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Chapter 1

Rubric

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`placeNumbers` Total	20
`closestNumbers`	
Test Cases	1×15
Compilation	5
`closestNumbers` Total	20
Total	100

Chapter 2

Metadata

2.1 Submitted Files

handin.time

```
09/26/2019 13:34:14 fsandhu: csce310h0mework02part02.cpp        - OK
09/26/2019 13:34:17 fsandhu: csce310h0mework02part02.h   - OK
09/26/2019 13:35:33 fsandhu: csce310h0mework02part02.cpp        - OK
09/26/2019 13:42:55 fsandhu: csce310h0mework02part02.cpp        - OK
09/26/2019 13:45:42 fsandhu: csce310h0mework02part02.cpp        - OK
09/26/2019 13:47:21 fsandhu: csce310h0mework02part02.cpp        - OK
09/26/2019 13:48:52 fsandhu: csce310h0mework02part02.cpp        - OK
09/26/2019 14:40:03 fsandhu: csce310h0mework02part01.cpp        - OK
09/26/2019 14:40:06 fsandhu: csce310h0mework02part01.h   - OK
09/26/2019 14:44:03 fsandhu: csce310h0mework02part01.cpp        - OK
09/26/2019 14:53:05 fsandhu: csce310h0mework02part01.cpp        - OK
09/26/2019 14:54:33 fsandhu: csce310h0mework02part01.cpp        - OK
09/26/2019 14:56:20 fsandhu: csce310h0mework02part02.cpp        - OK
09/26/2019 14:57:56 fsandhu: csce310h0mework02part02.cpp        - OK
09/26/2019 15:08:10 fsandhu: csce310h0mework02part01.cpp        - OK
09/26/2019 15:15:32 fsandhu: csce310h0mework02part01.cpp        - OK
09/26/2019 20:25:13 fsandhu: csce310h0mework02part01.cpp        - OK
09/26/2019 20:27:30 fsandhu: csce310h0mework02part01.cpp        - OK
09/26/2019 20:33:47 fsandhu: csce310h0mework02part01.cpp        - OK
09/26/2019 20:33:50 fsandhu: csce310h0mework02part01.h   - OK
09/26/2019 20:33:52 fsandhu: csce310h0mework02part02.cpp        - OK
09/26/2019 20:33:54 fsandhu: csce310h0mework02part02.h   - OK
09/26/2019 21:04:20 fsandhu: csce310h0mework02part03.cpp        - OK
09/26/2019 21:04:22 fsandhu: csce310h0mework02part03.h   - OK
09/26/2019 21:06:24 fsandhu: csce310h0mework02part03.cpp        - OK
09/26/2019 21:06:52 fsandhu: csce310h0mework02part03.cpp        - OK
09/27/2019 10:44:21 fsandhu: csce310h0mework02part03.cpp        - OK
09/28/2019 01:12:05 fsandhu: csce310h0mework02part03.cpp        - OK
09/28/2019 01:12:59 fsandhu: csce310h0mework02part03.cpp        - OK
09/28/2019 01:14:17 fsandhu: csce310h0mework02part03.cpp        - OK
09/28/2019 01:30:02 fsandhu: csce310h0mework02part03.cpp        - OK
09/28/2019 01:32:11 fsandhu: csce310h0mework02part03.cpp        - OK
09/28/2019 01:32:20 fsandhu: csce310h0mework02part03.h   - OK
09/28/2019 01:33:42 fsandhu: csce310h0mework02part03.cpp        - OK
09/28/2019 01:33:47 fsandhu: csce310h0mework02part03.h   - OK
09/28/2019 01:45:47 fsandhu: csce310h0mework02part03.cpp        - OK
09/28/2019 01:47:27 fsandhu: csce310h0mework02part03.cpp        - OK
09/28/2019 01:51:22 fsandhu: csce310h0mework02part03.cpp        - OK
09/28/2019 01:51:25 fsandhu: csce310h0mework02part03.h   - OK
09/28/2019 01:52:40 fsandhu: csce310h0mework02part03.cpp        - OK
09/28/2019 01:56:38 fsandhu: csce310h0mework02part03.cpp        - OK
```

```
09/28/2019 01:56:40 fsandhu: csce310h0mework02part03.h   - OK
09/28/2019 01:58:17 fsandhu: csce310h0mework02part03.cpp         - OK
09/28/2019 01:58:19 fsandhu: csce310h0mework02part03.h   - OK
09/28/2019 02:03:55 fsandhu: csce310h0mework02part03.cpp         - OK
10/01/2019 14:16:07 fsandhu: csce310h0mework02part03.cpp         - OK
10/01/2019 14:16:50 fsandhu: csce310h0mework02part03.cpp         - OK
10/09/2019 18:33:38 fsandhu: csce310h0mework02part03.cpp         - OK
10/09/2019 18:34:26 fsandhu: csce310h0mework02part03.cpp         - OK
10/09/2019 21:25:25 fsandhu: csce310hw02.pdf     - OK
```

