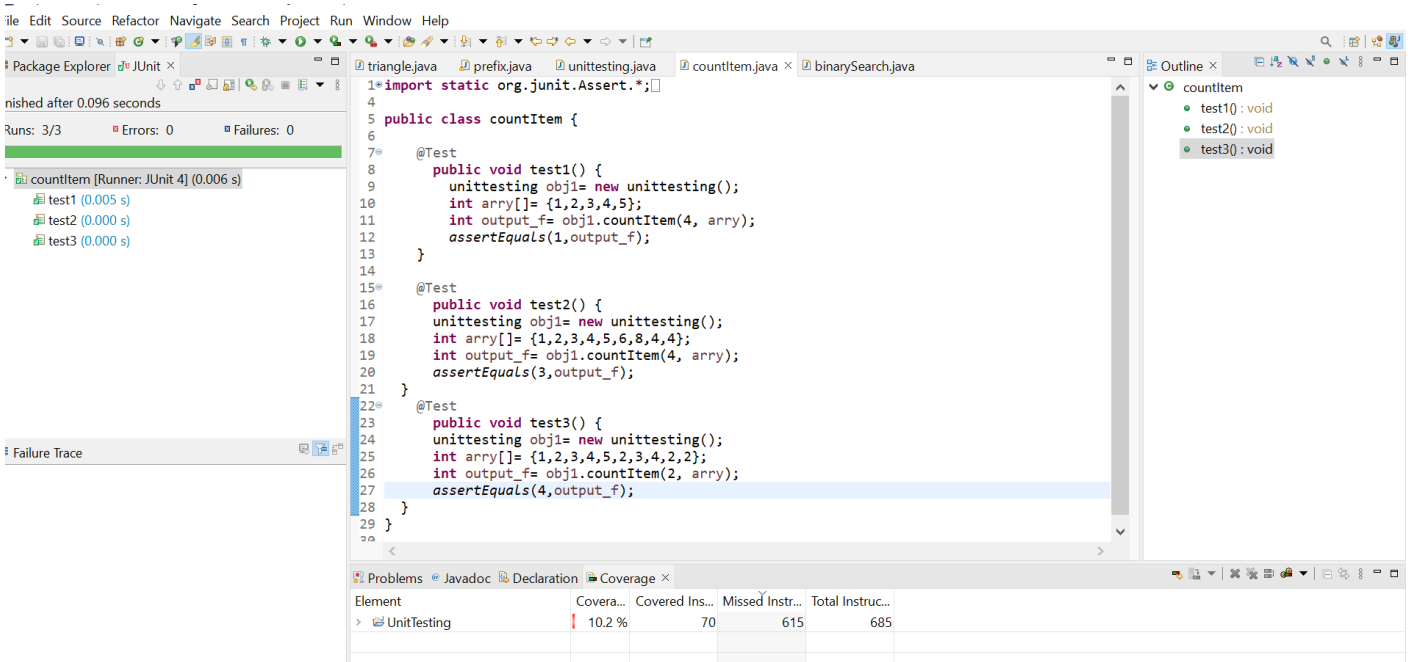
Boundary Value Analysis:

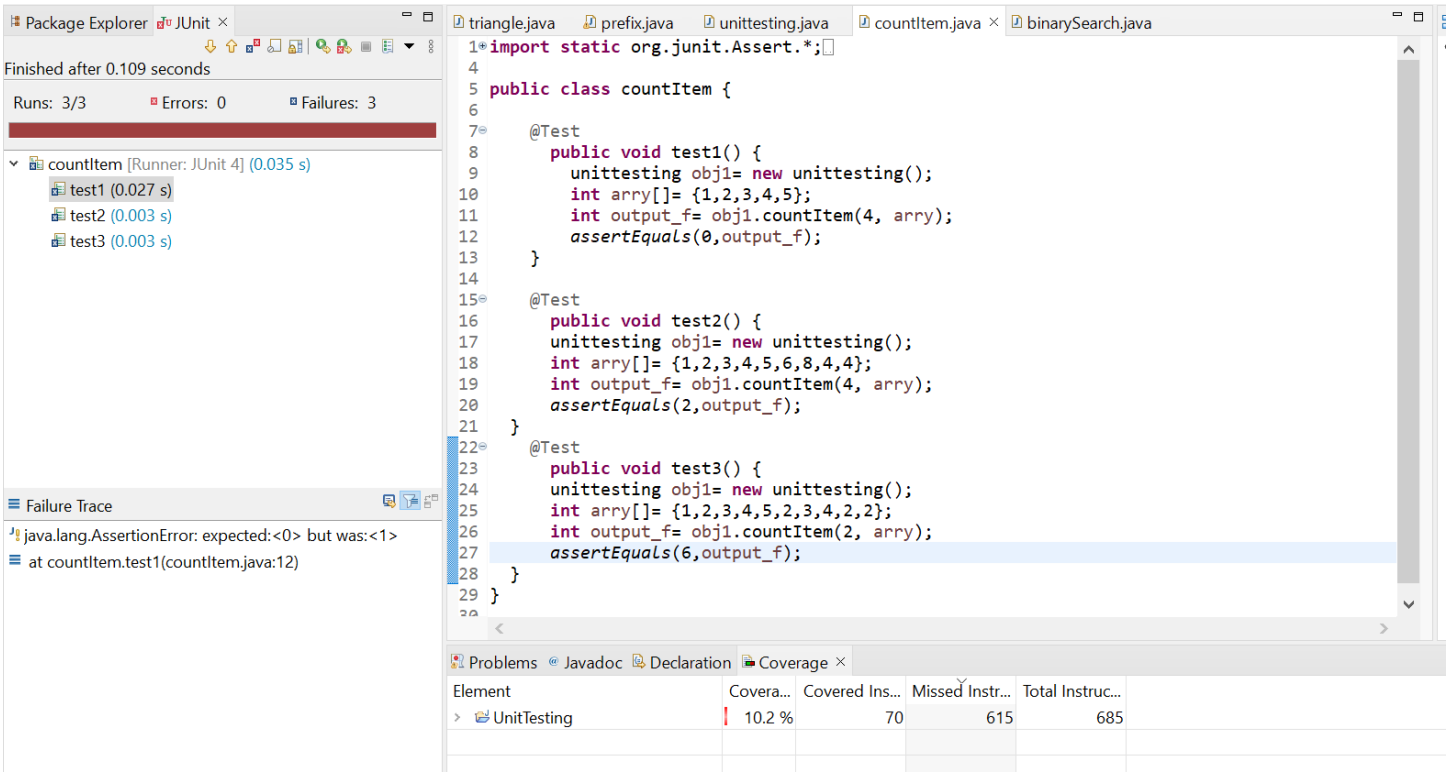
Tester Action and Input Data	Expected Outcome
Test with v as a non-existent value and an empty array a[]	-1
Test with v as a non-existent value and a non-empty array a[]	-1
Test with v as an existent value and an array a[] of length 0	-1
Test with v as an existent value and an array a[] of length 1, where v exists	0
Test with v as an existent value and an array a[] of length 1, where v does not exist	-1
Test with v as an existent value and an array a[] of length greater than 1, where v exists at the beginning of the array	0
Test with v as an existent value and an array a[] of length greater than 1, where v exists at the end of the array	the last index where v is found

