C950: Task 2

A. Develop a hash table, without using any additional libraries or classes, that has an insertion function that takes the package ID as input and inserts each of the following data components into the hash table:
- delivery address
- delivery deadline
- delivery city
- delivery zip code
- package weight
- delivery status (i.e., at the hub, en route, or delivered), including the delivery time

The Hash Table has an insert function, it stores all the given components into a tuple. The package ID is the key to this bucket.

```python
def insert (self,key):
    key = int(key)
```

```python
bd = self.hashPackageData[bucketID]
bucketPackage = (bd.address, bd.deadline, bd.city, bd.zipCode, bd.weight, bd.status)
```

```python
self.hashMap[bucketID] = Bucket(key, bucketPackage)
```

B. Develop a look-up function that takes the package ID as input and returns *each* of the following corresponding data components:
- delivery address
- delivery deadline
- delivery city
- delivery zip code
- package weight
- delivery status (i.e., at the hub, en route, or delivered), including the delivery time

The find() function uses the package ID as the key to retrieve all of the contents of that package which were stored into a bucket with a key that is equal to the package ID located in the Hash Table at an index that is key-1 (found using hash() function).

```python
def find(self, key):
    key = int(key)
```

```
bucketID = self.hash(key)
bucket = self.hashMap[bucketID]

return str(bucket)
```

C. Write an original program that will deliver *all* packages and meet all requirements using the attached supporting documents "Salt Lake City Downtown Map," "WGUPS Distance Table," and "WGUPS Package File."
   1. Create an identifying comment within the first line of a file named "main.py" that includes your student ID.

```
main.py M ×
main.py > ...
1    ### Blake Bulls StudentID: 011249334
```

2. Include comments in your code to explain both the process and the flow of the program.

Extensive comments are provided.

D. Provide an intuitive interface for the user to view the delivery status (including the delivery time) of any package at any time and the total mileage traveled by all trucks. (The delivery status should report the package as at the hub, en route, or delivered. Delivery status must include the time.)

Interface requests for the time from the user. And then asks what the user wants to do. If the user chooses Look up a Package, the interface will request a package ID. If the user chooses View All Packages, the interface will print all packages and then the time, total miles, and the verification messages that packages met all specifications.

```
Welcome to the WGUPS Delivery Interface

What time is it? __:__ AM/PM
```

```
1. Look up a Package
2. View All Packages

What would you like to do? Type 1 or 2
```

```
What would you like to do? Type 1 or 2
1

Checking the status of a package.....
What is the packageID that you would like to check?
```

```
Time: 04:00 PM
Total Miles Driven: 108.40
Packages 13, 14, 15, 16, 19, 20 are all grouped together
Packages 3, 18, 36, 38 are all on truck 2
Packages 6, 25, 28, 32 have left on time
Wrong address for package 9 has been corrected
```

