*Assumptions Regarding the Data*

My first assumption is that 1 unit on the grid is equal to 2 miles. I make this assumption since the clusters of scooters are spread out over ~0.05 units, and each cluster likely represents the area around and inside a location. I assigned the value of 2 miles, since this means every 0.05 units, which would presumably be the distance of a city block, is about 0.1 miles, or 528 feet.

I do have additionally assume that clarifies a statement regarding the situation. The bus must be able to theoretically stop to pick up the scooters, and I will also assume that the bus can hold around 1000 scooters, since they hypothetically can fold down and be stacked tightly into whatever form of charging station they have. Additionally, let’s assume it take 15 minutes to load and unload scooters from the bus.

One other assumption is that the bus can not presumably travel freely on a map, so it will have to travel only going on the x or y axis. Additionally, while the initial location may or may not be downtown, the prompt implies these scooters are located downtown, so I assume that the bus will have to follow the speed limit for a congested metropolitan area, which I assume is 25 mph, when travelling in the city.

An additional assumption is this only qualifies for the scooters that will be charged as of the data used. If we factor in the fact that people will be using these scooters, draining the battery, technically there is no finite way to determine how long it will take to charge these scooters, as the scooters will constantly be in use, constantly being in need of recharge.

The final assumption I am going to make is that shift changes will happen on site, and the bus will be swapped out with a second bus. The time it will take for this bus to go charge all these scooters will take a great amount of time. This means the bus will quickly change drivers when it stops at a location whenever a shift change needs to occur. Additionally, to prevent the bus from damage from constantly being run, I assume that there is a second bus, and they are swapped out daily, so the bus can be checked for maintenance, refueled, and kept in working order.

*Notable Data and Conclusions*

The first thing of note, as mentioned before, is that the scooters, when using the x and y coordinates to form a map, create clusters, which can be logically associated with locations of interest. There are 19 of said clusters on this map, each spanning roughly a city block. The centers of each cluster are as follows.

|  |  |  |  |
| --- | --- | --- | --- |
| **Cluster #** | **Number of Scooters** | **X Coordinates** | **Y Coordinates** |
| **Cluster 1** | 1367 | -0.08195 | -0.0862 |
| **Cluster 2** | 1558 | 0.40497 | 0.061864 |
| **Cluster 3** | 1517 | 1.3413 | 0.8774 |
| **Cluster 4** | 1540 | 0.973 | 0.73286 |
| **Cluster 5** | 1491 | 0.84164 | 1.1624 |
| **Cluster 6** | 1219 | 0.37036 | -0.1287 |
| **Cluster 7** | 2205 | 0.22556 | 0.13145 |
| **Cluster 8** | 988 | -0.16073 | -0.22126 |
| **Cluster 9** | 1461 | 0.75461 | 0.58497 |
| **Cluster 10** | 1366 | 0.95819 | 1.2957 |
| **Cluster 11** | 1219 | 0.94117 | 0.89752 |
| **Cluster 12** | 1334 | 0.24935 | -0.25021 |
| **Cluster 13** | 914 | 1.1645 | 1.327 |
| **Cluster 14** | 1603 | 0.21795 | -0.04084 |
| **Cluster 15** | 1313 | 0.90128 | 0.79737 |
| **Cluster 16** | 1333 | -0.26258 | 0.02409 |
| **Cluster 17** | 971 | -0.12144 | 0.32751 |
| **Cluster 18** | 1115 | 0.6023 | 1.0294 |
| **Cluster 19** | 1154 | -0.14856 | 0.048811 |

While cluster 14, located around (0.22, -0.04), contains the most scooters overall, clusters 11, 15, and 4 are so closely packed that they would logically make the point at which the scooters gather most frequently, at (0.94, 0.81).

