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Lab 7

Section - A

1. **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 previous date or invalid date. Design the equivalence class test cases?**

a. **Class 1: Valid Dates** (Dates from (1, 1, 1900) to (31, 12, 2015) such that day, month, and year are in the given ranges. ex: (11, 2, 2000), (30, 8, 2009), (12, 10, 1997) etc.)
b. **Class 2: Invalid Dates** (Dates from (1, 1, 1900) to (31, 12, 2015) such that day, month, and year are in the given ranges but the input is invalid. ex: (31, 4, 2003), (29, 2, 2010), (30, 2, 2008) etc.)
c. **Class 3: Invalid Range** (Dates from (1, 1, 1900) to (31, 12, 2015) such that day, month, and year are not in the given ranges. ex: (3, 61, 2020), (16,4,2033), (15,0,2021) etc.)
d. **Class 4**: **Invalid Input** (Dates from (1, 1, 1900) to (31, 12, 2015) such that day, month, and year are in the given ranges but the input is invalid. ex: (2.8, 1.1, 2012), (11, n, 2013), (4, -6, 2011) etc.)

- Tester Action and Input Data Expected Outcome:
  - **Valid Dates:**
    - Test Case 1:
      Input: (11, 2, 2000)
      Output: (10, 2, 2000)
    - Test Case 2:
      Input: (30,8,2009)
      Output: (29,8,2009)
    - Test Case 2:
      Input: (12, 9, 1997)
      Output: (11, 9, 1997)
  - **Invalid Dates:**
    - Test Case 1:
      Input: (31, 4, 2003)
      Output: (30, 4, 2003)
    - Test Case 2:
      Input: (29, 2, 2010)
      Output: (28, 2, 2010)
    - Test Case 3:
      Input: (3,7,2010)
      Output: (2,7,2010)
  - **Invalid Range:**
    - Test Case 1:
      Input: (3, 61, 2020)
      Output: Invalid Date
    - Test Case 2:
      Input: (16,4,2033)
      Output: Invalid Date
    - Test Case 3:
      Input: (15,0,2021)
      Output: Invalid Date

- **Invalid Input:**
  - Test Case 1:
    Input: (2.8, 1.1, 2012)
    Output: Invalid Date
  - Test Case 2:
    Input: (11, n, 2013)
    Output: Invalid Date
  - Test Case 3:
    Input: (4, -6, 2011)
    Output: Invalid Date

- Boundary Value Analysis:

  Test Case 1: Valid First Possible Date
  Input: (1,1,1900)
  Output: (31,12,1899) Which is not in range.

  Test Case 2: Valid Last Possible Date
  Input: (31,12,2015)
  Output: (30,12,2015)

  Test Case 3: One Day Before First Possible Date
  Input: (31,1,1899)
  Output: Invalid Input

  Test Case 4: One Day After Last Possible Date
  Input: (1,1,2016)
  Output: Invalid Input

  Test Case 5: Valid Leap Year Date
  Input: (29,2,2000)
  Output: (28,2,2000)

Test Case 6: Invalid Leap Year Date

Input: (29,2,1900)

Output: Invalid input

Test Case 7: Valid Date After Leap Year Date

Input: (1,3,2000)

Output: (29,2,2000)

Test Case 8: Valid Date After Non-Leap Year Date

Input: (1,3,2019)

Output: (28,2,2019)

Test Case 9: Valid First Day of Month

Input: (1,3,2000)

Output: (31,12,1999)

Test Case 10: Valid First Day of Year

Input: (1,1,2000)

Output: (31,12,1999)

Based on these boundary test cases, we can design the following test cases:

- Equivalence Class Testing:

Tester Action and Input Data	Expected Outcome
Valid Partition	
(1,1,1900)	(31,12,1899)
(31,12,2015)	(30,12,2015)
Invalid Partition	
(32,2,2022)	Invalid Date

