

The screenshot shows the Visual Studio Code interface with a WSL Ubuntu terminal. The Explorer sidebar on the left shows the file structure of a project named 'CPSC335.PROJECT1'. The main editor window displays the 'README.md' file with the following content:

```
1 # CPSC335
2 # 03/19/2023
3 # Project1
4 # Group Members:
5 # John Park (Sungwook_Park@csu.fullerton.edu)
6 # Alex Ha (studentAlexander123@csu.fullerton.edu)
7
```

The screenshot shows a terminal window with the following commands and output:

```
jspark1@MFJP: ~/desktop/CPSC335/CPSC335.project1
jspark1@MFJP:~/desktop/CPSC335/CPSC335.project1$ ls
README.md disk_test.cpp disks.hpp rubrictest.hpp
jspark1@MFJP:~/desktop/CPSC335/CPSC335.project1$ g++ -o project1 disk_test.cpp
jspark1@MFJP:~/desktop/CPSC335/CPSC335.project1$ ./project1
disk_state still works: passed, score 1/1
sorted_disks still works: passed, score 1/1
disk_state::is_initialized: passed, score 3/3
disk_state::is_sorted: passed, score 3/3
alternate, n=4: passed, score 1/1
alternate, n=3: passed, score 1/1
alternate, other values: passed, score 1/1
lawnmower, n=4: passed, score 1/1
lawnmower, n=3: passed, score 1/1
lawnmower, other values: passed, score 1/1
TOTAL SCORE = 14 / 14
jspark1@MFJP:~/desktop/CPSC335/CPSC335.project1$
```

isSorted Function:

for i = 0 to total count

 If i is less than half of total count (check left half is all white)

 If the color at index is dark disk

 return false

```

        else (checking the right side for light disk)
        If the color at index is light
            return false
    end for
    return true (all light disk on left and dark disk on right)
end

```

sort_alternate function:

```

Initialize numOfSwap = 0
Set disk state to before
for i = 0 to total count / 2
    for j = i to total count - i do j = j + 2 (checking every other index eg. [0,2,4,6,8] [1,3,5,7])
        (set j = i so j does not iterate from the beginning)
        check if color at index is dark disk and right disk is light
            swap index at with index + 1
            numOfSwap++
        end if
    end for
end for
return sorted disk at state and numOfSwap

```

$$\begin{aligned}
 SC &= \sum_{\text{initial}_1}^{\text{final}_1} \cdot \sum_{\text{initial}_2}^{\text{final}_2} * SC_{\text{block}} \quad SC_{\text{if}} = \text{condition} + \max(SC, SC) \\
 \text{Sort alt:} \quad & \rightarrow = 4 \\
 SC &= \sum_{i=0}^{n/2} \cdot \sum_{j=i}^{n-i} \cdot [1 + 2 + \max(1, 0)] \\
 &= \sum_{i=0}^{n/2} \cdot \left[\sum_{j=1}^{n-i} - \sum_{j=1}^{i-1} \right] * 4 = [n-i-i+1] * 4 \\
 &= \sum_{i=0}^{n/2} 4(n-2i+1) \\
 &= \sum_{i=0}^{n/2} 4n - \sum_{i=0}^{n/2} 8i + \sum_{i=0}^{n/2} 4 \\
 &= 4n\left(\frac{n}{2}+1\right) - 8 \cdot \frac{n}{2}\left(\frac{n}{2}+1\right) + 4\left(\frac{n}{2}+1\right) \\
 &= 2n^2 + 4 - \left[4 \cdot \left(\frac{n^2}{4} + \frac{n}{2} \right) \right] + 2n + 4 \\
 &= 2n^2 + 4 - n^2 + 2n + 2n + 4 \\
 &= n^2 + 4n + 8 \in O(n^2)
 \end{aligned}$$

Sort alt:

$$\begin{aligned} n^2 + 4n + 8 &\in O(n^2) \\ \lim_{n \rightarrow \infty} \frac{n^2 + 4n + 8}{n^2} &= \lim_{n \rightarrow \infty} \frac{n^2}{n^2} + \frac{4n}{n^2} + 8 \\ &\lim_{n \rightarrow \infty} \frac{4n}{n^2} + 8 \quad \text{L.H.} \quad \frac{4}{2n} \rightarrow 0 \\ \lim_{n \rightarrow \infty} \frac{4}{2(\infty)} &= 0 \quad \text{by limit theorem} \\ n^2 + 4n + 8 &\in O(n^2) \end{aligned}$$

Sort_lawnmower:

Initialize numOfSwap = 0

Set disk state to before

for i = 1 to total count / 2 do (starting at i = 1 because we know disk starts with light)

for j = i to total count - i - 1 do

(the first iteration can stop at total count - i - 1 since we know last disk is dark and 2nd index from the right will be swapped with 3rd index from the right)

check if color at index is dark disk and right disk is light

swap index at with index + 1

numOfSwap++

for j = total count - i - 2 to i + 1 do j--

(Start from the right side but consider after the first iteration, the last two index are already sorted with dark disk, so we can start from 3rd index from the right)

check if color at index is light disk and left disk is dark

swap index at with index - 1

numOfSwap++

end for

return sorted disk at state and numOfSwap

Lawmover Sort:

$$SC = \sum_{i=1}^{n/2} \left[\sum_{j=i}^{n-i-1} 1 + \sum_{j=n-i-2}^{i+1} 1 \right] \cdot 4$$

$$\sum_{j=i}^{n-i-1} 1 = n-i-1+1 = n$$

$$\sum_{j=1}^{i+1} 1 = i+1-n+i+2 = 2i-n+3$$

$$\sum_{i=1}^{n/2} 4(n+2i-n+3) = 4(2i+3)$$

$$\sum_{i=1}^{n/2} 8i + \sum_{i=1}^{n/2} 12 = 8 \cdot \left(\frac{\frac{n}{2}(\frac{n}{2}+1)}{2} \right) + \frac{n}{2} \cdot 12$$

$$8 \cdot \left(\frac{\frac{n^2}{4} + \frac{n}{2}}{2} \right) + 6n = 8 \left(\frac{n^2}{8} + \frac{n}{4} \right) + 6n$$

$$= n^2 + 2n + 6n = n^2 + 8n \in O(n^2)$$

Lawmover:

$$n^2 + 8n \in O(n^2)$$

$$\lim_{n \rightarrow \infty} \frac{n^2 + 8n}{n^2} = \frac{8}{n} \quad \lim_{n \rightarrow \infty} \frac{8}{n} = \frac{8}{\infty} \Rightarrow 0$$

by limit theorem $n^2 + 8n \in O(n^2)$