2.2 webgrader Runs

webgrader.time

```
2019-09-26T13:34:23-0500 10.43.1.171  fsandhu 002
2019-09-26T13:35:36-0500 10.43.1.171  fsandhu 002
2019-09-26T13:43:13-0500 10.43.1.171  fsandhu 002
2019-09-26T13:45:44-0500 10.43.1.171  fsandhu 002
2019-09-26T13:47:18-0500 10.43.1.171  fsandhu 002
2019-09-26T13:47:24-0500 10.43.1.171  fsandhu 002
2019-09-26T14:40:16-0500 10.43.1.171  fsandhu 002
2019-09-26T14:44:07-0500 10.43.1.171  fsandhu 002
2019-09-26T14:53:07-0500 10.43.1.171  fsandhu 002
2019-09-26T14:54:37-0500 10.43.1.171  fsandhu 002
2019-09-26T14:56:24-0500 10.43.1.171  fsandhu 002
2019-09-26T14:57:58-0500 10.43.1.171  fsandhu 002
2019-09-26T15:08:12-0500 10.43.1.171  fsandhu 002
2019-09-26T15:15:34-0500 10.43.1.171  fsandhu 002
2019-09-26T20:25:20-0500 76.84.50.181  fsandhu 002
2019-09-26T20:27:33-0500 76.84.50.181  fsandhu 002
2019-09-26T20:33:39-0500 76.84.50.181  fsandhu 002
2019-09-26T20:33:56-0500 76.84.50.181  fsandhu 002
2019-09-26T21:04:25-0500 76.84.50.181  fsandhu 002
2019-09-26T21:06:27-0500 76.84.50.181  fsandhu 002
2019-09-26T21:06:59-0500 76.84.50.181  fsandhu 002
2019-09-27T10:44:39-0500 10.43.118.108  fsandhu 002
2019-09-28T01:12:11-0500 97.98.163.171  fsandhu 002
2019-09-28T01:13:02-0500 97.98.163.171  fsandhu 002
2019-09-28T01:14:19-0500 97.98.163.171  fsandhu 002
2019-09-28T01:30:05-0500 97.98.163.171  fsandhu 002
2019-09-28T01:32:23-0500 97.98.163.171  fsandhu 002
2019-09-28T01:33:50-0500 97.98.163.171  fsandhu 002
2019-09-28T01:45:49-0500 97.98.163.171  fsandhu 002
2019-09-28T01:47:29-0500 97.98.163.171  fsandhu 002
2019-09-28T01:51:27-0500 97.98.163.171  fsandhu 002
2019-09-28T01:52:42-0500 97.98.163.171  fsandhu 002
2019-09-28T01:56:42-0500 97.98.163.171  fsandhu 002
2019-09-28T01:58:07-0500 97.98.163.171  fsandhu 002
2019-09-28T01:58:21-0500 97.98.163.171  fsandhu 002
2019-09-28T02:04:07-0500 97.98.163.171  fsandhu 002
2019-09-30T13:50:40-0500 10.43.63.145  fsandhu 002
2019-10-01T14:16:19-0500 10.43.114.9  fsandhu 002
2019-10-01T14:16:53-0500 10.43.114.9  fsandhu 002
2019-10-01T14:33:44-0500 10.43.114.9  fsandhu 002
2019-10-08T14:50:16-0500 10.43.23.54  fsandhu 002
2019-10-08T14:51:02-0500 10.43.23.54  fsandhu 002
2019-10-08T14:51:54-0500 10.43.23.54  fsandhu 002
2019-10-08T14:59:55-0500 10.43.23.54  fsandhu 002
2019-10-08T15:00:17-0500 10.43.23.54  fsandhu 002
2019-10-08T15:00:30-0500 10.43.23.54  fsandhu 002
```

```
2019-10-08T15:00:45-0500 10.43.23.54  fsandhu 002
2019-10-08T15:01:09-0500 10.43.23.54  fsandhu 002
2019-10-08T15:02:46-0500 10.43.23.54  fsandhu 002
2019-10-08T15:03:00-0500 10.43.23.54  fsandhu 002
2019-10-08T15:03:22-0500 10.43.23.54  fsandhu 002
2019-10-08T15:04:08-0500 10.43.23.54  fsandhu 002
2019-10-08T15:04:21-0500 10.43.23.54  fsandhu 002
2019-10-09T14:28:00-0500 10.43.67.76  fsandhu 002
2019-10-09T14:28:54-0500 10.43.67.76  fsandhu 002
2019-10-09T18:33:45-0500 76.84.50.181  fsandhu 002
2019-10-09T18:34:28-0500 76.84.50.181  fsandhu 002
2019-10-09T18:34:55-0500 76.84.50.181  fsandhu 002
2019-10-09T20:33:02-0500 76.84.50.181  fsandhu 002
2019-10-09T21:25:44-0500 76.84.50.181  fsandhu 002
2019-10-11T10:37:53-0500 10.43.47.170  fsandhu 002
2019-12-15T19:52:19-0600 76.84.219.87  fsandhu 002
```

