MP 3

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1 Task 1: Create a Simulator

For this task, I created a simulator using the simpy python package. This simulation models a Citi Bike usage over a 24 hour time frame. When creating the simulation, I first created an environment that would hold all station objects and their corresponding "queues," which represents how many bikes are remaining at each station.

When the simulation begins, riders enter a rate exponentially distributed with a mean of λ. After entering the simulation, they choose a station to start at with a random probability p. The time is then noted. Then, if needed, they wait for a bike to become available, and if it is, 1 is added to the success counter to keep track of the number of people that successfully borrowed a bike. Additionally, the time is once again noted when the rider obtains the bike to calculate the wait time. After the biker gets the bike, they choose the end location randomly with the probability that they will end up at station j given that they begin at station i. Then, the process stalls for the length of their bike ride, and then the bike is dropped off to their destination station.

To calculate the probability that the rider ends up at station j given that they begin at station i, I used the equation $P(A \mid B) = \frac{P(A \cap B)}{P(B)}$, and put these results into a dictionary with the key being the starting station, and the value being the ending station followed by the probability of ending at that station given the starting station.

To verify this simulation, I used numerous methods. First, I checked to see whether all of the probabilities summed to 1 for each station, which they did. This ensured that the data was analyzed and calculated correctly from the CSV files.

Additionally, I plugged in numerous values into the "number of bikes" parameter to ensure that the solutions lined up with the intuitive thought process. For example, with 10 bikes per each station and 81 stations, this means that there are 810 bikes spread out. Thus, with the number of riders being much lower than 810, one would expect that the total success rate is almost always 100, as this is running in a 24 hour time scale. This thinking lines up with my results, as the success rate was almost always 100 with low numbers such as 100 total riders, with the waiting time almost always staying at 0.0 at this value. When using larger values like 1000, the successful rider rate does not drop significantly, but the waiting time increases. This also aligns with the intuitive thinking, as there are not an overwhelming number of riders so that they cannot all be served withing the 24 hour time frame. However, each rider may have have to wait longer due to the higher congestion of riders using bikes. When increasing the number of riders more, this trend is emphasized. For example, when the number is 2000, the number of successful rides stays at 1989, but the waiting time increases to about 17 minutes. This aligns with the previous thinking. Thus, it is clear that the simulation is accurate as these test cases are giving values in the expected ranges.

2 Task 2: A Baseline Experiment

When the number of bikes available at every station is fixed at 10, and the number of riders is 3,500, the following values were produced:

1. Probability of "Successful Rental"= 97.3%
2. Average Wait Time = 35.67 minutes

Using the input data from the PDF and the probability values from the CSV files, I calculated a 90% confidence interval. I averaged the success rate over 5 iterations of the simulation and obtained the following output: $(0.9737, 0.9819)$

3 Task 3: An "Idealized" Experiment

To determine the minimum number of bikes needed to meet the demand of 3,500 riders given the restrictions and parameters outlined in the PDF, I created an attribute in the BikeStation class that tracks the amount of visitors that go to this station to take a bike. Each time a visitor chooses the station to get a bike, a this counter is increased by one. At the end of one simulation, the counter represents the total demand at that specific station. Running this simulation 50 times, I kept track of the demand at each station at each simulation, creating a dictionary where the keys represent the station names, and the values represent an array corresponding to the demand at each of the 50 simulations. To calculate the minimum number of bikes necessary to meet the demand fully at every station, I took the max of each of these lists to represent the max demand over 50 simulations at each station. The resulting dictionary is outlined below:

'South Waterfront Walkway - Sinatra Dr 1 St': 183,
'Grove St PATH': 186,
'Hoboken Terminal - Hudson St Hudson Pl': 138,
'Hoboken Terminal - River St Hudson Pl': 133,
'Newport Pkwy': 113,
'City Hall - Washington St 1 St': 121,
'Newport PATH': 107,
'12 St Sinatra Dr N': 105,
'Hoboken Ave at Monmouth St': 98,

'Marin Light Rail': 98,
'Hamilton Park': 98,
'14 St Ferry - 14 St Shipyard Ln': 94,
'Liberty Light Rail': 96,
'Columbus Dr at Exchange Pl': 83,
'Harborside': 80,
'11 St Washington St': 72,
'Washington St': 81,
'Sip Ave': 74,
'Hudson St 4 St': 80,
'8 St Washington St': 76,
'Madison St 1 St': 72,
'City Hall': 65,
'Warren St': 70,
'Newark Ave': 69,
'Columbus Park - Clinton St 9 St': 63,
'Grand St 14 St': 61,
'Church Sq Park - 5 St Park Ave': 62,
'Columbus Drive': 59,
'Van Vorst Park': 56,
'Clinton St Newark St': 63,
'Grand St': 56,
'Paulus Hook': 53,
'Manila 1st': 56,
'9 St HBLR - Jackson St 8 St': 52,
'Bloomfield St 15 St': 53,
'4 St Grand St': 57,
'7 St Monroe St': 50,
'JC Medical Center': 53,
'Clinton St 7 St': 47,
'Willow Ave 12 St': 53,
'Morris Canal': 47,
'McGinley Square': 48,
'Brunswick 6th': 52,
'Jersey 3rd': 44,
'Brunswick St': 51,
'Baldwin at Montgomery': 46,
'Adams St 2 St': 54,
'Southwest Park - Jackson St Observer Hwy': 47,
'Marshall St 2 St': 44,
'Journal Square': 42,
'Madison St 10 St': 41,
'6 St Grand St': 37,
'Dixon Mills': 40,
'Lafayette Park': 37,
'Riverview Park': 36,

'Stevens - River Ter 6 St': 37,
'Mama Johnson Field - 4 St Jackson St': 35,
'Pershing Field': 41,
'Hilltop': 37,
'Jersey 6th St': 38,
'Essex Light Rail': 35,
'Monmouth and 6th': 37,
'Oakland Ave': 37,
'Adams St 11 St': 43,
'Bergen Ave': 35,
'Fairmount Ave': 31,
'Montgomery St': 30,
'Christ Hospital': 29,
'Astor Place': 25,
'Heights Elevator': 28,
'Lincoln Park': 29,
'Leonard Gordon Park': 28,
'Communipaw Berry Lane': 26,
'5 Corners Library': 20,
'Glenwood Ave': 20,
'Union St': 18,
'Dey St': 18,
'Jackson Square': 13,
'Bergen Ave Stegman St': 8,
'Grant Ave MLK Dr': 6,
'JCBS Depot': 1