



IT-314

SOFTWARE ENGINEERING

Lab 8 (Black-Box)

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Q.1. Consider a program for determining the previous date. Its input is triple of day, month and year with the following ranges $1 \leq \text{month} \leq 12$, $1 \leq \text{day} \leq 31$, $1900 \leq \text{year} \leq 2015$. The possible output dates would be previous date or invalid date. Design the equivalence class test cases?

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.

- **Equivalence class partitioning:**

Equivalence Class	Equivalence Class Description
E1	month < 1, day < 1, year < 1900
E2	month < 1, day < 1, $1900 \leq \text{year} \leq 2015$
E3	month < 1, day < 1, year > 2015
E4	month < 1, $1 \leq \text{day} \leq 31$, year < 1900
E5	month < 1, $1 \leq \text{day} \leq 31$, $1900 \leq \text{year} \leq 2015$
E6	month < 1, $1 \leq \text{day} \leq 31$, year > 2015
E7	month < 1, day > 31, year < 1900
E8	month < 1, day > 31, $1900 \leq \text{year} \leq 2015$
E9	month < 1, day > 31, year > 2015
E10	$1 \leq \text{month} \leq 12$, day < 1, year < 1900
E11	$1 \leq \text{month} \leq 12$, day < 1, $1900 \leq \text{year} \leq 2015$
E12	$1 \leq \text{month} \leq 12$, day < 1, year > 2015
E13	$1 \leq \text{month} \leq 12$, $1 \leq \text{day} \leq 31$, year < 1900
E14	$1 \leq \text{month} \leq 12$, $1 \leq \text{day} \leq 31$, $1900 \leq \text{year} \leq 2015$
E15	$1 \leq \text{month} \leq 12$, $1 \leq \text{day} \leq 31$, year > 2015
E16	$1 \leq \text{month} \leq 12$, day > 31, year < 1900
E17	$1 \leq \text{month} \leq 12$, day > 31, $1900 \leq \text{year} \leq 2015$
E18	$1 \leq \text{month} \leq 12$, day > 31, year > 2015

E19	month > 12, day < 1, year < 1900
E20	month > 12, day < 1, 1900 ≤ year ≤ 2015
E21	month > 12, day < 1, year > 2015
E22	month > 12, 1 ≤ day ≤ 31, year < 1900
E23	month > 12, 1 ≤ day ≤ 31, 1900 ≤ year ≤ 2015
E24	month > 12, 1 ≤ day ≤ 31, year > 2015
E25	month > 12, day > 31, year < 1900
E26	month > 12, day > 31, 1900 ≤ year ≤ 2015
E27	month > 12, day > 31, year > 2015

- **Equivalence test cases analysis:**

Test Case	Valid / Invalid	Covered Equivalence Class
month=0, day=0, year=1899	Invalid	1
month=0, day=0, year=2000	Invalid	2
month=0, day=0, year=2016	Invalid	3
month=0, day=1, year=1899	Invalid	4
month=0, day=15, year=2000	Invalid	5
month=0, day=31, year=2016	Invalid	6
month=0, day=32, year=1899	Invalid	7
month=0, day=32, year=2000	Invalid	8
month=0, day=32, year=2016	Invalid	9
month=1, day=0, year=1899	Invalid	10
month=1, day=0, year=2000	Invalid	11
month=1, day=0, year=2016	Invalid	12

Test Case	Valid / Invalid	Covered Equivalence Class
month=1, day=1, year=1899	Invalid	13
month=1, day=15, year=2000	Valid	14
month=1, day=15, year=2016	Invalid	15
month=1, day=32, year=1899	Invalid	16
month=1, day=32, year=2000	Invalid	17
month=1, day=32, year=2016	Invalid	18
month=13, day=0, year=1899	Invalid	19
month=13, day=0, year=2000	Invalid	20
month=13, day=0, year=2016	Invalid	21
month=13, day=1, year=1899	Invalid	22
month=13, day=15, year=2000	Invalid	23
month=13, day=15, year=2016	Invalid	24
month=13, day=32, year=1899	Invalid	25
month=13, day=32, year=2000	Invalid	26
month=13, day=32, year=2016	Invalid	27

- **Boundary Test-Cases analysis:**

Test-Case	Valid / Invalid
Month = 0	Invalid
Month = 13	Invalid
Day = 0	Invalid
Day = 32	Invalid
Year = 1899	Invalid

Year = 2016	Invalid
Month = 1, Day = 1, Year = 1900	Valid
Month = 12, Day = 1, Year = 1900	Valid
Month = 1, Day = 31, Year = 1900	Valid
Month = 12, Day = 31, Year = 1900	Valid
Month = 1, Day = 1, Year = 2015	Valid
Month = 12, Day = 1, Year = 2015	Valid
Month = 1, Day = 31, Year = 2015	Valid
Month = 12, Day = 31, Year = 2015	Valid

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.