2.3 diffs

submission.diffs

Chapter 3

Written Exercises

Assignment 02

Fateh Sandhu
17286643

Q1) The algorithm is a recursive algorithm but it is incorrect because it does not have correct base cases. It does not take into account the last leaf and returns 0 if the node passed in is empty. The algorithm will return 0 if we run it as of now.

Corrected algorithm:
LeafCounter.

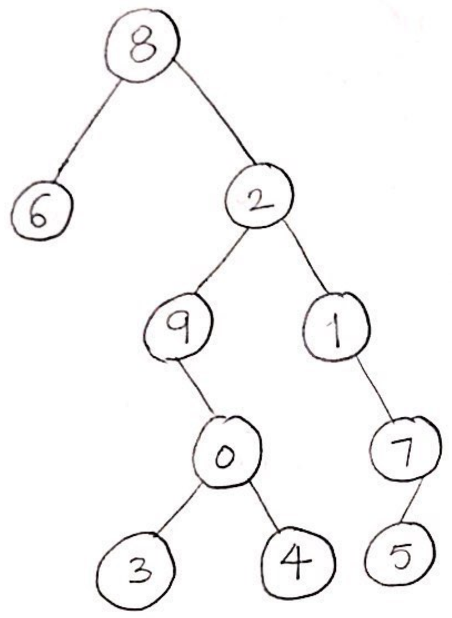
```
Input : A binary tree T
Output : The number of leaves in T

    if T = ∅
        return 0
    else if $T_{right} = \emptyset$ and $T_{left} = \emptyset$
        return 1
    else
        return LeafCounter($T_{left}$) + LeafCounter($T_{right}$)
```

Q2).

a) PRE : 8 6 2 9 0 3 4 1 7 5 NLR

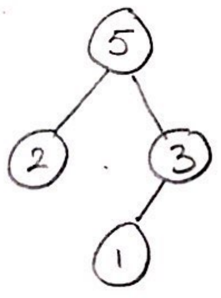
IN : 6 8 9 3 0 4 2 1 5 7 LNR



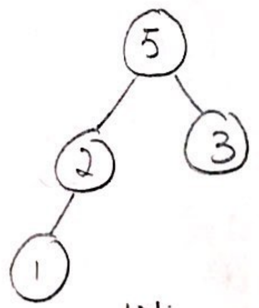
Resulting binary tree

b). PRE: 5 2 3 1

IN: 1 2 5 3



PRE



IN

They are traversals of the same binary tree

c) Construct Tree

```
// recursive algorithm
Input : preorder and inorder traversal    [i_0, i_1, . . . , i_{n-1}]
        of a tree                          [p_0, p_1, . . . p_{n-1}]
Output : Binary Tree OR invalid input

    for int i → n-1.
        if inorder[i] = preorder[0]
            print inorder[i].
            break
        else
            return error [invalid input ].

return Construct Tree ( inorder [0,1, ... , i_{k-1}]
                        preorder (p_1, p_2, ... p_k)] .

Construct Tree ( inorder [i_{k+1}, i_{k+2}, ... , i_{n-1}]
                 preorder [ p_{k+1}, p_{k+2}, ... p_{n-1} ]) .
// recursively build left and right subtrees .
```

Q3). If the search is only done once, then linear search would be a better option because it has only n comparisons. However, if we are doing multiple searches, presorting the algorithm would be better because we can now use binary search which requires $\log_2(n)$ comparison. for justification, we can calculate after how many searches will presort be better.

$$n\log_2(n) + K\log_2(n) \leq Kn$$ where K is the number of searches done.

$$n\log_2(n) \leq K(n - \log_2(n))$$

$$\frac{n\log_2(n)}{n-\log_2(n)} \leq K$$

for $n = 10^4$ elements.