(13,14,2003)	Invalid Date
(11,11,2020)	Invalid Date
(29,2,2002)	Invalid Date
(31,4,2010)	Invalid Date
(4.2, 2, 2022)	Invalid Date
(2, b, 2010)	Invalid Date
(30, 2, 2000)	Invalid Date
(31,1,1899)	Invalid Date

- Boundary Value Analysis:

Tester Action and Input Data	Expected Outcome
(1,1,1900)	(31,12,1899)
(31,12,2015)	(30,12,2015)
(31,1,1899)	Invalid input
(1,1,2016)	Invalid input
(29,2,2000)	(28,2,2000)
(29,2,1900)	Invalid input
(1,3,2000)	(29,2,2000)
(1,3,2019)	(28,2,2019)
(1,3,2000)	(31,12,1999)
(1,1,2000)	(31,12,1999)

2. Write a set of test cases (i.e., test suite) – specific set of data – to properly test the programs. Your test suite should include both correct and incorrect inputs.

1. Enlist which set of test cases have been identified using Equivalence Partitioning and Boundary Value Analysis separately.

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.

Equivalence Partitioning	Expected Outcome
a = [1, 2, 3, 4], v = 2	1
a = [5, 6, 7, 8], v = 10	-1
a = [1, 1, 2, 3], v = 1	0
a = null, v = 5	Error Message

Boundary Analysis	Expected Outcome
Minimum array length: a = [], v = 7	-1
Maximum array length: a = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10], v = 3	2
Minimum value of v: a = [5, 6, 7], v = 5	0
Maximum value of v: a = [1, 2, 3], v = 3	2

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

Equivalence Partitioning	Expected Outcome
Invalid input: v is not an integer	Error Message
Empty array: a = []	0
Single item array: a = [v], v = a[0]	1
Multiple item array with v appearing:	
v appears once	1
v appears multiple times	Count > 1
Multiple item array with v not appearing	0

Boundary Analysis	Expected Outcome
Minimum input values: v = a[0] = 1	Count > 0
Maximum input values: v = a[9999] = 10000	Count > 0
One occurrence of v: a = [1, 2, 3, ..., 9999, v-1, 10000]	1
All occurrences of v: a = [v, v, v, ..., v, v]	10000
No occurrences of v: a = [1, 2, 3, ..., 9999]	0

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.

Equivalence Partitioning	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 = 2, a = [1, 3, 5, 7, 9]	-1
v = 2, a = [1, 3, 5, 7, 9]	-1
v = 6, a = []	-1

Boundary Value Analysis	**Expected Outcome**
v = 5, a = [5, 6, 7]	0
v = 6, a = [5, 6, 7]	1
v = 7, a = [5, 6, 7]	2
v = 5, a = [1, 5, 6, 7, 9]	1
v = 6, a = [1, 5, 6, 7, 9]	2
v = 7, a = [1, 5, 6, 7, 9]	3
v = 9, a = [1, 5, 6, 7, 9]	4
v = 1, a = [1]	0
v = 5, a = [5]	0
v = 5, a = []	-1
v = 2, a = [1, 3, 5, 7, 9]	-1
v = 6, a = [1, 3, 5, 7, 9]	-1

v = 10, a = [1, 3, 5, 7, 9]	-1
v = 1, a = [2, 3, 4, 5, 6]	-1
v = 4, a = [2, 3, 4, 5, 6]	-1
v = 7, a = [2, 3, 4, 5, 6]	-1

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).

Equivalence Partitioning	Expected Outcome
a=b=c Where a, b, c are positive integers	Equilateral
a=b<c Where a, b, and c are positive integers	Isosceles
a=b=c=0	Invalid
a<b+c, b<a+c, c<a+b Where a, b, c are positive integers	Scalene
a=b>0, c=0	Invalid
a>b+c	Invalid

Boundary Value Analysis	Expected Outcome
a=1, b=1, c=1	Equilateral
a=1, b=2, c=2	Isosceles

a=0, b=0, c=0	Invalid
a=2147483647, b=2147483647, c=2147483647	Equilateral
a=2147483646, b=2147483647, c=2147483647	Isosceles
a=1, b=1, c=2^{31}-1	Scalene
a=0, b=1, c=1	Invalid

P5. The function prefix (String s1, String s2) returns whether the string s1 is a prefix of string s2 (you may assume that neither s1 nor s2 is null).

