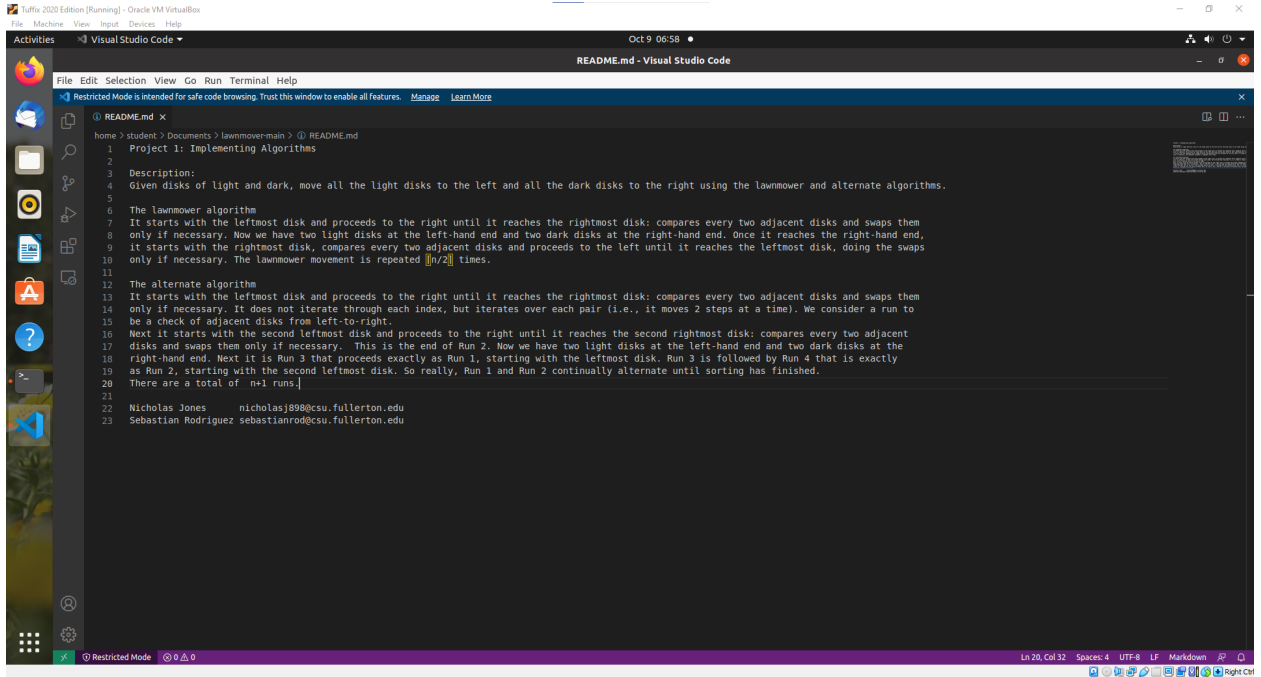
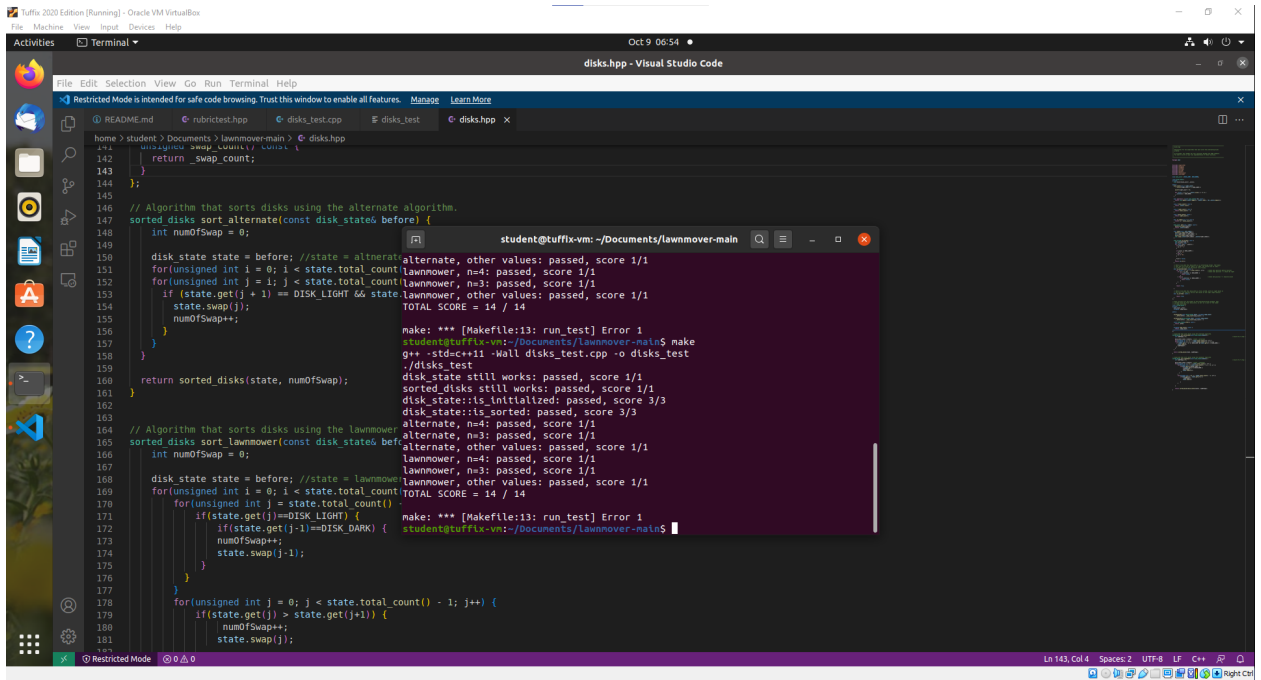


Project 1: Implementing Algorithms



The 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 Description:
4 Given disks of light and dark, move all the light disks to the left and all the dark disks to the right using the lawnmower and alternate algorithms.
5
6 The lawnmower algorithm
7 It starts with the leftmost disk and proceeds to the right until it reaches the rightmost disk: compares every two adjacent disks and swaps them
8 only if necessary. Now we have two light disks at the left-hand end and two dark disks at the right-hand end. Once it reaches the right-hand end,
9 it starts with the rightmost disk, compares every two adjacent disks and proceeds to the left until it reaches the leftmost disk, doing the swaps
10 only if necessary. The lawnmower movement is repeated  $\lfloor n/2 \rfloor$  times.
11
12 The alternate algorithm
13 It starts with the leftmost disk and proceeds to the right until it reaches the rightmost disk: compares every two adjacent disks and swaps them
14 only if necessary. It does not iterate through each index, but iterates over each pair (i.e., it moves 2 steps at a time). We consider a run to
15 be a check of adjacent disks from left-to-right.
16 Next it starts with the second leftmost disk and proceeds to the right until it reaches the second rightmost disk: compares every two adjacent
