

ASSIGNMENT 5

```
1. int distanceFromInterval(int x, int extremeA, int extremeB, int minLen) {
2.     if (minLen <= 0) {
3.         throw new IllegalArgumentException("minLen");
4.     }
5.     int upperB, lowerB;
6.     if (extremeA > extremeB) {
7.         upperB = extremeA;
8.         lowerB = extremeB;
9.     } else {
10.        upperB = extremeB;
11.        lowerB = extremeA;
12.    }
13.    int len = upperB - lowerB;
14.    if (len < minLen) {
15.        throw new RuntimeException("invalid interval");
16.    }
17.    if (x < lowerB) {
18.        return lowerB - x;
19.    } else if (x > upperB) {
20.        return x - upperB;
21.    } else {
22.        return 0;
23.    }
24. }
```

Identify the path of `distanceFromInterval` that get executed when the three inputs are equal to **`x=4`**, **`extremeA=1`**, **`extremeB=6`**, **`minLen=2`**, and build with **symbolic execution** the path condition that characterises the path. Describe the path conditions by using the following symbols for the symbolic values of the parameters: **VAL** as the initial symbolic value of **x**, **A** as the initial symbolic value of **extremeA**, **B** as the initial symbolic value of **extremeB**, and **ML** as the initial symbolic value of **minLen**

SYMBOLIC EXECUTION IF **`x=4`**, **`extremeA=1`**, **`extremeB=6`**, **`minLen=2`**:

LINE EXECUTED	VALUES	PATH CONDITION
AFTER LINE 1	x= 4, y extremeA=1, extremeB=6, minLen=2	true
AFTER LINE 2 (JUMP TO 5)	x= 4, y extremeA=1, extremeB=6, minLen=2	ML>0
AFTER LINE 5	x= 4, y extremeA=1, extremeB=6, minLen=2	ML>0
AFTER LINE 6 (JUMP TO 10)	x= 4, y extremeA=1, extremeB=6, minLen=2	ML>0 && A<=B
AFTER LINE 10	x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6	ML>0 && A<=B

AFTER LINE 11	x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6, lowerB=1	ML>0 && A<=B
AFTER LINE 13	x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6, lowerB=1, len = 5	ML>0 && A<=B
AFTER LINE 14 (JUMP TO 17)	x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6, lowerB=1, len = 5	ML>0 && A<=B && ML< B-A
AFTER LINE 17 (JUMP TO 19)	x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6, lowerB=1, len = 5	ML>0 && A<=B && ML< B-A && VAL >= A
AFTER LINE 19 (JUMP TO 22)	x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6, lowerB=1, len = 5	ML>0 && A<=B && ML< B-A && VAL >= A && VAL <= B
AT LINE 22	x= 4, y extremeA=1, extremeB=6, minLen=2, upperB=6, lowerB=1, len = 5	ML>0 && A<=B && ML< B-A && VAL >= A && VAL <= B

The path that gets executed when x=4, extremeA=1, extremeB=6, and minLen=2 is:

1, 5, 10, 11, 13, 22

Since the path was generated by fixed inputs we can say it is feasible.

*Then, working in the style of **dynamic symbolic execution**, identify the path conditions of the alternative subpaths, and use those path conditions to identify test cases that execute those subpaths.*

The path condition that will be used to derive the other possible paths is:

ML>0 && A<=B && ML< B-A && VAL >= A && VAL <= B

The alternative (sub-)paths are:

- 1) ML<=0
- 2) **ML>0 && A>B**
- 3) **ML>0 && A<=B && ML>=B-A**
- 4) **ML>0 && A<=B && ML< B-A && VAL<A**
- 5) **ML>0 && A<=B && ML< B-A && VAL>=A && VAL>B**

In order to check if these paths are feasible or not we need to find if exists an input that satisfies all the conditions in the sub-paths:

- 1) ML<=0: a test case that executes this path would be **x=4, extremeA=1, extremeB=6, minLen= -2**. The consequent path conditions generated by these inputs will be:

LINE EXECUTED	VALUES	PATH CONDITION
AFTER LINE 1	x= 4, y extremeA=1, extremeB=6, minLen=-2	true
AFTER LINE 2 (JUMP TO 3)	x= 4, y extremeA=1, extremeB=6, minLen=-2	ML<=0
AT LINE 3	x= 4, y extremeA=1, extremeB=6, minLen=-2	ML<=0

The path that gets executed when **x=4, extremeA=1, extremeB=6, minLen= -2** is:

1, 3

- 2) **ML>0 && A>B**: a test case that executes this path would be **x=4, extremeA=6, extremeB=1, minLen= 2**. The consequent path conditions generated by these inputs will be:

LINE EXECUTED	VALUES	PATH CONDITION
AFTER LINE 1	x=4, extremeA=6, extremeB=1, minLen= 2	true
AFTER LINE 2 (JUMP TO 5)	x=4, extremeA=6, extremeB=1, minLen= 2	ML>0
AFTER LINE 5	x=4, extremeA=6, extremeB=1, minLen= 2	ML>0
AFTER LINE 6 (JUMP TO 7)	x=4, extremeA=6, extremeB=1, minLen= 2	ML>0 && A>B
AFTER LINE 7	x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6	ML>0 && A>B
AFTER LINE 8	x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6, lowerB = 1	ML>0 && A>B
AFTER LINE 13	x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6, lowerB = 1, len= 5	ML>0 && A>B
AFTER LINE 14 (JUMP TO 17)	x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6, lowerB = 1, len= 5	ML>0 && A>B && ML<A-B
AFTER LINE 17 (JUMP TO 19)	x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6, lowerB = 1, len= 5	ML>0 && A>B && ML<A-B && VAL>= B
AFTER LINE 19 (JUMP TO 22)	x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6, lowerB = 1, len= 5	ML>0 && A>B && ML<A-B && VAL>= B && VAL <= A
AT LINE 22	x=4, extremeA=6, extremeB=1, minLen= 2, upperB = 6, lowerB = 1, len= 5	ML>0 && A>B && ML<A-B && VAL>= B && VAL <= A