P2. The function countItem returns the number of times a value v appears in an array of integers a.

```
int countItem(int v, int a[])

{
	int count = 0;
	for (int i = 0; i < a.length; i++)
	{
		if (a[i] == v)
			count++;

	}
	return (count);
}
```

Test Case in Eclipse




Package Explorer
JUnit
Finished after 0.109 seconds
Runs: 3/3
Errors: 0
Failures: 3
countItem [Runner: JUnit 4] (0.035 s)
test1 (0.027 s)
test2 (0.003 s)
test3 (0.003 s)
Failure Trace
java.lang.AssertionError: expected:<0> but was:<1>
at countItem.test1(countItem.java:12)
triangle.java
prefix.java
unittesting.java
countItem.java
binarySearch.java
1 import static org.junit.Assert.*;
4
5 public class countItem {
6
7 @Test
8 public void test1() {
9 unittesting obj1= new unittesting();
10 int arry[]= {1,2,3,4,5};
11 int output_f= obj1.countItem(4, arry);
12 assertEquals(0,output_f);
13 }
14
15 @Test
16 public void test2() {
17 unittesting obj1= new unittesting();
18 int arry[]= {1,2,3,4,5,6,8,4,4};
19 int output_f= obj1.countItem(4, arry);
20 assertEquals(2,output_f);
21 }
22 @Test
23 public void test3() {
24 unittesting obj1= new unittesting();
25 int arry[]= {1,2,3,4,5,2,3,4,2,2};
26 int output_f= obj1.countItem(2, arry);
27 assertEquals(6,output_f);
28 }
29 }
Problems
Javadoc
Declaration
Coverage
Element
Covera...
Covered Ins...
Missed Instr...
Total Instruc...
UnitTesting
10.2 %
70
615
685

Equivalence Partitioning:

Tester Action and Input Data	Expected Outcome
Test with v as a non-existent value and an empty array a[]	0
Test with v as a non-existent value and a non-empty array a[]	0
Test with v as an existent value and an empty array a[]	0
Test with v as an existent value and a non-empty array a[] where v exists multiple times	the number of occurrences of v in a[]
Test with v as an existent value and a non-empty array a[] where v exists only once	1

Boundary Value Analysis:

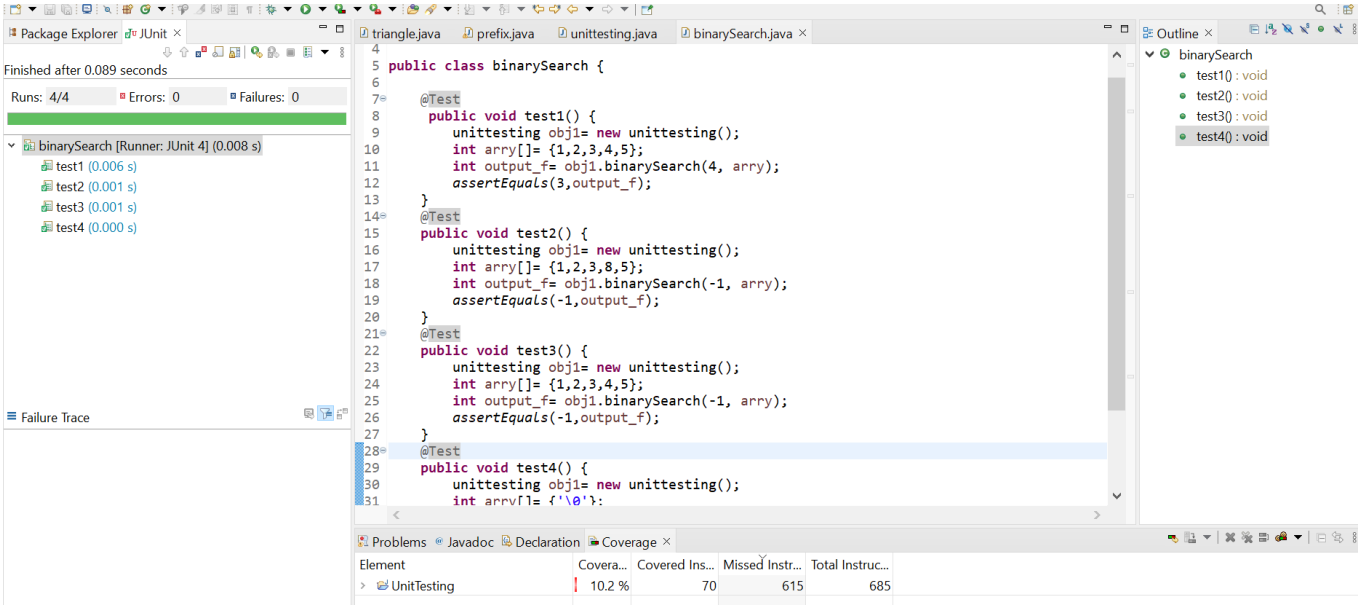
Tester Action and Input Data	Expected Outcome
Test with v as a non-existent value and an empty array a[]	0
Test with v as a non-existent value and a non-empty array a[]	0
Test with v as an existent value and an array a[] of length 0	0
Test with v as an existent value and an array a[] of length 1, where v exists	1
Test with v as an existent value and an array a[] of length 1, where v does not exist	0
Test with v as an existent value and an array a[] of length greater than 1, where v exists at the beginning of the array	the number of occurrences of v in a[]
Test with v as an existent value and an array a[] of length greater than 1, where v exists at the end of the array	the number of occurrences of v in a[]
Test with v as an existent value and an array a[] of length greater than 1, where v exists in the middle of the array	the number of occurrences of v in a[]

