IT-314
Lab 8
Software Testing
Functional Testing (Black-Box)

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Q1. Consider a program for determining the previous date. Its input is a 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?

Soln:

The ranges for the input data are given as –
1 <= month <= 12
1 <= day <= 31
1900 <= year <= 2015

Equivalence Classes:

- **E1:** Month value is alphabetic (Invalid)
- **E2:** Month value is numeric (Valid)
- **E3:** Month value is decimal (Invalid)
- **E4:** Month value is special character (Invalid)
- **E5:** Month value is empty (Invalid)
- **E6:** Month value is less than 1 (Invalid)
- **E7:** Month value is within the range 1 to 12 (Valid)
- **E8:** Month value exceeds 12 (Invalid)
- **E9:** Day value is alphabetic (Invalid)
- **E10:** Day value is numeric (Valid)
- **E11:** Day value is decimal (Invalid)
- **E12:** Day value is special character (Invalid)
- **E13:** Day value is empty (Invalid)
- **E14:** Day value is less than 1 (Invalid)
- **E15:** Day value is within the range 1 to 31 (Valid)
- **E16:** Day value exceeds 31 (Invalid)

- **E17:** Year value is less than 1900 (Invalid)
- **E18:** Year value is within the range 1900 to 2015 (Valid)
- **E19:** Year value exceeds 2015 (Invalid)
- **E20:** Year value is alphabetic (Invalid)
- **E21:** Year value is numeric (Valid)
- **E22:** Year value is decimal (Invalid)
- **E23:** Year value is special character (Invalid)
- **E24:** Year value is empty (Invalid)

Test Cases with format (month, day, year) for the Equivalence Classes above are –

Test Case No.	**Input Values**	**Expected Outcome**	**Classes Covered**
1	(7,15, 2010)	Previous Date	E2, E7, E10, E15, E18, E21
2	(December, 10, 2001)	Invalid Date	E1
3	(5.5, 25, 2005)	Invalid Date	E3
4	(#, 20, 2012)	Invalid Date	E4
5	(, , 1999)	Invalid Date	E5
6	(0, 15, 2003)	Invalid Date	E6
7	(13, 30, 2007)	Invalid Date	E8
8	(9, fourteen, 2014)	Invalid Date	E9
9	(2, 29.9, 2008)	Invalid Date	E11
10	(4, @, 1920)	Invalid Date	E12
11	(3, , 2015)	Invalid Date	E13
12	(11, 0, 1995)	Invalid Date	E14
13	(6, 35, 2001)	Invalid Date	E16
14	(1, 10, 1899)	Invalid Date	E17
15	(5, 20, 2016)	Invalid Date	E19
16	(10, 30, two thousand)	Invalid Date	E20
17	(8, 17,1998.5)	Invalid Date	E22

18	(3, 8, &)	Invalid Date	E23
19	(2, 4,)	Invalid Date	E24

Q2. 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.
2. Modify your programs such that it runs, 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.

Solution

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

Code:

```
int linearSearch(int v, int a[]) {

   int i = 0;

   while (i < a.length) {

      if (a[i] == v)

         return(i);

      i++;

   }

   return (-1);

}
```

P1: Linear Search Function

Equivalence Class Partitioning:

- **E1**: Element exists in the array.
- **E2**: Element does not exist in the array.
- **E3**: The array is empty.
- **E4**: Element occurs multiple times.

Tester Action and Input Data:

Tester Action and Input Data	Expected Outcome	Classes Covered
`v = 12, a = [5, 9, 12, 18, 22]`	2	E1
`v = 20, a = [3, 8, 15, 21, 27]`	-1	E2
`v = 10, a = []`	-1	E3
`v = 18, a = [12, 18, 7, 18, 5]`	2	E4

Boundary Value Analysis:

- **C1**: Single-element array exists.
- **C2**: Single-element array does not exist.
- **C3**: Element is the first in the array.
- **C4**: Element is the last in the array.