The solution of each problem must be given in the format as follows:

Tester Action and Input Data

Expected Outcome

Equivalence Partitioning

a, b, c

An Error message

a-1, b, c

Yes

Boundary Value Analysis

a, b, c-1

Yes

```
#include <iostream>
#include <tuple>

using namespace std;

string prev_date(int d, int m, int y) {
    if (m < 1 || m > 12 || y < 1900 || y > 2015 || d < 1 || d > 31) {
        return "Invalid";
    }

    return "Valid";
}
```

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 (EP):**

Equivalence Class Description:

- E1: The array is empty.
- E2: The value v is present in the array.
- E3: The value v is not present in the array.
- E4: The array contains only one element which is equal to v .
- E5: The array contains only one element which is not equal to v .

Test Case	Input Data (Array a , Value v)	Expected Outcome	Covered Equivalence Class
TC1	$a = [], v = 5$	-1	E1
TC2	$a = [1,2,3,4,5], v = 5$	4	E2
TC3	$a = [1,2,3,4,6], v = 5$	-1	E3
TC4	$a = [5], v = 5$	0	E4
TC5	$a = [4], v = 5$	-1	E5

- **Boundary Value Analysis (BVA):**

Boundary Conditions:

- The array size is at its minimum size, either empty or contains just one element.
- The value is at the start or end of the array.
- The value is not present, but close to elements in the array.

Boundary Value Test Cases:

Test Case	Input Data (Array a , Value v)	Expected Outcome	Boundary Condition
TC1	a = [5], v = 5	0	Single element array, value present
TC2	a = [5], v = 6	-1	Single element array, value absent
TC3	a = [1,2,3,4,5], v = 1	0	Value is at the start of the array
TC4	a = [1,2,3,4,5], v = 5	4	Value is at the end of the array
TC5	a = [1,2,3,4,5], v = 6	-1	Value absent but close to elements in the array

Linear-Search function:

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

int linearSearch(const vector<int>& a, int v) {
    for (int i = 0; i < a.size(); ++i) {
        if (a[i] == v) {
            return i; // Return the first index where a[i] == v
        }
    }
    return -1; // If not found, return -1
}

int main() {
    // Test cases
    vector<int> arr1 = {}; // Empty array
    vector<int> arr2 = {1, 2, 3, 5, 6}; // Value is present
    vector<int> arr3 = {1, 2, 3, 4, 6}; // Value is not present
    vector<int> arr4 = {5}; // Single element, value present
```

```

    vector<int> arr5 = {3}; // Single element, value
not present

    cout << "TC1: " << linearSearch(arr1, 5) << endl; // output -1
    cout << "TC2: " << linearSearch(arr2, 5) << endl; // output 3
    cout << "TC3: " << linearSearch(arr3, 5) << endl; // output -1
    cout << "TC4: " << linearSearch(arr4, 5) << endl; // output 0
    cout << "TC5: " << linearSearch(arr5, 5) << endl; // output -1

    return 0;
}

```

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

- **By Equivalence Class:-**

1. Array contains multiple occurrences of the value:
2. Array does not contain the value:
3. Empty array:
4. Single element array (element is the value):
5. Single element array (element is not the value):

- **Test-Case:-**

Test-Case	Expected Outcome	Class
v=1 && a[3]=[1,2,1]	2	1
v=1 && a[3]=[2,3,4]	0	2
v=1 && a=[]	0	3
v=2 && a[1]=[2]	1	4
v=2 && a[1]=[3]	0	5

- **Boundary Value Analysis :**

Test-Case	Expected Outcomes
v=1 && a[3]=[1,2,3]	1
v=1 && a[3]=[2,3,1]	1
v=1 && a=[]	0
v=2 && a[1]=[2]	1
v=2 && a[1]=[3]	0

- **Modified Programm && their output Besides of test-case :**