17 disks and swaps them only if necessary. This is the end of Run 2. Now we have two light disks at the left-hand end and two dark disks at the
18 right-hand end. Next it is Run 3 that proceeds exactly as Run 1, starting with the leftmost disk. Run 3 is followed by Run 4 that is exactly
19 as Run 2, starting with the second leftmost disk. So really, Run 1 and Run 2 continually alternate until sorting has finished.
20 There are a total of  $n-1$  runs.
21
22 Nicholas Jones nicholasj89@csu.fullerton.edu
23 Sebastian Rodriguez sebastianrod@csu.fullerton.edu
```



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

```
141 unsigned swap_count() const {
142     return _swap_count;
143 }
144 };
145
146 // Algorithm that sorts disks using the alternate algorithm.
147 sorted_disks sort_alternate(const disk_state& before) {
148     int numOfSwap = 0;
149
150     disk_state state = before; //state = alternate
151     for(unsigned int i = 0; i < state.total_count(); i++) {
152         for(unsigned int j = 1; j < state.total_count(); j++) {
153             if (state.get(j) == DISK_LIGHT && state.get(j-1) == DISK_DARK) {
154                 state.swap(j, j-1);
155                 numOfSwap++;
156             }
157         }
158     }
159     return sorted_disks(state, numOfSwap);
160 }
161
162 // Algorithm that sorts disks using the lawnmower algorithm.