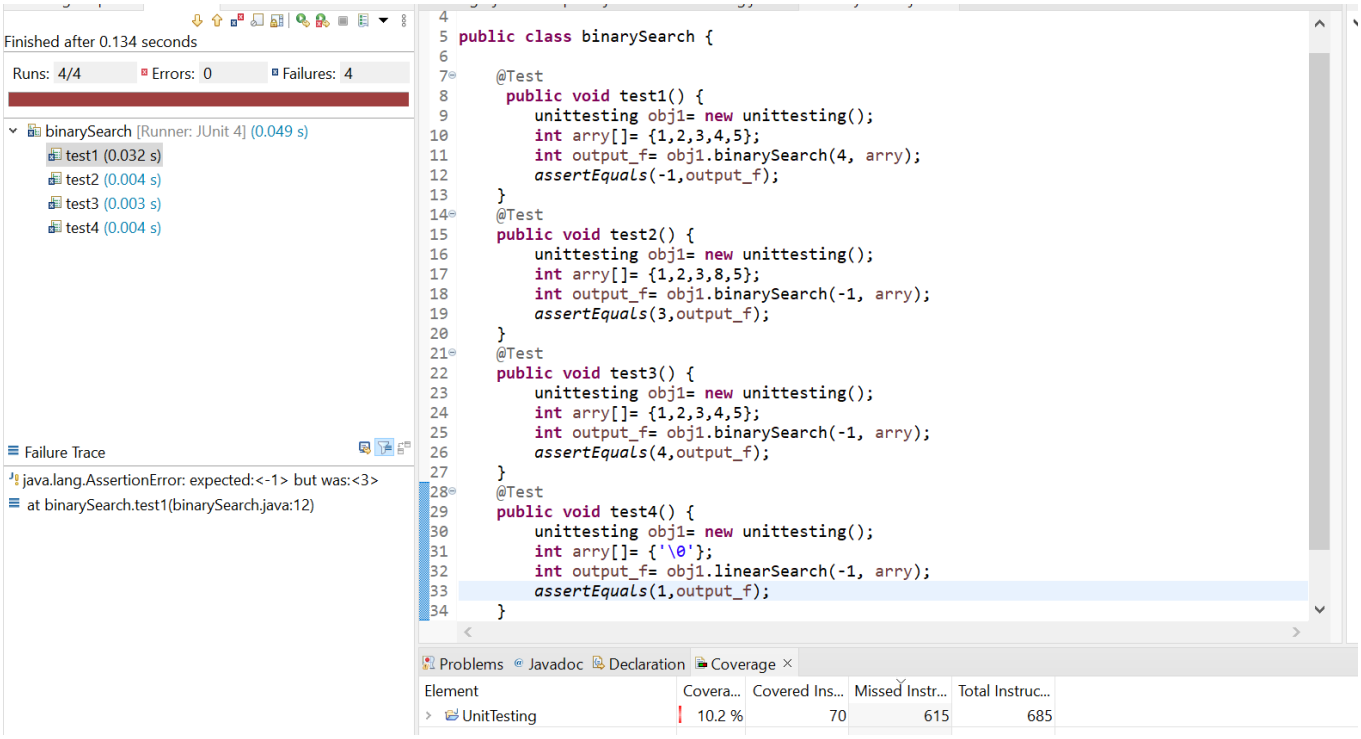
P3. The function binarySearch searches for a value v in an ordered array of integers a. If v appears in the array a, then the function returns an index i, such that a[i] == v; otherwise, -1 is returned. Assumption: the elements in the array are sorted in non-decreasing order.

```
int binarySearch(int v, int a[])
{
        int lo,mid,hi;
        lo = 0;
        hi = a.length-1;
        while (lo <= hi)
        {
                mid = (lo+hi)/2;

                if (v == a[mid])
```

```
            return (mid);

        else if (v < a[mid])
            hi = mid-1;

        Else
            lo = mid+1;

    }

    return(-1);
}
```

Test Case in Eclipse:




Finished after 0.134 seconds
Runs: 4/4
Errors: 0
Failures: 4
binarySearch [Runner: JUnit 4] (0.049 s)
test1 (0.032 s)
test2 (0.004 s)
test3 (0.003 s)
test4 (0.004 s)
Failure Trace
java.lang.AssertionError: expected:<-1> but was:<3>
at binarySearch.test1(binarySearch.java:12)
public class binarySearch {
@Test
public void test1() {
unittesting obj1= new unittesting();
int arry[]= {1,2,3,4,5};
int output_f= obj1.binarySearch(4, arry);
assertEquals(-1,output_f);
}
@Test
public void test2() {
unittesting obj1= new unittesting();
int arry[]= {1,2,3,8,5};
int output_f= obj1.binarySearch(-1, arry);
assertEquals(3,output_f);
}
@Test
public void test3() {
unittesting obj1= new unittesting();
int arry[]= {1,2,3,4,5};
int output_f= obj1.binarySearch(-1, arry);
assertEquals(4,output_f);
}
@Test
public void test4() {
unittesting obj1= new unittesting();
int arry[]= {'\0'};
int output_f= obj1.linearSearch(-1, arry);
assertEquals(1,output_f);
}
Problems
Javadoc
Declaration
Coverage
Element
Covera...
Covered Ins...
Missed Instr...
Total Instruc...
UnitTesting
10.2 %
70
615
685

Equivalence Partitioning:

Tester Action and Input Data	Expected Outcome
v=5, a=[1, 3, 5, 7, 9]	2
v=1, a=[1, 3, 5, 7, 9]	0
v=9, a=[1, 3, 5, 7, 9]	4
v=4, a=[1, 3, 5, 7, 9]	-1
v=11, a=[1, 3, 5, 7, 9]	-1

boundary Value Analysis:

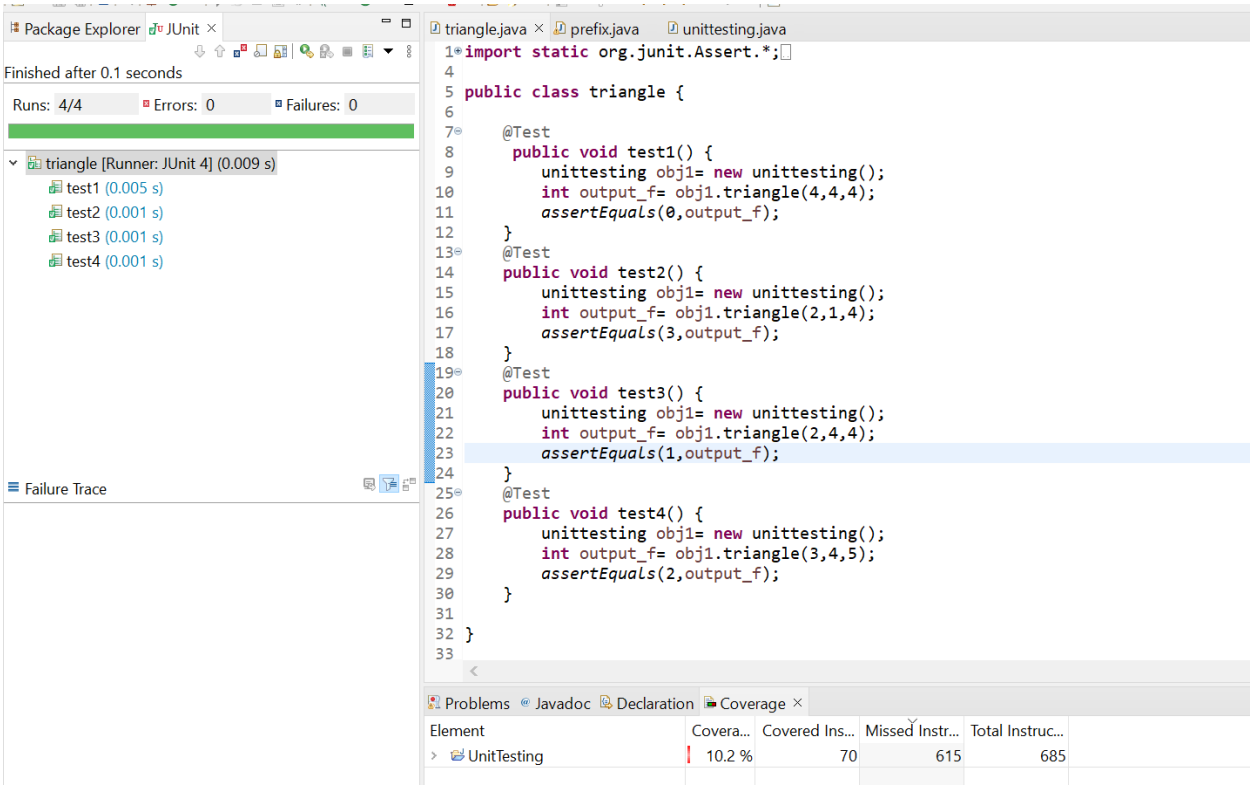
Tester Action and Input Data	Expected Outcome
v=1, a=[1]	0
v=9, a=[9]	0
v=5, a=[]	-1
v=5, a=[5, 7, 9]	0 (smallest element in the array)
v=5, a=[1, 3, 5]	2 (largest element in the array)

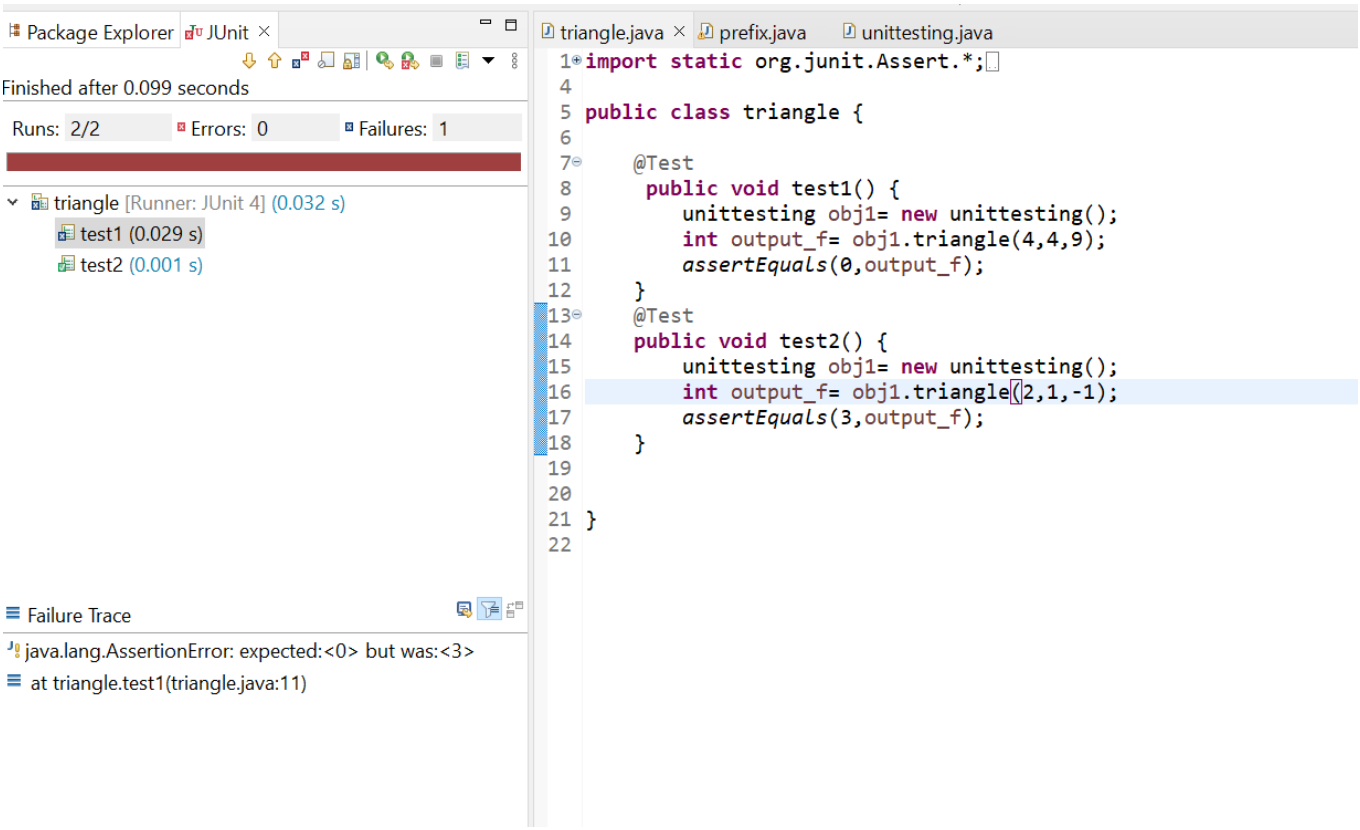
P4. The following problem has been adapted from The Art of Software Testing, by G. Myers (1979). The function triangle takes three integer parameters that are interpreted as the lengths of the sides of a triangle. It returns whether the triangle is equilateral (three lengths equal), isosceles (two lengths equal), scalene (no lengths equal), or invalid (impossible lengths).

```
final int EQUILATERAL = 0;
final int ISOSCELES = 1;
final int SCALENE = 2;
final int INVALID = 3;

int triangle(int a, int b, int c)
```

```
{
        if (a >= b+c || b >= a+c || c >= a+b)
            return(INVALID);

        if (a == b && b == c)
            return(EQUILATERAL);

        if (a == b || a == c || b == c)
            return(ISOSCELES);

        return(SCALENE);
```