The path that gets executed when **x=4, extremeA=6, extremeB=1, minLen= 2** is:

1, 5, 7, 8, 13, 22

- 3) **ML>0 && A<=B && ML>=B-A**: a test case that executes this path would be **x=4, extremeA=1, extremeB=6, minLen= 6**. The consequent path conditions generated by these inputs will be:

LINE EXECUTED	VALUES	PATH CONDITION
AFTER LINE 1	x=4, extremeA=1, extremeB=6, minLen= 6	true
AFTER LINE 2 (JUMP TO 5)	x=4, extremeA=1, extremeB=6, minLen= 6	ML>0
AFTER LINE 5	x=4, extremeA=1, extremeB=6, minLen= 6	ML>0
AFTER LINE 6 (JUMP TO 10)	x=4, extremeA=1, extremeB=6, minLen= 6	ML>0 && A<=B
AFTER LINE 10	x=4, extremeA=1, extremeB=6, minLen= 6, upperB= 6	ML>0 && A<=B
AFTER LINE 11	x=4, extremeA=1, extremeB=6, minLen= 6, upperB= 6, lowerB= 1	ML>0 && A<=B
AFTER LINE 13	x=4, extremeA=1, extremeB=6, minLen= 6, upperB= 6, lowerB= 1, len= 5	ML>0 && A<=B
AFTER LINE 14 (JUMP TO 15)	x=4, extremeA=1, extremeB=6, minLen= 6, upperB= 6, lowerB= 1, len= 5	ML>0 && A<=B && ML>= B-A
AT LINE 15	x=4, extremeA=1, extremeB=6, minLen= 6, upperB= 6, lowerB= 1, len= 5	ML>0 && A<=B && ML>= B-A

The path that gets executed when **x=4, extremeA=1, extremeB=6, minLen= 6** is:

1, 5, 10, 11, 13, 15

- 4) **ML>0 && A<=B && ML< B-A && VAL<A**: a test case that executes this path would be **x=0, extremeA=1, extremeB=6, minLen= 2**. The consequent path conditions generated by these inputs will be:

LINE EXECUTED	VALUES	PATH CONDITION
AFTER LINE 1	x=0, extremeA=1, extremeB=6, minLen= 2	true
AFTER LINE 2 (JUMP TO 5)	x=0, extremeA=1, extremeB=6, minLen= 2	ML>0
AFTER LINE 5	x=0, extremeA=1, extremeB=6, minLen= 2	ML>0
AFTER LINE 6 (JUMP TO 10)	x=0, extremeA=1, extremeB=6, minLen= 2	ML>0 && A<=B
AFTER LINE 10	x=0, extremeA=1, extremeB=6, minLen= 2, upperB= 6	ML>0 && A<=B
AFTER LINE 11	x=0, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1	ML>0 && A<=B
AFTER LINE 13	x=0, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5	ML>0 && A<=B
AFTER LINE 14 (JUMP TO 17)	x=0, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5	ML>0 && A<=B && ML< B-A
AFTER LINE 17 (JUMP TO 18)	x=0, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5	ML>0 && A<=B && ML< B-A && VAL<A
AT LINE 18	x=0, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5	ML>0 && A<=B && ML< B-A && VAL<A

The path that gets executed when **x=0, extremeA=1, extremeB=6, minLen= 2** is:

1, 5, 10, 11, 13, 18

- 5) **ML>0 && A<=B && ML< B-A && VAL>=A && VAL>B**: a test case that executes this path would be **x=9, extremeA=1, extremeB=6, minLen= 2**. The consequent path conditions generated by these inputs will be:

LINE EXECUTED	VALUES	PATH CONDITION
AFTER LINE 1	x=9, extremeA=1, extremeB=6, minLen= 2	true
AFTER LINE 2 (JUMP TO 5)	x=9, extremeA=1, extremeB=6, minLen= 2	ML>0
AFTER LINE 5	x=9, extremeA=1, extremeB=6, minLen= 2	ML>0
AFTER LINE 6 (JUMP TO 10)	x=9, extremeA=1, extremeB=6, minLen= 2	ML>0 && A<=B
AFTER LINE 10	x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6	ML>0 && A<=B
AFTER LINE 11	x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1	ML>0 && A<=B
AFTER LINE 13	x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5	ML>0 && A<=B

AFTER LINE 14 (JUMP TO 17)	x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5	ML>0 && A<=B && ML< B-A
AFTER LINE 17 (JUMP TO 19)	x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5	ML>0 && A<=B && ML< B-A && VAL>=A
AT LINE 19 (JUMP TO 20)	x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5	ML>0 && A<=B && ML< B-A && VAL>=A && VAL>B
AT LINE 20	x=9, extremeA=1, extremeB=6, minLen= 2, upperB= 6, lowerB= 1, len= 5	ML>0 && A<=B && ML< B-A && VAL>=A && VAL>B

The path that gets executed when **x=9, extremeA=1, extremeB=6, minLen= 2** is:

1, 5, 10, 11, 13, 20