163 sorted_disks sort_lawnmower(const disk_state& before) {
164     int numOfSwap = 0;
165
166     disk_state state = before; //state = lawnmower
167     for(unsigned int i = 0; i < state.total_count(); i++) {
168         for(unsigned int j = state.total_count() - 1; j > i; j--) {
169             if (state.get(j) == DISK_LIGHT && state.get(j-1) == DISK_DARK) {
170                 state.swap(j, j-1);
171                 numOfSwap++;
172             }
173         }
174     }
175     return sorted_disks(state, numOfSwap);
176 }
177
178 for(unsigned int j = 0; j < state.total_count() - 1; j++) {
179     if (state.get(j) > state.get(j+1)) {
180         numOfSwap++;
181         state.swap(j, j+1);
182     }
183 }
```

A terminal window is also open, showing the output of the make command and the results of the tests:

```
make *** [Makefile:13: run_test] Error 1
student@tuffix-vm:~/Documents/lawnmover-main$ make
g++ -std=c++11 -Wall disks_test.cpp -o disks_test
./disks_test
disk state still works: passed, score 1/1
sorted_disks still works: passed, score 1/1
disk state::initialized: passed, score 3/3
disk state::is_sorted: passed, score 3/3
alternate, n=4: 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
make *** [Makefile:13: run_test] Error 1
student@tuffix-vm:~/Documents/lawnmover-main$
```

Lawnmower Algorithm Pseudo Code:

Create local variable to count the swaps	1 tu
Create temp disk state	1 tu
For i from 0 to $n/2$	$n/2 + 1$ tu
For j total count - 1	$1-n$ tu
If j is less than total count - 1	2 tu
Increment	1 tu
Swap states	1 tu
Swap j-1 and j	3 tu
For j from 0 to $n-1$	$n-1$ tu
If j is greater than j+1	2 tu
Increment	1 tu
Swap states	1 tu
Swap j and j+1	3 tu

Mathematical Analysis

Step Count:

$O(n^2)$

$SC = 1 + 1 + \text{outer for loop}(SC \text{ first for loop} + SC \text{ second for loop}) + 1$

$$SC = 1 + 1 + ((n/2) + 1) ((1-n)(2 + \max(6, 0)) + n(2 + \max(5, 0)))$$

$$= 2 + ((n/2) + 1) (8 - 6n + 5n)$$

$$= 2 + ((n/2) + 1) (8 - 1n)$$

$$= 2 + ((8n/2) + 1)(8 - 1n)$$

$$\begin{aligned}
&= 2 + (8n/2) - (n^2/2) + 8 - n \\
&= 10 + (8n/2) - (n^2/2) + 8 - n \\
&= 10 + 3n - (n^2/2) \\
&= O((n^2/2) - 3n - 10) \\
&= O((n^2/2)) \\
&= \mathbf{O(n^2)}
\end{aligned}$$

Proof:

$$\begin{aligned}
&8n^2 + 3n + 8 \in O(n^2) \\
&\lim_{n \rightarrow \infty} (8n^2 + 3n + 8)/n^2 \\
&= \lim_{n \rightarrow \infty} (8n^2/n^2) + \lim_{n \rightarrow \infty} (3n/n^2) + \lim_{n \rightarrow \infty} (8/n^2) \\
&= \lim_{n \rightarrow \infty} (8) + \lim_{n \rightarrow \infty} (3/n) + \lim_{n \rightarrow \infty} (8/n^2) \\
&= 8 \geq 0 \text{ and is a constant} \\
&8n^2 + 3n + 8 \in O(n^2)
\end{aligned}$$

Alternate Algorithm Pseudo Code:

Create local variable to count the swaps	1 tu
Create temp disk state	1 tu
For i from 0 total count	$n/(2n+1)$ tu
For j = 1 total count - 1	n tu
If j+1 and j	2 tu
Swap states	1 tu
Increment	1 tu

Mathematical Analysis**Step Count:** **$O(n^2)$**

$$\begin{aligned}
 SC &= 1 + 1 + (n/2 + 1)n(2 + \max(3, 0)) \\
 &= 2 + (n/2 + 1)(n)(5) \\
 &= 2 + (n/2 + 1)(5n) \\
 &= 2 + (5n^2)/2 + 5n = (5n^2)/2 + 5n + 2 \\
 &= O((5n^2)/2 + 5n + 2) \\
 &= O((5n^2)/2) \\
 &= \mathbf{O(n^2)}
 \end{aligned}$$

Proof:

$$5n^2 + 5n + 2 \in O(n^2)$$

$$\lim_{n \rightarrow \infty} (5n^2 + 5n + 2)/(n^2)$$

$$= \lim_{n \rightarrow \infty} (5n^2/n^2) + \lim_{n \rightarrow \infty} (5n/n^2) + \lim_{n \rightarrow \infty} (2/n^2)$$

$$= \lim_{n \rightarrow \infty} (2) + \lim_{n \rightarrow \infty} (5n) + \lim_{n \rightarrow \infty} (5/n^2)$$

$$= 5 \geq 0 \text{ and is a constant}$$

$$5n^2 + 5n + 2 \in O(n^2)$$