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## Project 1: Implementing Algorithms

### **Alternating Algorithm:**

**Input:** a positive integer  $n$  and a list of  $2n$  disks of alternating colors light-dark, starting with light

**Output:** a list of  $2n$  disks, the first  $n$  disks are light, the next  $n$  disks are dark, and an integer  $m$  representing the number of swaps to move the dark ones after the light ones.

### **Pseudocode:**

```
def alternating(disks):
    swapCount = 0
    for i = 0 to 2n do
        indexCounter = 0
        while indexCounter + 1 is less than n do
            if n is greater than (n + 1)
                swap(indexCounter)
                increment swapCount
            endif
            indexCounter++
    return sorted disks
```

### **Big O Efficiency:**

swapCount = 0	- 1 tu	-
for i = 0 to 2n - 1 do	- $((2n - 1 - 0) / 1) + 1 = 2n$ tu	
indexCounter = 0	-1 tu	
while indexCounter + 1 is less than n do:	- $3(n + 1) = 3n + 3$	
if n is greater than (n + 1)	-1 + max (2,0) = 3 tu	
swap(indexCounter)	-1 tu	

```

                                increment swapCount -1 tu
                                endif
                                indexCounter++ -1u
                                return sorted disks

```

$$= 2n(3n + 3) + 1 = \underline{6n^2 + 6n + 1}$$

**Proving  $6n^2 + 6n + 1$  belongs to  $O(n^2)$  using limit theorem:**

$$f(n) = 6n^2 + 6n + 1$$

$$g(n) = n^2$$

$$\lim f(n) / g(n) \text{ // as } n \rightarrow \text{infinity}$$

$$= \lim (6n^2 + 6n + 1) / (n^2) \text{ // as } n \rightarrow \text{infinity}$$

using l'hospital:

$$\lim (12n + 6) / 2n \text{ // as } n \rightarrow \text{infinity}$$

using l'hospital again:

$$\lim 12 / 2 \text{ // as } n \rightarrow \text{infinity}$$

$$= 6 > 0$$

Because  $L = 6 > 0$ , by the Limit Theorem, we can say that  $6n^2 + 6n + 1$  belongs to

$$O(n^2)$$

**Time Complexity =  $O(n^2)$**

### **Lawnmower Algorithm:**

**Input:** a positive integer  $n$  and a list of  $2n$  disks of alternating colors light-dark, starting with light

**Output:** a list of  $2n$  disks, the first  $n$  disks are light, the next  $n$  disks are dark, and an integer  $m$  representing the number of swaps to move the dark ones after the light ones.

### **Pseudocode:**

```
def lawnmower(disks):
    swapCount = 0
    for i = 0 to n / 2 do:
        indexCounter = 0
        while indexCounter + 1 is less than n do
            if n is greater than (n + 1)
                swap(indexCounter)
                increment swapCount
            endif
            indexCounter++
    return sorted disks
```

### **Big O Efficiency:**

```
def lawnmower(disks):
    swapCount = 0           -1 tu
    for i = 0 to n / 2 do:  -((n / 2) / 1) + 1 = (n / 2) + 1 tu
        indexCounter = 0    -1 tu
        while indexCounter + 1 is less than n do      - 3(n + 1) = 3n + 3
            if n is greater than (n + 1)              -1 + max(2,0) = 3 tu
                swap(indexCounter)                     -1 tu
                increment swapCount                     -1 tu
            endif
            indexCounter++                               -1 tu
    return sorted disks
```

$$= ((n / 2) + 1) (3n + 3) + 1 = ((3n^2) / 2) + (3n / 2) + (3n) + 4 = \underline{\underline{((3n^2) / 2) + (9n / 2) + 4}}$$