1. Provide screenshots to show the status of *all* packages loaded onto *each* truck at a time between 8:35 a.m. and 9:25 a.m.

```
Welcome to the WGUPS Delivery Interface

What time is it? __:__ AM/PM
9:10 am

1. Look up a Package
2. View All Packages

What would you like to do? Type 1 or 2
2
Truck 1:
truckId: 0, Departure Time: 08:00 AM, Miles Driven: 21.00
PackageID: 15, Address: 4580 S 2300 E, Deadline: 09:00 AM, Status: delivered 08:11 AM

PackageID: 16, Address: 4580 S 2300 E, Deadline: 10:30 AM, Status: delivered 08:11 AM

PackageID: 34, Address: 4580 S 2300 E, Deadline: 10:30 AM, Status: delivered 08:11 AM

PackageID: 14, Address: 4300 S 1300 E, Deadline: 10:30 AM, Status: delivered 08:18 AM

PackageID: 29, Address: 1330 2100 S, Deadline: 10:30 AM, Status: delivered 08:29 AM

PackageID: 37, Address: 410 S State St, Deadline: 10:30 AM, Status: delivered 08:43 AM

PackageID: 30, Address: 300 State St, Deadline: 10:30 AM, Status: delivered 08:46 AM

PackageID: 13, Address: 2010 W 500 S, Deadline: 10:30 AM, Status: delivered 09:00 AM

PackageID: 39, Address: 2010 W 500 S, Deadline: 04:00 PM, Status: delivered 09:00 AM

PackageID: 31, Address: 3365 S 900 W, Deadline: 10:30 AM, Status: en route 09:10 AM

PackageID: 40, Address: 380 W 2880 S, Deadline: 10:30 AM, Status: en route 09:10 AM

PackageID: 40, Address: 380 W 2880 S, Deadline: 10:30 AM, Status: en route 09:10 AM

PackageID: 1, Address: 195 W Oakland Ave, Deadline: 10:30 AM, Status: en route 09:10 AM

PackageID: 19, Address: 177 W Price Ave, Deadline: 04:00 PM, Status: en route 09:10 AM

PackageID: 20, Address: 3595 Main St, Deadline: 10:30 AM, Status: en route 09:10 AM

PackageID: 21, Address: 3595 Main St, Deadline: 04:00 PM, Status: en route 09:10 AM

Truck 2:
truckId: 1, Departure Time: 09:05 AM, Miles Driven: 1.50
PackageID: 25, Address: 5383 South 900 East #104, Deadline: 10:30 AM, Status: en route 09:10 AM

PackageID: 26, Address: 5383 South 900 East #104, Deadline: 04:00 PM, Status: en route 09:10 AM

PackageID: 18, Address: 1488 4800 S, Deadline: 04:00 PM, Status: en route 09:10 AM

PackageID: 36, Address: 2300 Parkway Blvd, Deadline: 04:00 PM, Status: en route 09:10 AM

PackageID: 6, Address: 3060 Lester St, Deadline: 10:30 AM, Status: en route 09:10 AM

PackageID: 32, Address: 3365 S 900 W, Deadline: 04:00 PM, Status: en route 09:10 AM

PackageID: 28, Address: 2835 Main St, Deadline: 04:00 PM, Status: en route 09:10 AM

PackageID: 3, Address: 233 Canyon Rd, Deadline: 04:00 PM, Status: en route 09:10 AM

PackageID: 38, Address: 410 S State St, Deadline: 04:00 PM, Status: en route 09:10 AM
```

All Packages on Each Truck

Time: 9:10 AM

Total Miles Driven = 22.50 mi

```
Truck 3:
truckId: 2, Departure Time: 10:20 AM, Miles Driven: 0.00
PackageID: 22, Address: 6351 South 900 East, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 24, Address: 5025 State St, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 11, Address: 2600 Taylorsville Blvd, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 23, Address: 5100 South 2700 West, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 12, Address: 3575 W Valley Central Station bus Loop, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 7, Address: 1330 2100 S, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 10, Address: 600 E 900 South, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 5, Address: 410 S State St, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 9, Address: 300 State St, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 8, Address: 300 State St, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 27, Address: 1060 Dalton Ave S, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 35, Address: 1060 Dalton Ave S, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 17, Address: 3148 S 1100 W, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 4, Address: 380 W 2880 S, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 2, Address: 2530 S 500 E, Deadline: 04:00 PM, Status: at the hub 09:10 AM

PackageID: 33, Address: 2530 S 500 E, Deadline: 04:00 PM, Status: at the hub 09:10 AM
```

```
Time: 09:10 AM
Total Miles Driven: 22.50
Packages 13, 14, 15, 16, 19, 20 are all grouped together
Packages 3, 18, 36, 38 are all on truck 2
Packages 6, 25, 28, 32 have left on time
WARNING: Wrong address for package 9 has not updated
```