Equivalence Partitioning	Expected Outcome
s1 is empty, s2 is non-empty string	True
s1 is non-empty string, s2 is empty	False
s1 is a prefix of s2	True
s1 is not a prefix of s2	False
s1 has same characters as s2, but not a prefix	False

Boundary Value Analysis	Expected Outcome
s1 = "a", s2 = "ab"	True
s1 = "ab", s2 = "a"	False
s1 = "a", s2 = "a"	True
s1 = "a", s2 = "A"	False
s1 = "abcdefghijklmnopqrstuvwxyz", s2 = "abcdefghijklmnopqrstuvwxyz"	True

s1 = "abcdefghijklmnopqrstuvwxyz", s2 = "abcdefghijklmno"	True
s1 = "", s2 = ""	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.

Class 1: Invalid inputs (negative or zero values)
Class 2: Non-triangle (sum of the two shorter sides is not greater than the longest side)
Class 3: Scalene triangle (no sides are equal)
Class 4: Isosceles triangle (two sides are equal)
Class 5: Equilateral triangle (all sides are equal)
Class 6: Right-angled triangle (satisfies the Pythagorean theorem)

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)

For Class 1: -1, 0,3
For Class 2: 1, 2, 5
For Class 3: 3, 4, 5
For Class 4: 5, 5, 7
For Class 5: 6, 6, 6
For Class 6: 3, 4, 5

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

(1) 2, 3, 6
(2) 3, 4, 8

Both test cases have two sides shorter than the third side and should not form a triangle.

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

(1) 2, 3, 3
(2) 5, 6, 5
Both test cases have two equal sides and should form an isosceles triangle.

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

(1) 5, 5, 5
(2) 9, 9, 9
Both test cases have all sides equal and should form an equilateral triangle.

f) For the boundary condition A^2 + B^2 = C^2 case (right-angle triangle), identify test cases to verify the boundary.

(1) 3, 4, 5
(2) 5, 12, 13
Both test cases satisfy the Pythagorean theorem and should form a right-angled triangle.

g) For the non-triangle case, identify test cases to explore the boundary.

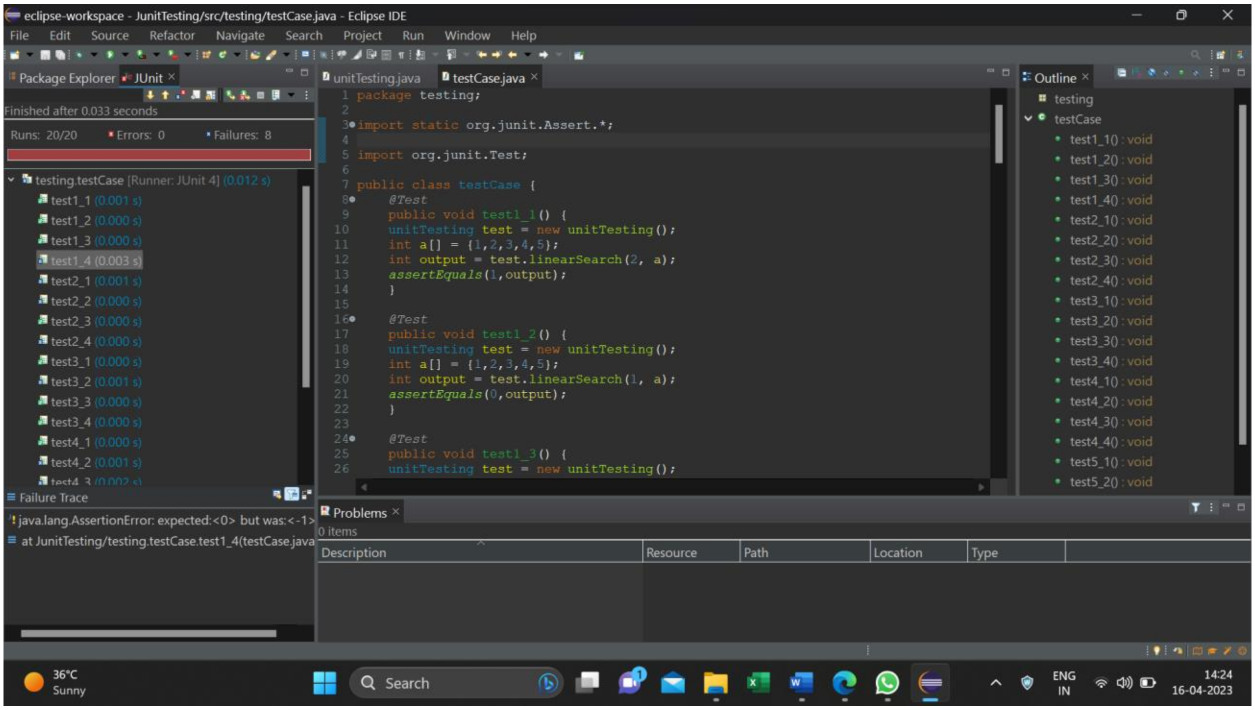
(1) 2, 2, 4
(2) 3, 6, 9
Both test cases have two sides that add up to the third side and should not form a triangle.