```
#include <iostream>
using namespace std;
int countItem(int target, int array[], int size) {
    int count = 0;
    for (int i = 0; i < size; i++) {
        if (array[i] == target)
            count++;
    }
    return count;}

int main() {
    int a1[] = {1, 2, 1, 4, 1};
    int a2[] = {};
    int a3[] = {-1, -2, -1};
    int a4[] = {2};
    int a5[] = {1};
    cout << "Test 1 (v=1): " << countItem(1, a1, 5) << endl; //output: 3
    cout << "Test 2 (v=6): " << countItem(6, a1, 5) << endl; //output: 0
    cout << "Test 3 (Empty array): " << countItem(3, a2, 0) << endl; //
output: 0
    cout << "Test 4 (Negative numbers): " << countItem(-1, a3, 3) << endl;
// output: 2
    cout << "Test 5 (Single element): " << countItem(2, a4, 1) << endl;
// output: 1
    cout << "Test 6 (Single element not found): " << countItem(2, a5, 1)
<< endl; // output: 0
```

```

        cout << "Test 7 (v=1, First element): " << countItem(1, a1, 5) << endl; // output: 3
        cout << "Test 8 (v=3, Last element): " << countItem(3, a1, 5) << endl; // output: 0
        cout << "Test 9 (Empty array): " << countItem(2, a2, 0) << endl; // output: 0
        cout << "Test 10 (v=4, Not found): " << countItem(4, a1, 5) << endl; // output: 0

        return 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.

Assumption: the elements in the array `a` are sorted in non-decreasing order.

Equivalence Partitioning (EP):

Equivalence Class Description:

- E1: The array is empty.
- E2: The value `v` is present in the array.
- E3: The value `v` is not present in the array.
- E4: The array contains only one element which is equal to `v`.
- E5: The array contains only one element which is not equal to `v`.

Equivalence Class Test Cases:

Test Case	Input Data (Array <code>a</code> , Value <code>v</code>)	Expected Outcome	Covered Equivalence Class
TC1	<code>a = [], v = 5</code>	-1	E1
TC2	<code>a = [1,2,3,4,5], v = 5</code>	4	E2
TC3	<code>a = [1,2,3,4,6], v = 5</code>	-1	E3
TC4	<code>a = [5], v = 5</code>	0	E4

TC5	a = [4], v = 5	-1	E5
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Boundary Value Analysis (BVA):

Boundary Conditions:

- The array size is at its minimum size, either empty or contains just one element.
- The value is at the start, middle, or end of the array.
- The value is not present but close to elements in the array.

Boundary Value Test Cases

Test Case	Input Data (Array a , Value v)	Expected Outcome	Boundary Condition
TC1	a = [5], v = 5	0	Single element array, value present
TC2	a = [5], v = 6	-1	Single element array, value absent
TC3	a = [1,2,3,4,5], v = 1	0	Value is at the start of the array
TC4	a = [1,2,3,4,5], v = 3	2	Value is in the middle of the array
TC5	a = [1,2,3,4,5], v = 5	4	Value is at the end of the array
TC6	a = [1,2,3,4,5], v = 6	-1	Value absent but close to elements in the array

Binary-search Code:

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

int binarySearch(const vector<int>& a, int v) {
    int left = 0;
    int right = a.size() - 1;
```

```

while (left <= right) {
    int mid = left + (right - left) / 2;

    if (a[mid] == v) {
        return mid; // Value found at index mid
    }
    else if (a[mid] < v) {
        left = mid + 1; // Search in the right half
    }
    else {
        right = mid - 1; // Search in the left half
    }
}

return -1; // Value not found
}

int main() {
    // Test cases
    vector<int> arr1 = {}; // Empty array
    vector<int> arr2 = {1, 2, 3, 5, 6}; // Value is present
    vector<int> arr3 = {1, 2, 3, 4, 6}; // Value is not present
    vector<int> arr4 = {5}; // Single element, value
present
    vector<int> arr5 = {3}; // Single element, value
not present

    cout << "TC1: " << binarySearch(arr1, 5) << endl; // output -1
    cout << "TC2: " << binarySearch(arr2, 5) << endl; // output 3
    cout << "TC3: " << binarySearch(arr3, 5) << endl; // output -1
    cout << "TC4: " << binarySearch(arr4, 5) << endl; // output 0
    cout << "TC5: " << binarySearch(arr5, 5) << endl; // output -1