2. Provide screenshots to show the status of *all* packages loaded onto *each* truck at a time between 9:35 a.m. and 10:25 a.m.

```
Welcome to the WGUPS Delivery Interface

What time is it? __:__ AM/PM
10:23 am

1. Look up a Package
2. View All Packages

What would you like to do? Type 1 or 2
2
Truck 1:
truckId: 0, Departure Time: 08:00 AM, Miles Driven: 31.20
PackageID: 15, Address: 4580 S 2300 E, Deadline: 09:00 AM, Status: delivered 08:11 AM

PackageID: 16, Address: 4580 S 2300 E, Deadline: 10:30 AM, Status: delivered 08:11 AM

PackageID: 34, Address: 4580 S 2300 E, Deadline: 10:30 AM, Status: delivered 08:11 AM

PackageID: 14, Address: 4300 S 1300 E, Deadline: 10:30 AM, Status: delivered 08:18 AM

PackageID: 29, Address: 1330 2100 S, Deadline: 10:30 AM, Status: delivered 08:29 AM

PackageID: 37, Address: 410 S State St, Deadline: 10:30 AM, Status: delivered 08:43 AM

PackageID: 30, Address: 300 State St, Deadline: 10:30 AM, Status: delivered 08:46 AM

PackageID: 13, Address: 2010 W 500 S, Deadline: 10:30 AM, Status: delivered 09:00 AM

PackageID: 39, Address: 2010 W 500 S, Deadline: 04:00 PM, Status: delivered 09:00 AM

PackageID: 31, Address: 3365 S 900 W, Deadline: 10:30 AM, Status: delivered 09:20 AM

PackageID: 40, Address: 380 W 2880 S, Deadline: 10:30 AM, Status: delivered 09:25 AM

PackageID: 1, Address: 195 W Oakland Ave, Deadline: 10:30 AM, Status: delivered 09:29
PackageID: 1, Address: 195 W Oakland Ave, Deadline: 10:30 AM, Status: delivered 09:29 AM

PackageID: 19, Address: 177 W Price Ave, Deadline: 04:00 PM, Status: delivered 09:35 AM

PackageID: 20, Address: 3595 Main St, Deadline: 10:30 AM, Status: delivered 09:37 AM

PackageID: 21, Address: 3595 Main St, Deadline: 04:00 PM, Status: delivered 09:37 AM

Truck 2:
truckId: 1, Departure Time: 09:05 AM, Miles Driven: 23.40
PackageID: 25, Address: 5383 South 900 East #104, Deadline: 10:30 AM, Status: delivered 09:13 AM

PackageID: 26, Address: 5383 South 900 East #104, Deadline: 04:00 PM, Status: delivered 09:13 AM

PackageID: 18, Address: 1488 4800 S, Deadline: 04:00 PM, Status: delivered 09:34 AM

PackageID: 36, Address: 2300 Parkway Blvd, Deadline: 04:00 PM, Status: delivered 09:47 AM

PackageID: 6, Address: 3060 Lester St, Deadline: 10:30 AM, Status: delivered 09:53 AM

PackageID: 32, Address: 3365 S 900 W, Deadline: 04:00 PM, Status: delivered 09:58 AM

PackageID: 28, Address: 2835 Main St, Deadline: 04:00 PM, Status: delivered 10:07 AM

PackageID: 3, Address: 233 Canyon Rd, Deadline: 04:00 PM, Status: en route 10:23 AM

PackageID: 38, Address: 410 S State St, Deadline: 04:00 PM, Status: en route 10:23 AM
```