h) For non-positive input, identify test points.

(1) 0, 1, 2
(2) -1, -2, -3
Both test cases have at least one non-positive value, which is an invalid input.

2. Modify your programs such that it runs on eclipse IDE, and then execute your test suites on the program. While executing your input data in a program, check whether the identified expected outcome (mentioned by you) is correct or not.

- I have considered 20 test cases from which some are correct and some are incorrect.



- Modified Java Codes for the given programs:

```
package testing;

public class unitTesting {

        public int linearSearch(int v, int a[]) // p1
        {
                int i = 0;
                while (i < a.length)
                {
                        if (a[i] == v)
                                return(i);
                        i++;
                }
                return (-1);
        }

        public int countItem(int v, int a[]) //p2
        {
                int count = 0;
                for (int i = 0; i < a.length; i++)
                {
                        if (a[i] == v)
                                count++;
                }
```

```java
            return (count);
        }

        public int binarySearch(int v, int a[]) //p3
        {
            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);
        }

        final int EQUILATERAL = 0;
        final int ISOSCELES = 1;
        final int SCALENE = 2;
        final int INVALID = 3;
        public int triangle(int a, int b, int c) //p4
        {
            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);
        }

        public boolean prefix(String s1, String s2) //p5
        {
            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 Cases with Coverage:

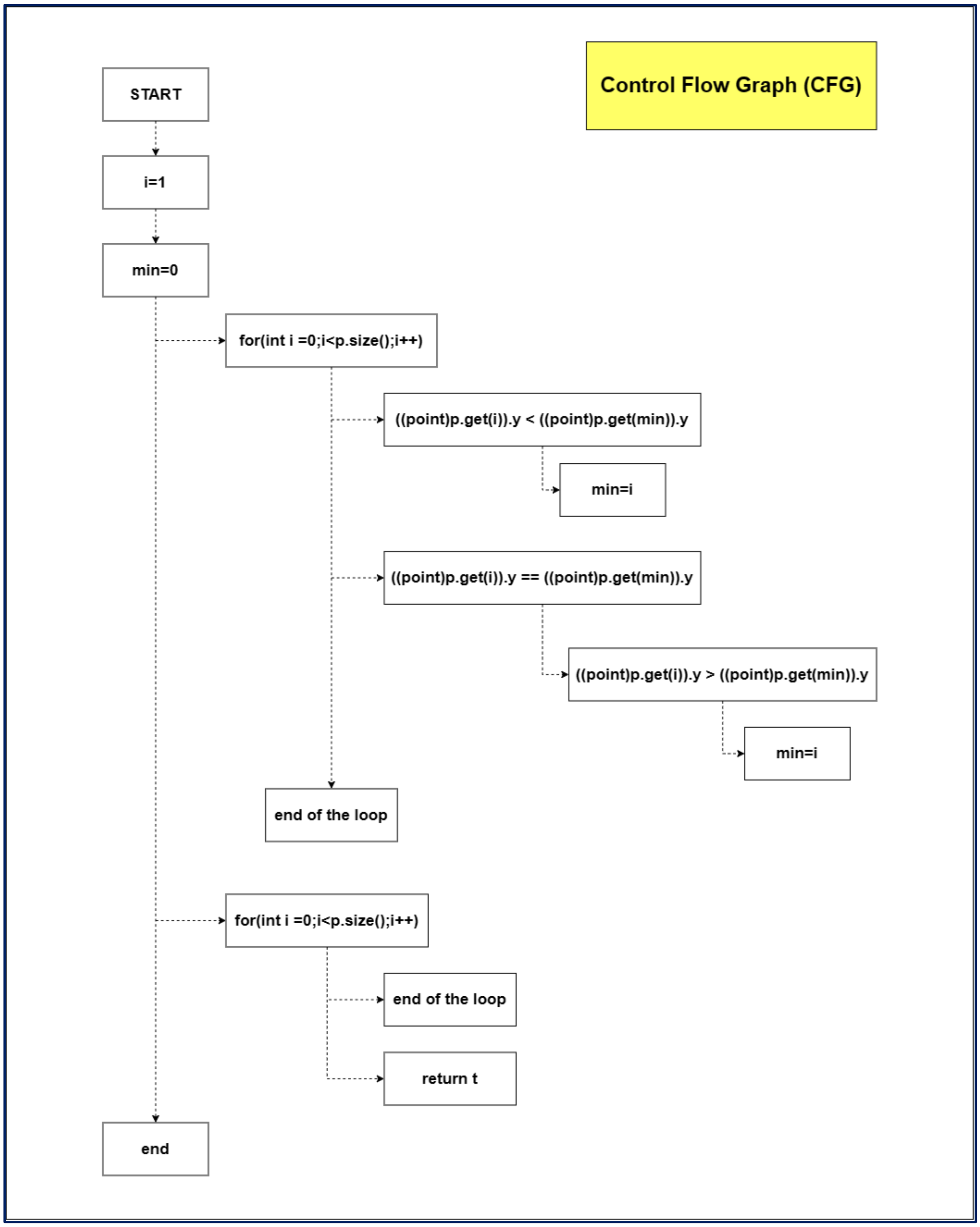
```
package testing;

import static org.junit.Assert.*;

import org.junit.Test;

public class testCase {
      @Test
      public void test1_1() {
      unitTesting test = new unitTesting();
      int a[] = {1,2,3,4,5};
      int output = test.linearSearch(2, a);
      assertEquals(1,output);
      }

      @Test
      public void test1_2() {
      unitTesting test = new unitTesting();
      int a[] = {1,2,3,4,5};
      int output = test.linearSearch(1, a);
      assertEquals(0,output);
      }

      @Test
      public void test1_3() {
      unitTesting test = new unitTesting();
      int a[] = {1,2,3,4,5};
      int output = test.linearSearch(7, a);
      assertEquals(-1,output);
      }

      @Test
      public void test1_4() {
      unitTesting test = new unitTesting();
      int a[] = {1,2,3,4,5};
      int output = test.linearSearch(7, a);
      assertEquals(0,output);
      }

      @Test
      public void test2_1() { // no of element p2
      unitTesting test = new unitTesting();
      int a[] = {1,2,3,4,5};
      int output = test.countItem(2, a);
      assertEquals(2,output);
      }

      @Test
      public void test2_2() { //no of element p2
      unitTesting test = new unitTesting();
      int a[] = {1,2,3,4,5};
      int output = test.countItem(4, a);
      assertEquals(2,output);
```