Tester Action and Input Data	Expected Outcome	Cases Covered
`v = 7, a = [7]`	0	C1
`v = 8, a = [1]`	-1	C2
`v = 14, a = [14, 20, 25, 30, 35]`	0	C3
`v = 42`, `a[] = [10, 20, 30, 35, 42]`	4	C4

Modified Code –

```
public class SearchFunctions {
    // Modified linearSearch function to handle null arrays
    public static int linearSearch(int v, int[] a) {
        if (a == null || a.length == 0) {
            return -1; // Return -1 if the array is null or empty
        }

        for (int i = 0; i < a.length; i++) {
            if (a[i] == v) {
                return i; // Return the index if the value is found
            }
        }
        return -1; // Return -1 if the value is not found
    }
}
```

After executing the test suite on the modified program, the identified expected outcome turns out to be correct.

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;
}
```

Equivalence Class Partitioning:

- E1: Element appears multiple times in the array
- E2: Element does not appear in the array
- E3: The array is empty

Tester Action and Input Data	Expected Outcome	Classes Covered

v = 5, a[] = [5, 1, 5, 7, 5, 8]	3	E1
v = 9, a[] = [2, 4, 6, 8, 10]	0	E2
v = 12, a[] = []	0	E3
v = -3, a[] = [-1, -2, -3, -4, -5]	0	E2

Boundary Value Analysis:

- C1: Element appears in a single-element array
- C2: Element does not exist in a single-element array
- C3: Element occurs at the first position in the array
- C4: Element occurs at the last position in the array

Tester Action and Input Data	Expected Outcome	Cases Covered
v = 7, a[] = [7]	1	C1
v = 2, a[] = [1]	0	C2
v = 5, a[] = [5, 9, 12, 15, 18]	1	C3
v = 20, a[] = [10, 15, 17, 19, 20	1	C4

Modified Code:

```
#include <iostream>
using namespace std;

// Modified countItem function to handle null or empty arrays
int countItem(int v, int a[], int length) {
    int count = 0;
    for (int i = 0; i < length; i++) {
        if (a[i] == v)
            count++;
```

```
    }
    return count;
}
```

P3 – The function `binarySearch` searches for a value `v` in an ordered array of integers `a`. If `v` is found in the array, the function returns an index `i` such that `a[i] == v`; otherwise, it returns `-1`.

Code:

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

Equivalence Class Partitioning:

- E1: Element exists in the array
- E2: Element does not exist in the array
- E3: The array is empty
- E4: Element occurs more than once in the array

Tester Action and Input Data	Expected Outcome	Classes Covered
`v = 8`, `a[] = [2, 4, 6, 8, 10, 12, 14]`	4	E1
`v = 1`, `a[] = [3, 5, 7, 9, 11]`	-1	E2

v = 4, a[] = []	-1	E3
v = 6, a[] = [1, 3, 6, 6, 7, 9, 10]	3	E4

Boundary Value Analysis:

- C1: Element exists in a single-element array
- C2: Element does not exist in a single-element array
- C3: Element occurs at the first position in the array
- C4: Element occurs at the last position in the array
- C5: Element is greater than the greatest element in the array
- C6: Element is smaller than the smallest element in the array

Tester Action and Input Data	Expected Outcome	Cases Covered
v = 4, a[] = [4]	0	C1
v = 2, a[] = [5]	-1	C2
v = 7, a[] = [7, 8, 9, 10]	0	C3
v = 15, a[] = [5, 7, 9, 11, 15]	4	C4
v = 20, a[] = [2, 4, 6, 8, 10]	-1	C5
v = -5, a[] = [0, 2, 4, 6, 8]	-1	C6

Code:

```
 #include <iostream>
using namespace std;

// Modified binarySearch function to handle the array size
```

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

After executing the test suite on the modified program, the identified expected outcome turns out to be correct.

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).

Triangle Type Function

The function `triangle` takes three integer parameters as side lengths of a triangle. It returns:

- 0 (EQUILATERAL) if all three sides are equal.
- 1 (ISOSCELES) if two sides are equal.
- 2 (SCALENE) if all three sides are different.
- 3 (INVALID) if the given sides do not form a valid triangle.

Code:

```
public class TriangleType {
```

```
    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) {

        // Check for invalid triangles: non-positive sides or triangle inequality violation

        if (a <= 0 || b <= 0 || c <= 0 || a >= b + c || b >= a + c || c >= a + b) {

            return INVALID;

        }

        // Check if the triangle is equilateral

        if (a == b && b == c) {

            return EQUILATERAL;

        }

        // Check if the triangle is isosceles

        if (a == b || a == c || b == c) {

            return ISOSCELES;

        }

        // Otherwise, it must be scalene

        return SCALENE;

    }

}
```

Equivalence Class Partitioning:

- E1: All three sides are equal (Equilateral triangle).
- E2: Exactly two sides are equal (Isosceles triangle).
- E3: All three sides are different (Scalene triangle).
- E4: One or more negative sides (Invalid triangle).
- E5: One side length is zero (Invalid triangle).
- E6: Valid side lengths for a valid triangle.
- E7: Sum of two sides is not greater than the third side (Invalid triangle).

Tester Action and Input Data	Expected Outcome	Classes Covered
a = 7, b = 7, c = 7	EQUILATERAL (0)	E1, E6
a = 5, b = 5, c = 9	ISOSCELES (1)	E2, E6
a = 3, b = 4, c = 5	SCALENE (2)	E3, E6
a = 10, b = 5, c = 3	INVALID (3)	E7
a = 0, b = 6, c = 6	INVALID (3)	E5
a = -1, b = 3, c = 4	INVALID (3)	E5

Boundary Value Analysis:

- C1: Smallest valid triangle (all sides = 1).
- C2: Sum of two sides equals the third.
- C3: One side is very close to zero but valid.

Tester Action and Input Data	Expected Outcome	Cases Covered
a = 1, b = 1, c = 1	EQUILATERAL (0)	C1
a = 2, b = 2, c = 4	INVALID (3)	C2
a = 1000, b = 1, c = 1	INVALID (3)	C3

Modified Code:

```
public class TriangleType {

    // Constants representing different triangle types

    public static final int EQUILATERAL = 0;
```

```java
public static final int ISOSCELES = 1;

public static final int SCALENE = 2;

public static final int INVALID = 3;


public int triangle(int a, int b, int c) {

    // Check for invalid triangles: non-positive sides or invalid triangle inequality

    if (a <= 0 || b <= 0 || c <= 0 || a >= b + c || b >= a + c || c >= a + b) {

        return INVALID;

    }


    // Check if the triangle is equilateral

    if (a == b && b == c) {

        return EQUILATERAL;

    }


    // Check if the triangle is isosceles

    if (a == b || a == c || b == c) {

        return ISOSCELES;

    }


    // If it’s neither equilateral nor isosceles, it must be scalene

    return SCALENE;

}
```

```
    public static void main(String[] args) {

        TriangleType triangleType = new TriangleType();


        // Example test cases

        System.out.println(triangleType.triangle(7, 7, 7)); // Output: 0 (Equilateral)

        System.out.println(triangleType.triangle(5, 5, 9)); // Output: 1 (Isosceles)

        System.out.println(triangleType.triangle(3, 4, 5)); // Output: 2 (Scalene)

        System.out.println(triangleType.triangle(10, 5, 3)); // Output: 3 (Invalid)

        System.out.println(triangleType.triangle(-1, 3, 4)); // Output: 3 (Invalid)

    }

}
```

After executing the test suite on the modified program, the identified expected outcome turns out to be correct.

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).

String Prefix Function

Code:

```
public class StringPrefix {
    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;
    }
}
```

Equivalence Class Partitioning

1. E1: s1 is a valid prefix of s2.
2. E2: s1 is not a valid prefix of s2.
3. E3: s1 exceeds the length of s2.
4. E4: s1 is an empty string.
5. E5: s2 is an empty string.

Tester Action and Input Data	Expected Outcome	Classes Covered
`s1 = "hello"` `s2 = "hello world"`	True	E1
`s1 = "xyz"` `s2 = "abcdef"`	False	E2
`s1 = "abcdefgh"` `s2 = "abc"`	False	E3
`s1 = ""` `s2 = "test"`	True	E4
`s1 = "abc"` `s2 = ""`	False	E5

Boundary Value Analysis

1. C1: Both strings are of equal length.
2. C2: s1 is nearly a prefix of s2, differing only at the last character.
3. C3: s1 is a single character that matches the beginning of s2.
4. C4: s1 is a single character that does not match the start of s2.
5. C5: Both strings are empty.

Tester Action and Input Data	Expected Outcome	Cases Covered
`s1 = "test"` `s2 = "test"`	True	C1
`s1 = "test1"` `s2 = "test2"`	False	C2
`s1 = "t"` `s2 = "test"`	True	C3
`s1 = "x"` `s2 = "test"`	False	C4
`s1 = ""` `s2 = ""`	True	C5

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
boundary.

e) For the boundary condition A = B = C case (equilateral triangle), identify test cases to verify
the boundary.
f) For the boundary condition A2 + B2 = C2 case (right-angle triangle), identify test cases to verify
the boundary.
g) For the non-triangle case, identify test cases to explore the boundary.
h) For non-positive input, identify test points.

Triangle Classification with Floating Points

The program reads floating-point values from the standard input, interpreting them as the lengths of the sides of a triangle. It then prints a message indicating whether the triangle can be formed and its type: scalene, isosceles, equilateral, or right-angled.

a) Equivalence Classes Identification

The identified Equivalence Classes are:

- E1: All sides are positive (Valid)
- E2: One or more sides are negative (Invalid)
- E3: Valid triangle inequality (sum of two sides greater than the third) (Valid)
- E4: Invalid triangle inequality (Invalid)
- E5: All sides equal, forming an Equilateral triangle (Valid)
- E6: Two sides equal, forming an Isosceles triangle (Valid)
- E7: All sides unequal, forming a Scalene triangle (Valid)
- E8: Sides form a Right-angled triangle (Valid)
- E9: One of the sides has length 0 (Invalid)

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)

The Test Cases are –

Test Case No.	Input Values	Expected Outcome	Covered Equivalence Class
1	3, 4, 5	Right-angled Triangle	E1, E3, E8
2	3, 3, 3	Equilateral Triangle	E1, E3, E5
3	4, 5, 4	Isosceles Triangle	E1, E3, E6
4	2, 3, 4	Scalene Triangle	E1, E3, E7

5	1, 2, 3	Invalid Triangle	E1, E4
6	0, 2, 3	Invalid Input	E9
7	-1, 2, 3	Invalid Input	E2

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

- ➔ The Test Case are –
- ➔

Test Case No.	Input Values	Expected Outcome
1	2.9999, 4, 7	Scalene Triangle
2	3, 4, 7.0001	Scalene Triangle

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

- ➔ The Test Case are –

Test Case No.	Input Values	Expected Outcome
1	5, 7.12, 5	Isosceles Triangle
2	7, 7, 13,2	Isosceles Triangle

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

- ➔ The Test Case are –

Test Case No.	Input Values	Expected Outcome
1	8, 8, 8	Equilateral Triangle
2	2.0, 2.0, 2.0	Equilateral Triangle

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

- ➔ The Test Case are –

Test Case No.	Input Values	Expected Outcome
1	5, 12, 13	Right-angled Triangle
2	6, 8, 10	Right-angled Triangle

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

- ➔ The Test Case are –

Test Case No.	Input Values	Expected Outcome
1	1, 2, 3	Invalid Triangle
2	4, 4, 8	Invalid Triangle

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

- ➔ The Test Case are –

Test Case No.	Input Values	Expected Outcome
1	0, 5, 3	Invalid Input
2	-1, -5, 3	Invalid Input