$$K \geq \frac{10^4 \log_2(10^4)}{10^4 - \log_2(10^4)} \Rightarrow K \geq 13.30539202$$

$$\Rightarrow K \approx 14$$

after 14 searches, presort will be justified for 10^4 elements

for $n = 10^7$ elements

$$K \geq \frac{10^7 \log_2(10^7)}{10^7 - \log_2(10^7)} \Rightarrow K \geq 23.2535507368$$

$$K \approx 24$$

after 24 searches, presort will be justtified for 10^7 elements

Q4)

a) Input : An array of n numbers

Out put : closest distance b/w two numbers in array

<u>Sort</u> the array with the most efficient sorting algorithm based on size

we use merge sort as an example.

```
closestDistance = $|a[0] - a[1]|$.

for i = 1 → size - 2.
    if (closestDistance > $|a[i] - a[i+1]|$)
        set closestDistance = $|a[i] - a[i+1]|$

return closestDistance.
```

time complexity : $\underbrace{n\log_2(n)}_{\text{mergesort worst case}} + \underbrace{n-1}_{\text{closestDist worst Case}}$

$\Rightarrow O(n\log_2(n))$

b). Brute force worst case time complexity : $O(n^2)$

Presort time complexity $\Rightarrow O(n\log_2(n))$.
worst case

Presort is way efficient than brute force.

Q5) programming part 1. refer for algorithm with comments.

Input : a list of n distinct integers
a sequence of boxes with signs preset

Output : place numbers into boxes accordingly.

```
(merge sort) sort the list in ascending order
    numbersPlacedfromend = 0
    for i = 0 → sizeOfList
    |   if sign[i] = ">"
place into next available box (list [sizeofList - numbers PlacedfromEnd ])
    |   numberPlacedfromEnd ++
        else if sign [i] = "<"
place into next available box (list [i - numberPlaced from End])

for last box ↓
    place into box (list [sizeOfList - numbersPlacedfromEnd])

            return sequence of boxes.
```

time complexity $\underbrace{n\log_2(n)}_{\text{merge sort}} + n$

$\Rightarrow O(n\log_2(n))$.

Q6)

number of additions = $(n+1)$.

number of multiplications $= (n+1) + (1+2+3+ \cdots + n)$

$$= (n+1) + \frac{n(n+1)}{2}$$

$$= \frac{2(n+1) + n(n+1)}{2}$$

$$= \frac{(n+2)(n+1)}{2}$$

$$= \frac{n^2 + 2n + n + 2}{2}$$

$$= \frac{n^2 + 3n + 2}{2}.$$

Chapter 4

Programming Exercises

4.1 csce310h0mework02part01

4.1.1 Test 01

diff

part01test01.diff

Input

part01test01.input

```
<><>><
10 16 26 51 60 74 96
```

Submission Output

part01test01.output

```
10 < 96 > 16 < 74 > 60 > 26 < 51

VALID
```

Solution Output

part01test01.solution

```
10
^
96
v
16
^
74
v
60
v
26
^
51
VALID
```

stderr

part01test01.err

4.1.2 Test 02

diff

part01test02.diff

Input

part01test02.input

```
>><><><<><<><<
4 7 9 10 15 45 51 60 61 63 64 76 80 81 91
```

Submission Output

part01test02.output

```
91 > 81 > 4 < 80 > 7 < 76 > 9 < 10 < 64 > 15 < 45 < 63 > 51 < 60 < 61

VALID
```

Solution Output

part01test02.solution

```
91
v
81
v
4
^
80
v
7
^
76
v
9
^
10
^
64
v
15
^
45
^
63
v
51
^
60
^
61
VALID
```

stderr

part01test02.err

4.1.3 Test 03

diff

part01test03.diff

Input

part01test03.input

```
<<><<>>><<>
2 19 28 30 43 50 52 59 84 92 93 94
```

Submission Output

part01test03.output

```
2 < 19 < 94 > 28 < 93 > 30 < 92 > 84 > 59 > 43 < 52 > 50

VALID
```

Solution Output

part01test03.solution

```
2
^
19
^
94
v
28
^
93
v
30
^
92
v
84
v
59
v
43
^
52
v
50
VALID
```

stderr

part01test03.err

4.1.4 Test 04

diff

part01test04.diff

Input

part01test04.input

```
<<><><<<<>>>
4 21 24 25 28 29 33 37 40 43 84 90 98
```

Submission Output

part01test04.output

```
4 < 21 < 98 > 24 < 90 > 25 < 28 < 29 < 33 < 84 > 43 > 40 > 37

VALID
```

Solution Output

part01test04.solution

```
4
^
21
^
98
v
24
^
90
v
25
^
28
^
29
^
33
^
84
v
43
v
40
v
37
VALID
```

stderr

part01test04.err

4.1.5 Test 05

diff

part01test05.diff

Input

part01test05.input

```
<<><<><>><
4 16 27 30 48 51 86 96 97 98 99
```

Submission Output

part01test05.output

```
4 < 16 < 99 > 27 < 30 < 98 > 48 < 97 > 96 > 51 < 86

VALID
```