Test Case in Eclipse:





Equivalence Partitioning:

Tester Action and Input Data	Expected Outcome
Valid input: a=3, b=3, c=3	EQUILATERAL
Valid input: a=4, b=4, c=5	ISOSCELES
Valid input: a=5, b=4, c=3	SCALENE
Invalid input: a=0, b=0, c=0	INVALID
Invalid input: a=-1, b=2, c=3	INVALID
Valid input: a=1, b=1, c=1	EQUILATERAL
Valid input: a=2, b=2, c=1	ISOSCELES
Valid input: a=3, b=4, c=5	SCALENE
Invalid input: a=0, b=1, c=1	INVALID
Invalid input: a=1, b=0, c=1	INVALID
Invalid input: a=1, b=1, c=0	INVALID

Boundary Value Analysis:

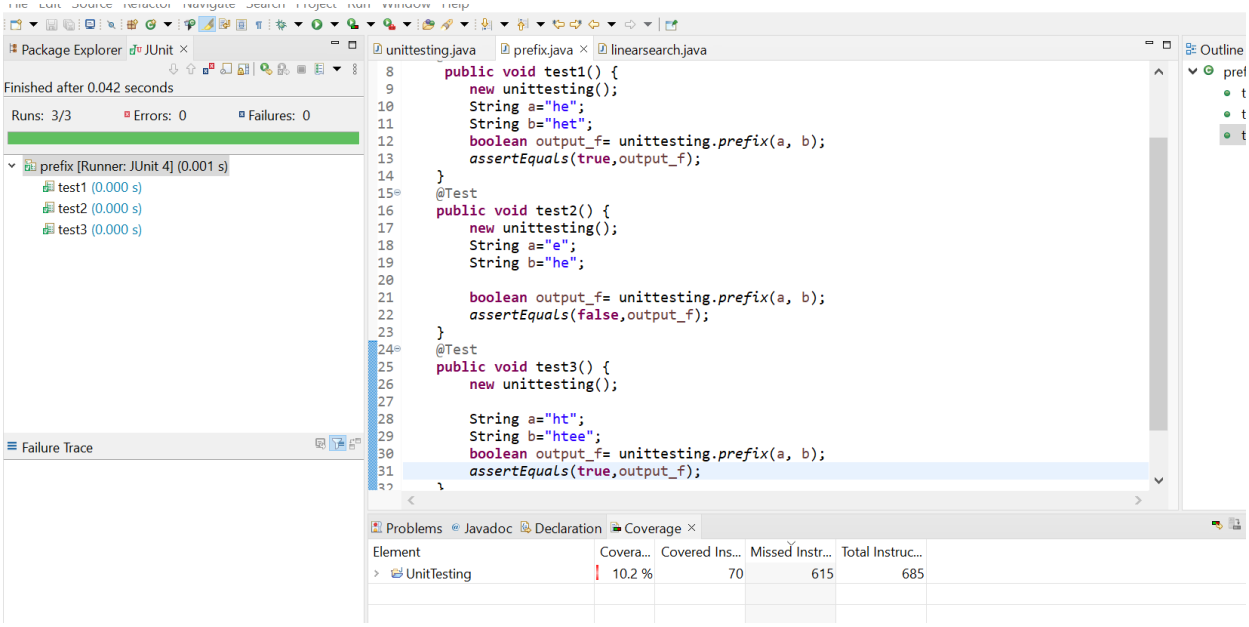
Tester Action and Input Data	Expected Outcome
Invalid inputs: a = 0, b = 0, c = 0	INVALID
Invalid inputs: a + b = c or b + c = a or c + a = b (a=3, b=4, c=8)	INVALID
Equilateral triangles: a = b = c = 1	EQUILATERAL
Equilateral triangles: a = b = c = 100	EQUILATERAL
Isosceles triangles: a = b ≠ c = 10	ISOSCELES
Isosceles triangles: a ≠ b = c = 10	ISOSCELES
Isosceles triangles: a = c ≠ b = 10	ISOSCELES