    return 0;
}

```

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).

- **By Equivalence Class:**

1. Valid equilateral triangle:
2. Valid isosceles triangle:
3. Valid scalene triangle:
4. Invalid triangle (sum of any two sides must be greater than the third):
5. Negative lengths:
6. Zero lengths:

- **Test-Case:**

Test-Case	Expected Outcomes
a=3 ,b=3,c=3	Equilateral
a=4,b=4,c=5	Isosceles
a=3,b=4,c=5	Scalene
a=1,b=2,c=3	Invalid
a=-1,b=3,c=4	Invalid
a=0,b=3,c=4	Invalid

- **Boundary Value Analysis :**

Test-Case	Expected Outcomes
a = 2, b = 2, c = 2	Equilateral
a = 1, b = 1, c = 2	Invalid
a = -1, b = 1, c = 1	Invalid

a = 0, b = 1, c = 1	Invalid
a = 1, b = 1, c = 1	Equilateral

- **Modified Programm && their output Besides of test-case :**

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

const char* triangle(int a, int b, int c) {
    if (a <= 0 || b <= 0 || c <= 0 || a + b <= c || a + c <= b || b + c <=
a) {
        return "Invalid";
    }
    if (a == b && b == c) {
        return "Equilateral";
    }
    if (a == b || b == c || a == c) {
        return "Isosceles";
    }
    return "Scalene";
}

int main() {
    cout << "Test 1: " << triangle(3, 3, 3) << endl;    // Output:
Equilateral
    cout << "Test 2: " << triangle(4, 4, 5) << endl;    // Output: Isosceles
    cout << "Test 3: " << triangle(3, 4, 5) << endl;    // Output: Scalene
    cout << "Test 4: " << triangle(1, 2, 3) << endl;    // Output: Invalid
    cout << "Test 5: " << triangle(-1, 2, 3) << endl;   // Output: Invalid
    cout << "Test 6: " << triangle(0, 2, 2) << endl;   // Output: Invalid

    cout << "Test 7: " << triangle(1, 1, 1) << endl;    // Output:
Equilateral
    cout << "Test 8: " << triangle(1, 1, 2) << endl;    // Output: Invalid
    cout << "Test 9: " << triangle(-1, 1, 1) << endl;   // Output: Invalid
    cout << "Test 10: " << triangle(0, 1, 1) << endl;   // Output: Invalid
    cout << "Test 11: " << triangle(2, 2, 2) << endl;   // Output:
Equilateral

    return 0;
}
```

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).

Equivalence Partitioning (EP):

Equivalence Class Description:

- E1: `s1` is longer than `s2` (impossible to be a prefix).
- E2: `s1` is a valid prefix of `s2`.
- E3: `s1` is not a prefix of `s2`.
- E4: `s1` is an empty string (edge case).
- E5: `s2` is an empty string (edge case).

Equivalence Class Test Cases:

Test Case	Input Data (<code>s1</code> , <code>s2</code>)	Expected Outcome	Covered Equivalence Class
TC1	"abcdef", "abc"	false	E1
TC2	"abc", "abcdef"	true	E2
TC3	"xyz", "abcdef"	false	E3
TC4	"", "abcdef"	true	E4
TC5	"abc", ""	false	E5

Boundary Value Analysis (BVA):

Boundary Conditions:

- Length of `s1` is greater than the length of `s2`.
- `s1` is an empty string, `s2` is a non-empty string.
- `s2` is an empty string, `s1` is non-empty.
- `s1` equals `s2`.

Boundary Value Test Cases:

Test Case	Input Data (s1, s2)	Expected Outcome	Boundary Condition
TC1	"a", ""	false	S2 is empty
TC2	"abcdef", "abcdef"	true	s1 equals s2
TC3	"abc", "abc"	true	Shorter but equal strings
TC4	"" , ""	true	Both strings are empty

Prefix Function:

```
#include <iostream>
#include <string>

using namespace std;

bool prefix(string s1, string s2) {
    if (s1.length() > s2.length()) {
        return false;
    }
    for (int i = 0; i < s1.length(); i++) {
        if (s1[i] != s2[i]) {
            return false;
        }
    }
    return true;
}

int main() {
    // Equivalence Partitioning Test Cases
    cout << "TC1: " << (prefix("abcdef", "abc") ? "true" : "false") <<
endl; // output false
    cout << "TC2: " << (prefix("abc", "abcdef") ? "true" : "false") <<
endl; // output true
    cout << "TC3: " << (prefix("xyz", "abcdef") ? "true" : "false") <<
endl; // output false
```



```

    cout << "TC4: " << (prefix("", "abcdef") ? "true" : "false") << endl;
// output true
    cout << "TC5: " << (prefix("abc", "") ? "true" : "false") << endl;
// output false

    // Boundary Value Test Cases
    cout << "TC6: " << (prefix("a", "") ? "true" : "false") << endl;
// output false
    cout << "TC7: " << (prefix("abcdef", "abcdef") ? "true" : "false") <<
endl; // output true
    cout << "TC8: " << (prefix("abc", "abc") ? "true" : "false") << endl;
// output true
    cout << "TC9: " << (prefix("", "") ? "true" : "false") << endl;
// output true

    return 0;
}

```

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:

- Identify the equivalence classes for the system
- 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 the boundary condition $A + B > C$ case (scalene triangle), identify test cases to verify the boundary.
- For the boundary condition $A = C$ case (isosceles triangle), identify test cases to verify the boundary.
- For the boundary condition $A = B = C$ case (equilateral triangle), identify test cases to verify the boundary.
- For the boundary condition $A^2 + B^2 = C^2$ 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.