Solution Output

part01test05.solution

```
4
^
16
^
```

```
99
v
27
^
30
^
98
v
48
^
97
v
96
v
51
^
86
VALID
```

stderr

part01test05.err

4.1.6 Test 06

diff

part01test06.diff

Input

part01test06.input

```
<><
26 72 90 95
```

Submission Output

part01test06.output

```
26 < 95 > 72 < 90

VALID
```

Solution Output

part01test06.solution

```
26
^
95
v
72
^
90
VALID
```

stderr

part01test06.err

4.1.7 Test 07

diff

part01test07.diff

Input

part01test07.input

```
><>><<><><>
17 40 42 51 58 61 74 76 77 92 96 100
```

Submission Output

part01test07.output

```
100 > 17 < 96 > 92 > 40 < 42 < 77 > 51 < 76 > 58 < 74 > 61

VALID
```

Solution Output

part01test07.solution

```
100
v
17
^
96
v
92
v
40
^
42
^
77
v
51
^
76
v
58
^
74
v
61
VALID
```

stderr

part01test07.err

4.1.8 Test 08

diff

part01test08.diff

Input

part01test08.input

```
><<<><>><><<>><>
12 23 28 29 30 31 35 38 54 56 60 70 73 75 81 87 88
```

Submission Output

part01test08.output

```
88 > 12 < 23 < 28 < 87 > 29 < 81 > 75 > 30 < 73 > 31 < 35 < 70 > 60 > 38 < 56 > 54

VALID
```

Solution Output

part01test08.solution

```
88
v
12
^
23
^
28
^
87
v
29
^
81
v
75
v
30
^
73
v
31
^
35
^
70
v
60
v
38
^
56
v
54
VALID
```

`stderr`

part01test08.err

4.1.9 Test 09

`diff`

part01test09.diff

Input

part01test09.input

```
><>><>><><><><>
6 13 24 26 35 47 48 60 66 70 74 81 85 90 95 98
```

Submission Output

part01test09.output

```
98 > 6 < 95 > 90 > 13 < 85 > 81 > 24 < 74 > 26 < 70 > 35 < 66 > 47 < 60 > 48

VALID
```

Solution Output

part01test09.solution

```
98
v
6
^
95
v
90
v
13
^
85
v
81
v
24
^
74
v
26
^
70
v
35
^
66
v
47
^
60
v
48
VALID
```

stderr

part01test09.err

4.1.10 Test 10

diff

part01test10.diff

Input

part01test10.input

```
>><<>>><><>
3 8 9 18 40 49 50 56 57 66 73 78
```

Submission Output

part01test10.output

```
78 > 73 > 3 < 8 < 66 > 57 > 56 > 9 < 50 > 18 < 49 > 40

VALID
```

Solution Output

part01test10.solution

```
78
v
73
v
3
^
8
^
66
v
57
v
56
v
9
^
50
v
18
^
49
v
40
VALID
```

stderr

part01test10.err

4.1.11 Test 11

diff

part01test11.diff

Input

part01test11.input

```
<>><>><
4 5 27 45 47 70 90 97
```

Submission Output

part01test11.output

```
4 < 97 > 90 > 5 < 70 > 47 > 27 < 45

VALID
```

Solution Output

part01test11.solution

```
4
```

```
^
97
v
90
v
5
^
70
v
47
v
27
^
45
VALID
```

```
stderr
```

part01test11.err

4.1.12 Test 12

```
diff
```

part01test12.diff

Input

part01test12.input

```
><>>><><><<>><>><
3 7 9 13 17 28 29 33 34 42 47 49 56 57 58 62 79 83 87 95
```

Submission Output

part01test12.output

```
95 > 3 < 87 > 83 > 79 > 7 < 62 > 9 < 58 > 13 < 57 > 17 < 28 < 56 > 49 > 29 < 47 > 42 >
    33 < 34

VALID
```

Solution Output

part01test12.solution

```
95
v
3
^
87
v
83
v
79
v
7
^
62
v
9
^
58
```

```
v
13
^
57
v
17
^
28
^
56
v
49
v
29
^
47
v
42
v
33
^
34
VALID
```

stderr

part01test12.err

4.1.13 Test 13

diff

part01test13.diff

Input

part01test13.input

```
<>><
10 33 53 62 91
```

Submission Output

part01test13.output

```
10 < 91 > 62 > 33 < 53

VALID
```

Solution Output

part01test13.solution

```
10
^
91
v
62
v
33
^
53
VALID
```

`stderr`

part01test13.err

4.1.14 Test 14

`diff`

part01test14.diff

Input

part01test14.input

```
<><><><><<>><<
18 20 30 31 38 44 45 48 65 77 79 88 91 98 100
```