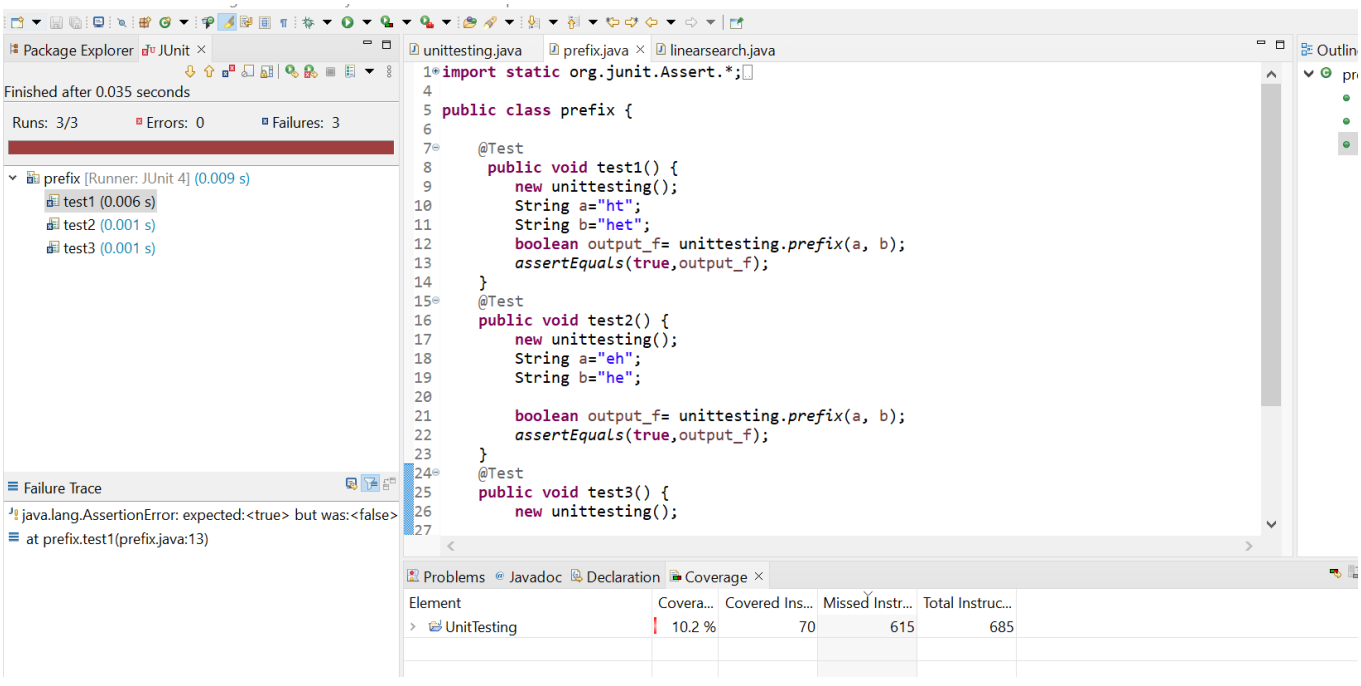
Scalene triangles: a = b + c - 1	SCALENE
Scalene triangles: b = a + c - 1	SCALENE
Scalene triangles: c = a + b - 1	SCALENE
Maximum values: a, b, c = Integer.MAX_VALUE	INVALID
Minimum values: a, b, c = Integer.MIN_VALUE	INVALID

P5. The function prefix (String s1, String s2) returns whether or not the string s1 is a prefix of string s2 (you may assume that neither s1 nor s2 is null).

```
public static boolean prefix(String s1, String s2)
{
	if (s1.length() > s2.length())
	{
	   return false;
	}

	for (int i = 0; i < s1.length(); i++)
	{
	   if (s1.charAt(i) != s2.charAt(i))
	   {
			return false;
	   }
	}

	return true;
}
```

Test Case in Eclipse:





Equivalence Partitioning:

Tester Action and Input Data	Expected Outcome
Valid Inputs: s1 = "hello", s2 = "hello world"	true
Valid Inputs: s1 = "a", s2 = "abc"	true
Invalid Inputs: s1 = "", s2 = "hello world"	false
Invalid Inputs: s1 = "world", s2 = "hello world"	false

Boundary Value Analysis:

Tester Action and Input Data	Expected Outcome
s1 = "", s2 = "abc"	False
s1 = "ab", s2 = "abc"	True
s1 = "abc", s2 = "ab"	False
s1 = "a", s2 = "ab"	True
s1 = "hello", s2 = "hellooo"	True
s1 = "abc", s2 = "abc"	True
s1 = "a", s2 = "b"	False
s1 = "a", s2 = "a"	True

P6: Consider again the triangle classification program (P4) with a slightly different specification: The program reads floating values from the standard input. The three values A, B, and C are interpreted as representing the lengths of the sides of a triangle. The program then prints a message to the standard output that states whether the triangle, if it can be formed, is scalene, isosceles, equilateral, or right angled. Determine the following for the above program:

a. Identify the equivalence classes for the system

b. Identify test cases to cover the identified equivalence classes. Also, explicitly mention which test case would cover which equivalence class. (Hint: you must need to be ensure that the identified set of test cases cover all identified equivalence classes)

c. For the boundary condition A + B > C case (scalene triangle), identify test cases to verify the boundary.

d. For the boundary condition A = C case (isosceles triangle), identify test cases to verify the
e. boundary.

f. For the boundary condition A = B = C case (equilateral triangle), identify test cases to verify the boundary.

g. For the boundary condition A2 + B2 = C2 case (right-angle triangle), identify test cases to verify the boundary.

h. For the non-triangle case, identify test cases to explore the boundary.
i. For non-positive input, identify test points.

Ans:

Equivalence Class:

Tester Action and Input Data	Expected Outcome
a = -1, b = 2, c = 3	Invalid input
a = 1, b = 1, c = 1	Equilateral triangle
a = 2, b = 2, c = 3	Isosceles triangle
a = 3, b = 4, c = 5	Scalene right-angled triangle
a = 3, b = 5, c = 4	Scalene right-angled triangle
a = 5, b = 3, c = 4	Scalene right-angled triangle
a = 3, b = 4, c = 6	Not a triangle

Test Case:

Invalid inputs:

a = 0, b = 0, c = 0, a + b = c, b + c = a, c + a = b

Invalid inputs:

a = -1, b = 1, c = 1, a + b = c

Equilateral triangles:

a = b = c = 1, a = b = c = 100

Isosceles triangles:

a = b = 10, c = 5;

a = c = 10, b = 3;

b = c = 10,

a = 6

Scalene triangles:

a = 4, b = 5, c = 6;

a = 10, b = 11, c = 13

Right angled triangle:

a = 3, b = 4, c = 5;

a = 5, b = 12, c = 13

Non-triangle:

a = 1, b = 2, c = 3

Non-positive input:

a = -1, b = -2, c = -3

c) Boundary condition A + B > C:

a = Integer.MAX_VALUE, b = Integer.MAX_VALUE, c = 1

a = Double.MAX_VALUE, b = Double.MAX_VALUE, c = Double.MAX_VALUE

d) Boundary condition A = C:

a = Integer.MAX_VALUE,

b = 2,

c = Integer.MAX_VALUE

a = Double.MAX_VALUE,

b = 2.5,

c = Double.MAX_VALUE

e) Boundary condition A = B = C:

a = Integer.MAX_VALUE, b = Integer.MAX_VALUE, c = Integer.MAX_VALUE a = Double.MAX_VALUE, b = Double.MAX_VALUE, c = Double.MAX_VALUE f) Boundary condition A^2 + B^2 = C^2:

a = Integer.MAX_VALUE,

b = Integer.MAX_VALUE,

c = Integer.MAX_VALUE

a = Double.MAX_VALUE,

b = Double.MAX_VALUE,

c = Math.sqrt(Math.pow(Double.MAX_VALUE, 2) + Math.pow(Double.MAX_VALUE, 2))

g) Non-triangle:

a = 1, b = 2, c = 4 a = 2, b = 4, c = 8

h) Non-positive input:

a = -1, b = -2, c = -3 a = 0, b = 1, c = 2

Section - B

The code below is part of a method in the ConvexHull class in the VMAP system. The following is a small fragment of a method in the ConvexHull class. For the purposes of this exercise you do not need to know the intended function of the method. The parameter p is a Vector of Point objects, p.size() is the size of the vector p, (p.get(i)).x is the x component of the ith point appearing in p, similarly for (p.get(i)).y. This exercise is concerned with structural testing of code and so the focus is on creating test sets that satisfy some particular coverage criterion.

```
Vector doGraham(Vector p) {
        int i,j,min,M;

        Point t;
        min = 0;

        // search for minimum:
        for(i=1; i < p.size(); ++i) {
            if( ((Point) p.get(i)).y <
                        ((Point) p.get(min)).y )
            {
                min = i;
            }
        }

        // continue along the values with same y component
        for(i=0; i < p.size(); ++i) {
            if(( ((Point) p.get(i)).y ==
                        ((Point) p.get(min)).y ) &&
                 (((Point) p.get(i)).x >
                        ((Point) p.get(min)).x ))
            {
                 min = i;
            }
        }
```

For the given code fragment you should carry out the following activities.

1. Convert the Java code comprising the beginning of the doGraham method into a control flow graph (CFG).

2. Construct test sets for your flow graph that are adequate for the following criteria:

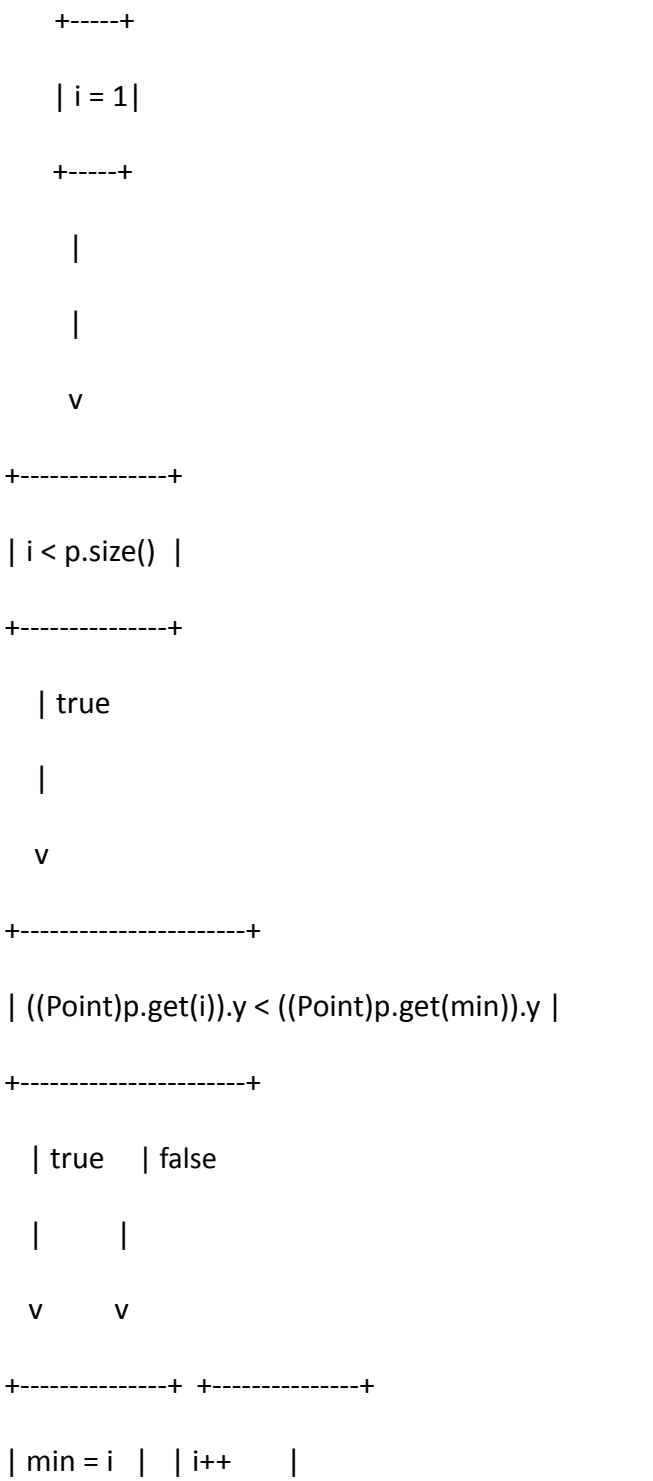
a. Statement Coverage.