The bus will take a route as follows, travelling a distance as listed below. I’ve already transferred the data from units on the graph into miles for convenience.

|  |  |  |  |
| --- | --- | --- | --- |
| **Start** | **Distance (miles)** | **Time Taken (minutes)** | **End** |
| Starting Space | 75.777 | 90.93 | Cluster 13 |
| Cluster 13 | 0.475 | 1.14 | Cluster 10 |
| Cluster 10 | 0.500 | 1.20 | Cluster 5 |
| Cluster 5 | 0.745 | 1.79 | Cluster 18 |
| Cluster 18 | 1.782 | 4.28 | Cluster 3 |
| Cluster 3 | 0.841 | 2.02 | Cluster 11 |
| Cluster 11 | 0.280 | 0.67 | Cluster 15 |
| Cluster 15 | 0.272 | 0.65 | Cluster 4 |
| Cluster 4 | 0.733 | 1.76 | Cluster 9 |
| Cluster 9 | 2.267 | 5.44 | Cluster 17 |
| Cluster 17 | 0.889 | 2.13 | Cluster 16 |
| Cluster 16 | 0.277 | 0.67 | Cluster 19 |
| Cluster 19 | 0.403 | 0.97 | Cluster 1 |
| Cluster 1 | 0.428 | 1.03 | Cluster 8 |
| Cluster 8 | 0.878 | 2.11 | Cluster 12 |
| Cluster 12 | 0.482 | 1.16 | Cluster 14 |
| Cluster 14 | 0.360 | 0.86 | Cluster 7 |
| Cluster 7 | 0.498 | 1.2 | Cluster 2 |
| Cluster 2 | 0.450 | 1.08 | Cluster 6 |

For it to travel to each cluster of scooters, it will have to travel a total distance of 88.34 miles, 12.56 of which it will have to travel while travelling at half speed due to traffic laws. Assuming each stop takes 15 minutes to remove charged bikes or add uncharged bikes, travelling to each stop and swapping out bikes at each location would take a total of 6.77 hours. Travelling from Cluster 13, through this route, to Cluster 2 takes 5.25 hours, travelling over 12.56 miles.

With the data provided, we additionally know there are a total of 25,668 scooters, with around 4,200 scooters at each level of charge. We can only fit 1000 scooters on the bus at any given time, so we need to find a system within which we can get scooters constantly flowing in and out of the bus.

*Ideal Method of Charging*

The bus will start at it’s starting point. When it reaches the 1st stop, cluster 13, it will pick up 25% of the scooters with 0 charge there and begin charging them. Since they take 5 hours to charge, these first scooters will be charged by the time they reach Cluster 7, the second to last stop on the route. At this point, they should drop off the scooters they began charging from Cluster 13 and begin charging 25% of the scooters from Cluster 7. From this point on, whenever it reaches a new cluster, the bus should drop off the charged scooters it currently has and grab a number of the uncharged scooters from that spot equal to 25% of the number of scooters from the beginning with no charge. Whenever the bus reaches Cluster 2, it should travel back to Cluster 13, adding 10.8 minutes over the course of 4.50 miles to their route.

Repeating this pattern, dropping off the charged scooters and grabbing 25% of the uncharged scooters that were there from the beginning, by the time the bus has travelled around this loop 4 times, all uncharged scooters will be either full, or on the bus ready to be dropped off. By the time all uncharged scooters will be on the bus, the bus will have travelled over 23.07 hours. The rest of the time will be spent bringing the bus back to the starting point at (20.19, 20.19), since the bus needs time to refuel and for maintenance. Adding in this travel time, the bus will have travelled for 24.58 hours, over the distance of 155.11 miles. While the bus is being swapped out for a second bus, the scooters will be swapped into the second bus, adding an additional 15 minutes, then the second bus will continue the route of the first and head back to Cluster 13.

Once the bus has returned, it will repeat the same process as the previous bus did the day before, only this time it will be picking up scooters with a charge of 1. This will take slightly less time, travelling around this route listed above for 79.49 miles over the course of 22.24 hours. Once again, the bus will make a round trip to it’s starting point, swap out the scooters into the other bus, and return. The bus will then repeat the cycle for scooters with a charge of 2, then 3, then 4.

In total, the bus will travel a total distance of 984.78 miles, over the course of 150.32 hours, or 6.3 days. It will have gone around the cycle of locations listed in the chart above 20 times, made 4 pit stops, and charged 25,668 scooters.