Submission Output

part01test14.output

```
18 < 100 > 20 < 98 > 30 < 91 > 31 < 88 > 38 < 44 < 79 > 77 > 45 < 48 < 65

VALID
```

Solution Output

part01test14.solution

```
18
^
100
v
20
^
98
v
30
^
91
v
31
^
88
v
38
^
44
^
79
v
77
v
45
^
48
^
65
VALID
```

`stderr`

part01test14.err

4.1.15 Test 15

diff

part01test15.diff

Input

part01test15.input

```
<>><>>><
14 22 27 37 39 43 69 74 88
```

Submission Output

part01test15.output

```
14 < 88 > 74 > 22 < 69 > 43 > 39 > 27 < 37

VALID
```

Solution Output

part01test15.solution

```
14
^
88
v
74
v
22
^
69
v
43
v
39
v
27
^
37
VALID
```

stderr

part01test15.err

4.1.16 Source Code

csce310h0mework02part01.h

```
#ifndef CSCE310H0MEWORK02PART01_H
#define CSCE310H0MEWORK02PART01_H

#include <string>
#include <vector>

using namespace std;

vector<int> placeNumbers( vector<int> , string );

#endif
```

csce310h0mework02part01.cpp

```
/*
 * Author: Fateh Karan Singh Sandhu
 * NUID: 17286643
 *
 * This function takes in a vector and string of signs and outputs a new vector
 * with all values placed in accordance with the signs
 */

#include "csce310h0mework02part01.h"
#include <string>
#include <vector>
#include <algorithm>

using namespace std;

vector<int> placeNumbers( vector<int> numbers , string signs ){

    int numbersPlacedFromEnd = 0; //count for numbers placed from the end of the vector
    vector<int> numbersPlaced; //new vector with numbers placed in accordance to signs
    for (int i = 0 ; i < numbers.size() ; i++) {
        if (signs[i] == '>') {
            numbersPlaced.push_back(numbers[numbers.size()-1-numbersPlacedFromEnd]); //add to new vector
            numbersPlacedFromEnd++; //iterate variable for every number added from end
        } else if (signs[i] == '<') {
            numbersPlaced.push_back(numbers[i-numbersPlacedFromEnd]);
        }
    }
    numbersPlaced.push_back(numbers[numbers.size()-1-numbersPlacedFromEnd]); //insert last number into the vector
    return numbersPlaced; //return new vector
}
```

4.2 csce310h0mework02part02

4.2.1 Test 01

diff

part02test01.diff

Input

part02test01.input

```
6349 5080 3861 2182 -61 -1070 -3151
```

Submission Output

part02test01.output

```
The closest numbers are 1009.000000 apart.
```

Solution Output

part02test01.solution

```
The closest numbers are 1009.000000 apart.
```

stderr

part02test01.err

4.2.2 Test 02

`diff`

part02test02.diff

Input

part02test02.input

```
8397 -4088 -6723
```

Submission Output

part02test02.output

```
The closest numbers are 2635.000000 apart.
```

Solution Output

part02test02.solution

```
The closest numbers are 2635.000000 apart.
```

`stderr`

part02test02.err

4.2.3 Test 03

`diff`

part02test03.diff

Input

part02test03.input

```
8506 8502 8076 7953 5421 5035 2421 224 -3749 -6154
```

Submission Output

part02test03.output

```
The closest numbers are 4.000000 apart.
```

Solution Output

part02test03.solution

```
The closest numbers are 4.000000 apart.
```

`stderr`

part02test03.err

4.2.4 Test 04

`diff`

part02test04.diff

Input

part02test04.input

```
9231 1136 390 208 -960 -975 -2258 -5332 -6129 -9195
```

Submission Output

part02test04.output

```
The closest numbers are 15.000000 apart.
```

Solution Output

part02test04.solution

```
The closest numbers are 15.000000 apart.
```

`stderr`

part02test04.err

4.2.5 Test 05

`diff`

part02test05.diff

Input

part02test05.input

```
9712 8980 8877 4992 3827 1743 -3781 -6009 -8375 -9441
```

Submission Output

part02test05.output

```
The closest numbers are 103.000000 apart.
```

Solution Output

part02test05.solution

```
The closest numbers are 103.000000 apart.
```

`stderr`

part02test05.err

4.2.6 Test 06

`diff`

part02test06.diff

Input

part02test06.input

```
6020 5552 2242 -22 -4703 -5817 -9722
```

Submission Output

part02test06.output

```
The closest numbers are 468.000000 apart.
```

Solution Output

part02test06.solution

```
The closest numbers are 468.000000 apart.
```

`stderr`

part02test06.err

4.2.7 Test 07

`diff`

part02test07.diff

Input

part02test07.input

```
6970 5861 2579 1471 1457 -392 -7644 -8043 -8517 -9296
```