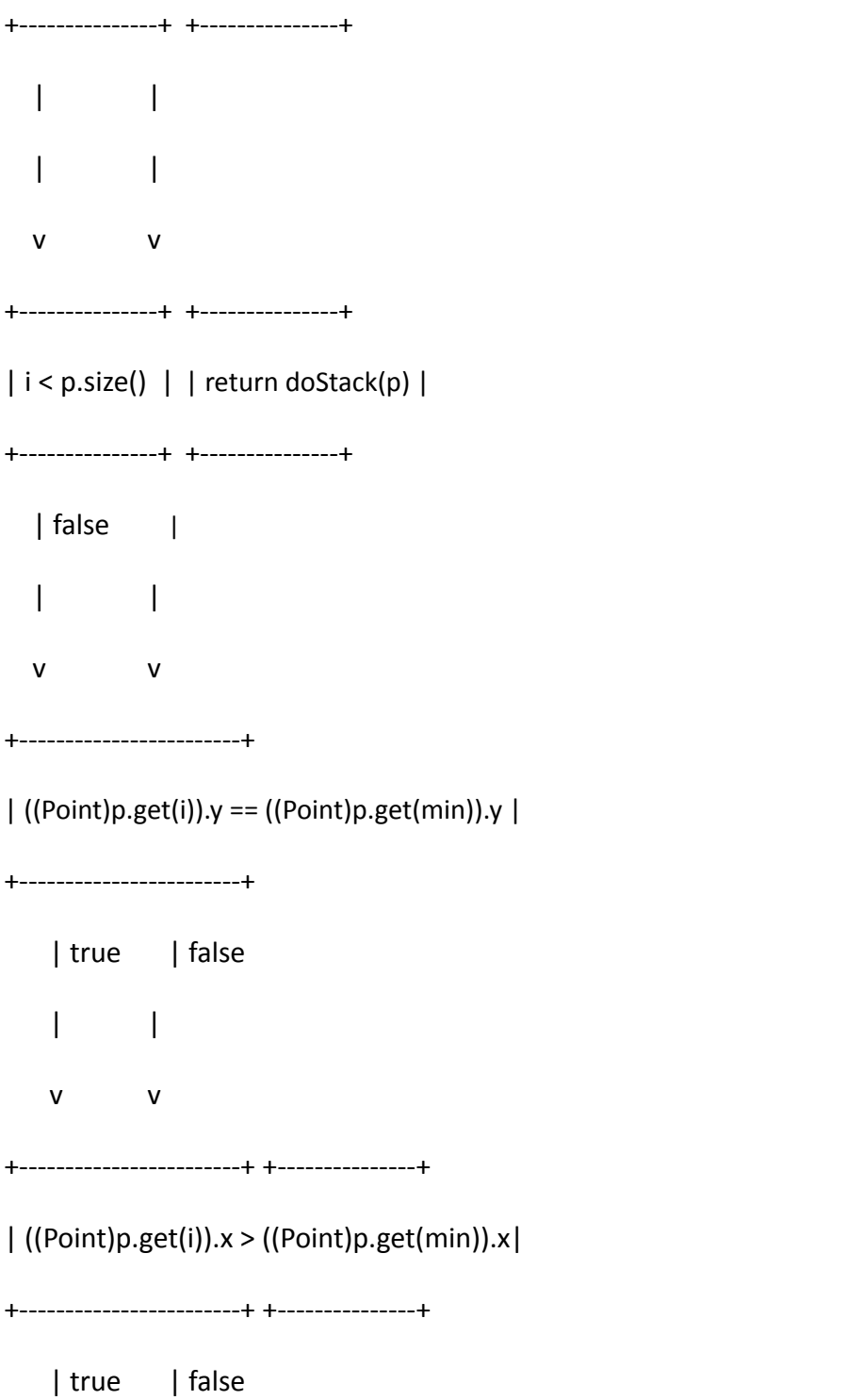
b. Branch Coverage.

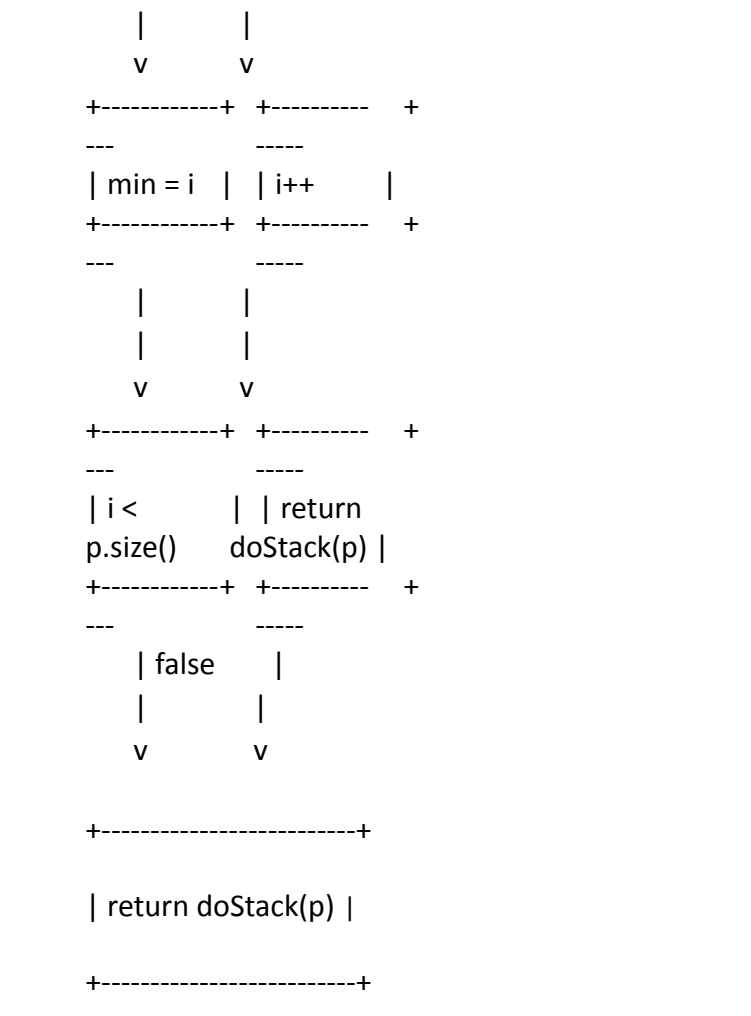
c. Basic Condition Coverage.

Ans:

Control Flow Graph (CFG):




+---------------+ +---------------+
| |
| |
v v
+---------------+ +---------------+
| i < p.size() | | return doStack(p) |
+---------------+ +---------------+
| false |
| |
v v
+------------------------+
| ((Point)p.get(i)).y == ((Point)p.get(min)).y |
+------------------------+
| true | false
| |
v v
+------------------------+ +---------------+
| ((Point)p.get(i)).x > ((Point)p.get(min)).x|
+------------------------+ +---------------+
| true | false



Test sets for each coverage criterion:

a. Statement Coverage:

Test 1: p = {new Point(0, 0), new Point(1, 1)}

Test 2: p = {new Point(0, 0), new Point(1, 0), new Point(2, 0)}

b. Branch Coverage:

Test 1: p = {new Point(0, 0), new Point(1, 1)}

Test 2: p = {new Point(0, 0), new Point(1, 0), new Point(2, 0)}

Test 3: p = {new Point(0, 0), new Point(1, 0), new Point(1, 1)}

c. Basic Condition Coverage:

Test 1: p = {new Point(0, 0), new Point(1, 1)}

Test 2: p = {new Point(0, 0), new Point(1, 0), new Point(2, 0)}

Test 3: p = {new Point(0, 0), new Point(1, 0), new Point(1, 1)}

Test 4: p = {new Point(0, 0), new Point(1, 0), new Point(0, 1)}

Test 5: p = {new Point(0, 0), new Point(0, 1), new Point(1, 1)}