- **By Equivalence Class:**

1. Valid equilateral triangle: All sides are equal.
2. Valid isosceles triangle: Exactly two sides are equal.
3. Valid scalene triangle: All sides are different.
4. Valid right-angled triangle: Follows the Pythagorean theorem.
5. Invalid triangle (non-triangle): Sides do not satisfy triangle inequalities.
6. Invalid input (non-positive values): One or more sides are non-positive.

- **Test-Case:**

Test-Case	Output	Class
A = 3.0, B = 3.0, C = 3.0	Equilateral	1
A = 4.0, B = 4.0, C = 5.0	Isosceles	2
A = 3.0, B = 4.0, C = 5.0	Scalene	3
A = 3.0, B = 4.0, C = 6.0	Invalid	5
A = -1.0, B = 2.0, C = 3.0	Invalid	6
A = 5.0, B = 12.0, C = 13.0	Right-angled	4

- **Boundary Conditions:**

c) Boundary Conditions for $A + B > C$ (Scalene Triangle)

Test-Case	Output
A = 1.0, B = 1.0, C = 1.9999	Scalene
A = 2.0, B = 3.0, C = 4.0	Scalene

d) Boundary Conditions for A = C (Isosceles Triangle)

Test-Case	Output
A = 3.0, B = 3.0, C = 4.0	Isosceles
A = 2.0, B = 2.0, C = 3.0	Isosceles
A = 2.0, B = 2.0, C = 2.0	Equilateral

E) Boundary Conditions for A = B = C (Equilateral Triangle)

Test-Case	Output
A = 2.0, B = 2.0, C = 2.0	Equilateral
A = 1.9999, B = 1.9999, C = 1.9999	Equilateral

f) Boundary Conditions for $A^2 + B^2 = C^2$ (Right-Angle Triangle)

Test-Case	Output
A = 3.0, B = 4.0, C = 5.0	Right-angled
A = 5.0, B = 12.0, C = 13.0	Right-angled

g) Test Cases for Non-Triangle Case

Test-Case	Output
A = 1.0, B = 2.0, C = 3.0	Invalid
A = 1.0, B = 2.0, C = 2.0	Invalid
A = 1.0, B = 1.0, C = 3.0	Invalid

h) Test Cases for Non-Positive Input

Test-Case	Output
A = 0.0, B = 2.0, C = 3.0	Invalid
A = -1.0, B = -2.0, C = 3.0	Invalid

A = 3.0, B = 0.0, C = 2.0	Invalid
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- **Modified Programm && their output Besides of test-case :**

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

const char* classifyTriangle(float A, float B, float C) {
    if (A <= 0 || B <= 0 || C <= 0 || A + B <= C || A + C <= B || B + C <= A) {
        return "Invalid";
    }
    if (fabs(pow(A, 2) + pow(B, 2) - pow(C, 2)) < 1e-6 ||
        fabs(pow(A, 2) + pow(C, 2) - pow(B, 2)) < 1e-6 ||
        fabs(pow(B, 2) + pow(C, 2) - pow(A, 2)) < 1e-6) {
        return "Right-angled";
    }

    if (A == B && B == C) {
        return "Equilateral";
    }

    if (A == B || B == C || A == C) {
        return "Isosceles";
    }

    return "Scalene";
}

int main() {
    cout << "Test 1: " << classifyTriangle(3.0, 3.0, 3.0) << endl; // Output: Equilateral
    cout << "Test 2: " << classifyTriangle(4.0, 4.0, 5.0) << endl; // Output: Isosceles
    cout << "Test 3: " << classifyTriangle(3.0, 4.0, 5.0) << endl; // Output: Scalene
    cout << "Test 4: " << classifyTriangle(3.0, 4.0, 6.0) << endl; // Output: Invalid
    cout << "Test 5: " << classifyTriangle(-1.0, 2.0, 3.0) << endl; // Output: Invalid
    cout << "Test 6: " << classifyTriangle(0.0, 2.0, 2.0) << endl; // Output: Invalid
    cout << "Test 7: " << classifyTriangle(5.0, 12.0, 13.0) << endl; // Output:
    Right-angled
}
```

```
return 0;
```

```
}
```