Submission Output

part02test07.output

```
The closest numbers are 14.000000 apart.
```

Solution Output

part02test07.solution

```
The closest numbers are 14.000000 apart.
```

`stderr`

part02test07.err

4.2.8 Test 08

`diff`

part02test08.diff

Input

part02test08.input

```
1418 400 -9182
```

Submission Output

part02test08.output

```
The closest numbers are 1018.000000 apart.
```

Solution Output

part02test08.solution

```
The closest numbers are 1018.000000 apart.
```

`stderr`

part02test08.err

4.2.9 Test 09

`diff`

part02test09.diff

Input

part02test09.input

```
7252 6645 5741 5203 1904 -762 -1482 -6490 -9525
```

Submission Output

part02test09.output

```
The closest numbers are 538.000000 apart.
```

Solution Output

part02test09.solution

```
The closest numbers are 538.000000 apart.
```

`stderr`

part02test09.err

4.2.10 Test 10

`diff`

part02test10.diff

Input

part02test10.input

```
6168 -5176 -8589
```

Submission Output

part02test10.output

```
The closest numbers are 3413.000000 apart.
```

Solution Output

part02test10.solution

```
The closest numbers are 3413.000000 apart.
```

`stderr`

part02test10.err

4.2.11 Test 11

`diff`

part02test11.diff

Input

part02test11.input

```
9578 599 -4904
```

Submission Output

part02test11.output

```
The closest numbers are 5503.000000 apart.
```

Solution Output

part02test11.solution

```
The closest numbers are 5503.000000 apart.
```

`stderr`

part02test11.err

4.2.12 Test 12

`diff`

part02test12.diff

Input

part02test12.input

```
6757 5818
```

Submission Output

part02test12.output

```
The closest numbers are 939.000000 apart.
```

Solution Output

part02test12.solution

```
The closest numbers are 939.000000 apart.
```

`stderr`

part02test12.err

4.2.13 Test 13

`diff`

part02test13.diff

Input

part02test13.input

```
8665 7053 6059 -270 -8186 -8653
```

Submission Output

part02test13.output

```
The closest numbers are 467.000000 apart.
```

Solution Output

part02test13.solution

```
The closest numbers are 467.000000 apart.
```

`stderr`

part02test13.err

4.2.14 Test 14

`diff`

part02test14.diff

Input

part02test14.input

```
5991 5825 4966 2230 1482 173 -3642
```

Submission Output

part02test14.output

```
The closest numbers are 166.000000 apart.
```

Solution Output

part02test14.solution

```
The closest numbers are 166.000000 apart.
```

`stderr`

part02test14.err

4.2.15 Test 15

`diff`

part02test15.diff

Input

part02test15.input

```
8221 -2097 -4044 -4791
```

Submission Output

part02test15.output

```
The closest numbers are 747.000000 apart.
```

Solution Output

part02test15.solution

```
The closest numbers are 747.000000 apart.
```

`stderr`

part02test15.err

4.2.16 Source Code

csce310h0mework02part02.h

```
#ifndef CSCE310H0MEWORK02PART02_H
#define CSCE310H0MEWORK02PART02_H

#include <vector>

using namespace std;

double closestNumbers( vector<double> );

#endif
```

csce310h0mework02part02.cpp

```
/*
 * Author: Fateh Karan Singh Sandhu
 * NUID: 17286643
 *
 * This function takes in a vector of multiple values and returns the
 * closest difference between two values.
 */

#include "csce310h0mework02part02.h"
#include <vector>
#include <iostream>
#include <cmath>

    using namespace std;

    double closestNumbers( vector<double> numbers )
    {
        double closestDistance = abs(numbers[0]-numbers[1]);
        if (numbers.size() == 2) {
            return closestDistance; // if vector is of size 2, return the difference
   of first 2 and exit
        } else {
        for (int i = 1 ; i < numbers.size()-1 ; i++) {
            if (abs(numbers[i] - numbers[i+1]) < closestDistance) {
                closestDistance = abs(numbers[i] - numbers[i+1]); // update new
   closest distance
            }
        }
        return closestDistance; //return closest distance
        }
    }
```