**Proving  $(3n^2)/2 + (9n/2) + 4$  belongs to  $O(n^2)$  using limit theorem:**

$$f(n) = (3n^2)/2 + (9n/2) + 4$$

$$g(n) = n^2$$

$$\lim f(n) / g(n) \text{ // as } n \rightarrow \text{infinity}$$

$$= \lim ((3n^2)/2 + 9n/2 + 4) / (n^2) \text{ // as } n \rightarrow \text{infinity}$$

using l'hospital:

$$\lim (6n + 9/2) / 2n \text{ // as } n \rightarrow \text{infinity}$$

using l'hospital again:

$$\lim 6 / 2 \text{ // as } n \rightarrow \text{infinity}$$

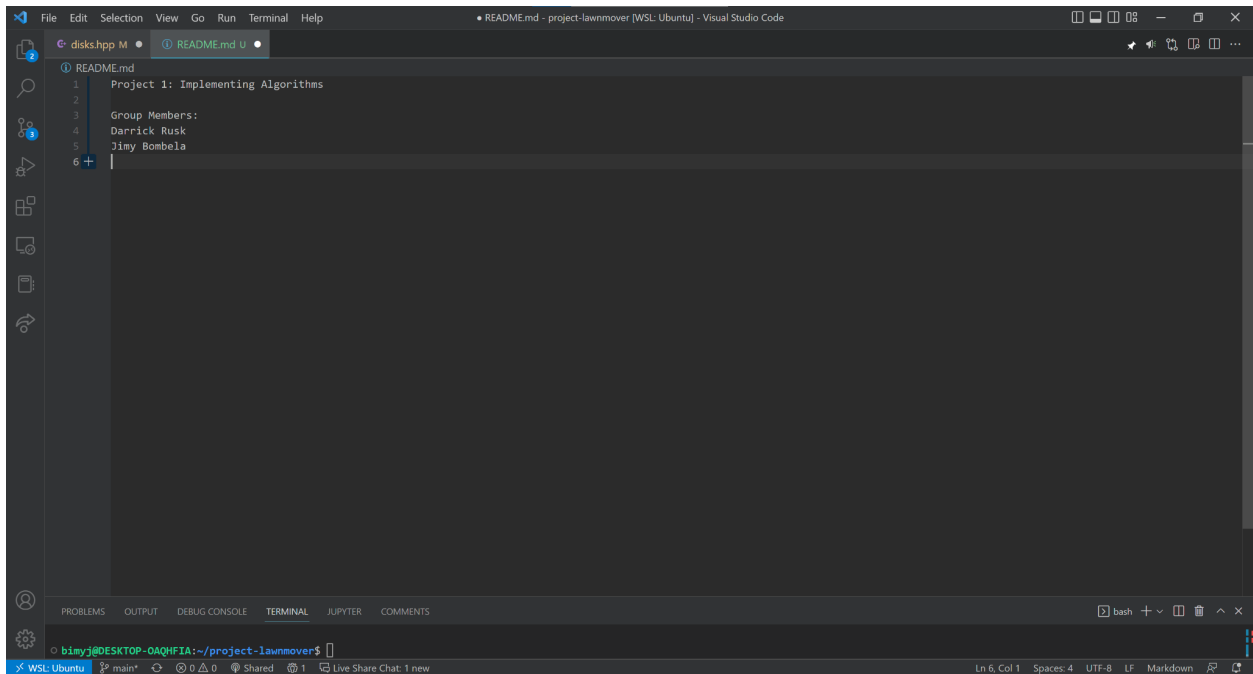
$$= 3 > 0$$

Because  $L = 3 > 0$ , by the Limit Theorem, we can say that  $(3n^2)/2 + (9n/2) + 4$