```
        }

        @Test
        public void test2_3() { //no of element p2
        unitTesting test = new unitTesting();
        int a[] = {1,2,3,4,5};
        int output = test.countItem(6, a);
        assertEquals(0,output);
        }

        @Test
        public void test2_4() { //no of element p2
        unitTesting test = new unitTesting();
        int a[] = {1,2,3,4,5};
        int output = test.countItem(6, a);
        assertEquals(-1,output);
        }

        @Test
        public void test3_1() { //binary search p3
        unitTesting test = new unitTesting();
        int a[] = {1,2,3,4,5};
        int output = test.binarySearch(2, a);
        assertEquals(1,output);
        }

        @Test
        public void test3_2() { //binary search p3
        unitTesting test = new unitTesting();
        int a[] = {1,2,3,4,5};
        int output = test.binarySearch(3, a);
        assertEquals(3,output);
        }
        @Test
        public void test3_3() { //binary search p3
        unitTesting test = new unitTesting();
        int a[] = {1,2,3,4,5};
        int output = test.binarySearch(8, a);
        assertEquals(-1,output);
        }

        @Test
        public void test3_4() { //binary search p3
        unitTesting test = new unitTesting();
        int a[] = {1,2,3,4,5};
        int output = test.binarySearch(8, a);
        assertEquals(-1,output);
        }

        @Test
        public void test4_1() {
        unitTesting test = new unitTesting();
        int output = test.triangle(8,8,8);
        assertEquals(0,output);
        }

        @Test
```

```java
        public void test4_2() {
        unitTesting test = new unitTesting();
        int output = test.triangle(8,8,10);
        assertEquals(2,output);
        }

        @Test
        public void test4_3() {
        unitTesting test = new unitTesting();
        int output = test.triangle(0,0,0);
        assertEquals(1,output);
        }

        @Test
        public void test4_4() {
        unitTesting test = new unitTesting();
        int output = test.triangle(0,0,0);
        assertEquals(3,output);
        }

        @Test
        public void test5_1() {
        unitTesting test = new unitTesting();
        boolean output = test.prefix("","nonEmpty");
        assertEquals(true,output);
        }

        @Test
        public void test5_2() { // example of s1 is prefix of s2
        unitTesting test = new unitTesting();
        boolean output = test.prefix("hello","hello world");
        assertEquals(true,output);
        }

        @Test
        public void test5_3() { // example of s1 is not prefix of s2
        unitTesting test = new unitTesting();
        boolean output = test.prefix("hello","world hello");
        assertEquals(false,output);
        }

        @Test
        public void test5_4() { // example of s1 is not prefix of s2
        unitTesting test = new unitTesting();
        boolean output = test.prefix("hello","world hello");
        assertEquals(true,output);
        }
}
```

Section B

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.

To satisfy statement coverage, we need to ensure that each statement in the CFG is executed at least once. We can achieve this by providing a test case with a single point in the vector. In this case, both loops will not execute, and the return statement will be executed. A test set that satisfies statement coverage would be:

p = [Point (0,0)]

b. Branch Coverage.

To satisfy branch coverage, we need to ensure that each branch in the CFG is executed at least once. We can achieve this by providing a test case with two points such that one of the points has the minimum y-coordinate, and the other has a greater x-coordinate than the minimum. In this case, both loops will execute, and the second branch in the second loop will be taken. A test set that satisfies branch coverage would be:

p = [Point (0,0), Point (1,1)]

c. Basic Condition Coverage.

To satisfy basic condition coverage, we need to ensure that each condition in the CFG is evaluated to both true and false at least once. We can achieve this by providing a test case with three points such that two of the points have the same y-coordinate, and the other has a greater x-coordinate than the minimum. In this case, both loops will execute, and the second condition in the second loop will be evaluated to true and false. A test set that satisfies basic condition coverage would be:

p = [Point (0,0), Point (1,1), Point (2,0)]