4.3 csce310h0mework02part03

4.3.1 Test 01

diff

part03test01.diff

Input

part03test01.input

```
11 45 76 77 84 97
```

Submission Output

part03test01.output

```
On average, 2.333333 comparisons are needed.
```

Solution Output

part03test01.solution

```
On average, 2.333333 comparisons are needed.
```

stderr

part03test01.err

4.3.2 Test 02

diff

part03test02.diff

Input

part03test02.input

```
18 19 25 29 33 35 36 39 47 50 51 52 53 70 81 82
```

Submission Output

part03test02.output

```
On average, 3.375000 comparisons are needed.
```

Solution Output

part03test02.solution

```
On average, 3.375000 comparisons are needed.
```

`stderr`

part03test02.err

4.3.3 Test 03

`diff`

part03test03.diff

Input

part03test03.input

```
20 48 57 63
```

Submission Output

part03test03.output

```
On average, 2.000000 comparisons are needed.
```

Solution Output

part03test03.solution

```
On average, 2.000000 comparisons are needed.
```

`stderr`

part03test03.err

4.3.4 Test 04

`diff`

part03test04.diff

Input

part03test04.input

```
23 24 42 45 55 59 61 62 66
```

Submission Output

part03test04.output

```
On average, 2.777778 comparisons are needed.
```

Solution Output

part03test04.solution

```
On average, 2.777778 comparisons are needed.
```

stderr

part03test04.err

4.3.5 Test 05

diff

part03test05.diff

Input

part03test05.input

```
11 19 32 36 40 45 55 63 72 87 96 97
```

Submission Output

part03test05.output

```
On average, 3.083333 comparisons are needed.
```

Solution Output

part03test05.solution

```
On average, 3.083333 comparisons are needed.
```

stderr

part03test05.err

4.3.6 Test 06

diff

part03test06.diff

Input

part03test06.input

```
24 25 36 41 42 48 56 60 70 76 87 88 98
```

Submission Output

part03test06.output

```
On average, 3.153846 comparisons are needed.
```

Solution Output

part03test06.solution

```
On average, 3.153846 comparisons are needed.
```

stderr

part03test06.err

4.3.7 Test 07

diff

part03test07.diff

Input

part03test07.input

```
13 15 21 34 41 48 49 57 58 63 67 74 84 88 90 92
```

Submission Output

part03test07.output

```
On average, 3.375000 comparisons are needed.
```

Solution Output

part03test07.solution

```
On average, 3.375000 comparisons are needed.
```

`stderr`

part03test07.err

4.3.8 Test 08

`diff`

part03test08.diff

Input

part03test08.input

```
38 54 61 62 69 77 93
```

Submission Output

part03test08.output

```
On average, 2.428571 comparisons are needed.
```

Solution Output

part03test08.solution

```
On average, 2.428571 comparisons are needed.
```

`stderr`

part03test08.err

4.3.9 Test 09

`diff`

part03test09.diff

Input

part03test09.input

```
15 17 18 19 21 33 39 48 49 50 54 57 65 73 80 89 92
```

Submission Output

part03test09.output

```
On average, 3.470588 comparisons are needed.
```

Solution Output

part03test09.solution

```
On average, 3.470588 comparisons are needed.
```

stderr

part03test09.err

4.3.10 Test 10

diff

part03test10.diff

Input

part03test10.input

```
22 41 49 50 52 76
```

Submission Output

part03test10.output

```
On average, 2.333333 comparisons are needed.
```

Solution Output

part03test10.solution

```
On average, 2.333333 comparisons are needed.
```

stderr

part03test10.err

4.3.11 Source Code

csce310h0mework02part03.h

```
#ifndef CSCE310H0MEWORK02PART03_H
#define CSCE310H0MEWORK02PART03_H

#include <vector>

using namespace std;

double averageComparisons( vector<int> );

#endif
```

csce310h0mework02part03.cpp

```
/*
 * Author: Fateh Karan Singh Sandhu
 * NUID: 17286643
 *
 * This function takes an array as an input and returns the average number
 * of comparisons in a binary search of the array
 */

#include "csce310h0mework02part03.h"
#include <vector>
```

```
#include <iostream>
#include <cmath>

using namespace std;

double averageComparisons( vector<int> numbers )
{
    //handle edge case for array size 1 and 2
    if (numbers.size() == 1) {
        return 1;
    }

    double averageComparisons = 0.0;
    int depthOfTree = ceil(log2(numbers.size())); //assume every array is a perfect
   BST
    int countOfLeaves = 0;
    if (depthOfTree - floor(log2(numbers.size())) == 0) {
        //if arraysize != 2 and is a perfect log2, add 1 depth for the last node
        depthOfTree++;
    }
    for (int i = 1 ; i < depthOfTree ; i++) {
        averageComparisons += i * pow(2, i-1); //increment averageComparisons
        countOfLeaves += pow(2, i-1); //update count of leaves in tree
    }
    int leavesAtLast = numbers.size() - countOfLeaves; //count leaves at last level
   since BST may not be fully filled
    averageComparisons += depthOfTree * leavesAtLast; //add comparisons for last level

    return (averageComparisons/numbers.size());
}
```