belongs to  $O(n^2)$

**Time Complexity =  $O(n^2)$**

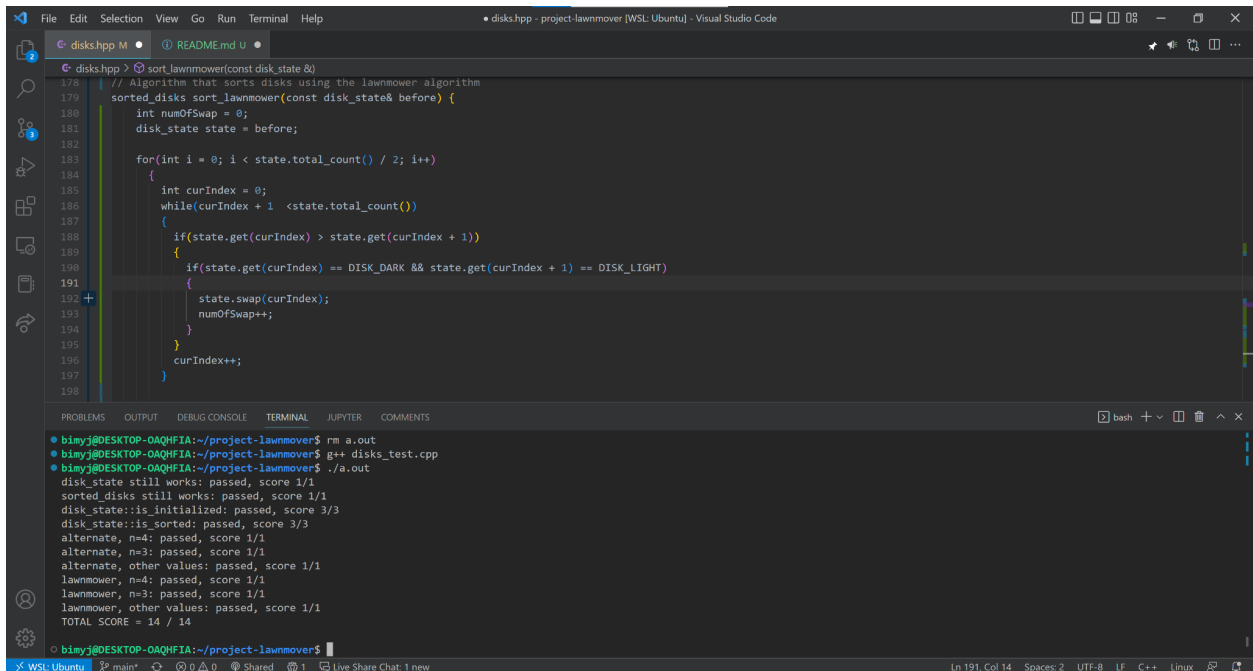
## Screenshots:



This screenshot shows the Visual Studio Code editor with the README.md file open. The file contains the following text:

```
1 Project 1: Implementing Algorithms
2
3 Group Members:
4 Darrick Rusk
5 Jimmy Bombela
6 +
```

The bottom of the window shows the terminal with the command prompt: `bimyj@DESKTOP-OAQHFIA:~/project-lawnmower$`.



This screenshot shows the Visual Studio Code editor with the disks.hpp file open. The file contains the following code:

```
178 // Algorithm that sorts disks using the lawnmower algorithm
179 sorted_disks sort_lawnmower(const disk_state& before) {
180     int numOfSwap = 0;
181     disk_state state = before;
182
183     for(int i = 0; i < state.total_count() / 2; i++)
184     {
185         int curIndex = 0;
186         while(curIndex + 1 < state.total_count())
187         {
188             if(state.get(curIndex) > state.get(curIndex + 1))
189             {
190                 if(state.get(curIndex) == DISK_DARK && state.get(curIndex + 1) == DISK_LIGHT)
191                 {
192                     state.swap(curIndex);
193                     numOfSwap++;
194                 }
195             }
196             curIndex++;
197         }
198     }
```

The bottom of the window shows the terminal with the following output:

```
bimyj@DESKTOP-OAQHFIA:~/project-lawnmower$ rm a.out
bimyj@DESKTOP-OAQHFIA:~/project-lawnmower$ g++ disks_test.cpp
bimyj@DESKTOP-OAQHFIA:~/project-lawnmower$ ./a.out
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
bimyj@DESKTOP-OAQHFIA:~/project-lawnmower$
```