All Packages on Each Truck

Time: 10:23 AM

Total Miles Driven = 55.50 mi

```
Truck 3:
truckId: 2, Departure Time: 10:20 AM, Miles Driven: 0.90
PackageID: 22, Address: 6351 South 900 East, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 24, Address: 5025 State St, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 11, Address: 2600 Taylorsville Blvd, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 23, Address: 5100 South 2700 West, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 12, Address: 3575 W Valley Central Station bus Loop, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 7, Address: 1330 2100 S, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 10, Address: 600 E 900 South, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 9, Address: 410 S State St, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 5, Address: 410 S State St, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 8, Address: 300 State St, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 27, Address: 1060 Dalton Ave S, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 35, Address: 1060 Dalton Ave S, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 17, Address: 3148 S 1100 W, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 4, Address: 380 W 2880 S, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 2, Address: 2530 S 500 E, Deadline: 04:00 PM, Status: en route 10:23 AM
PackageID: 33, Address: 2530 S 500 E, Deadline: 04:00 PM, Status: en route 10:23 AM
```

```
Time: 10:23 AM
Total Miles Driven: 55.50
Packages 13, 14, 15, 16, 19, 20 are all grouped together
Packages 3, 18, 36, 38 are all on truck 2
Packages 6, 25, 28, 32 have left on time
Wrong address for package 9 has been corrected
```
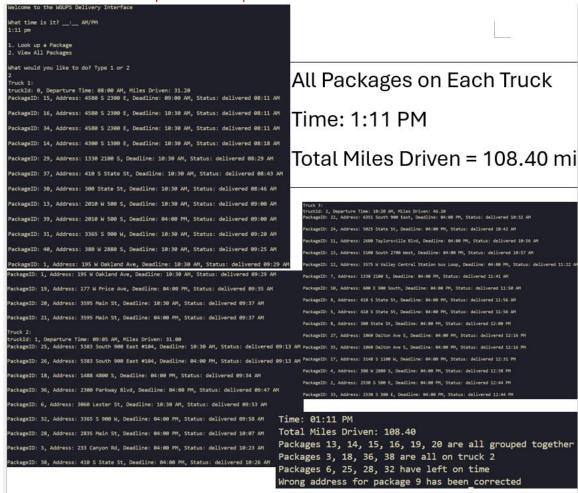
3. Provide screenshots to show the status of *all* packages loaded onto *each* truck at a time between 12:03 p.m. and 1:12 p.m.
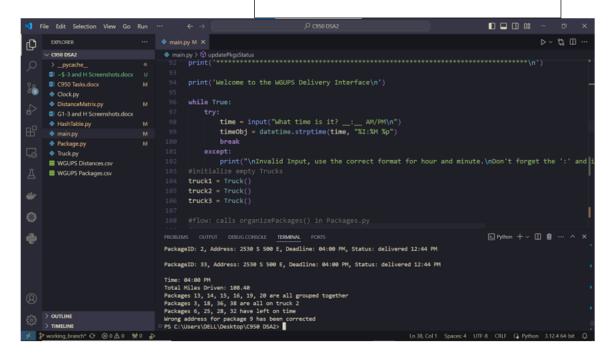
```
Welcome to the WGUPS Delivery Interface

What time is it? __:__ AM/PM
1:11 pm

1. Look up a Package
2. View All Packages

What would you like to do? Type 1 or 2
2
Truck 1:
truckId: 0, Departure Time: 08:00 AM, Miles Driven: 31.20
PackageID: 15, Address: 4580 S 2300 E, Deadline: 09:00 AM, Status: delivered 08:11 AM

PackageID: 16, Address: 4580 S 2300 E, Deadline: 10:30 AM, Status: delivered 08:11 AM

PackageID: 34, Address: 4580 S 2300 E, Deadline: 10:30 AM, Status: delivered 08:11 AM

PackageID: 14, Address: 4300 S 1300 E, Deadline: 10:30 AM, Status: delivered 08:18 AM

PackageID: 29, Address: 1330 2100 S, Deadline: 10:30 AM, Status: delivered 08:29 AM

PackageID: 37, Address: 410 S State St, Deadline: 10:30 AM, Status: delivered 08:43 AM

PackageID: 30, Address: 300 State St, Deadline: 10:30 AM, Status: delivered 08:46 AM

PackageID: 13, Address: 2010 W 500 S, Deadline: 10:30 AM, Status: delivered 09:00 AM

PackageID: 39, Address: 2010 W 500 S, Deadline: 04:00 PM, Status: delivered 09:00 AM

PackageID: 31, Address: 3365 S 900 W, Deadline: 10:30 AM, Status: delivered 09:20 AM

PackageID: 40, Address: 380 W 2880 S, Deadline: 10:30 AM, Status: delivered 09:25 AM

PackageID: 1, Address: 195 W Oakland Ave, Deadline: 10:30 AM, Status: delivered 09:29 AM
PackageID: 1, Address: 195 W Oakland Ave, Deadline: 10:30 AM, Status: delivered 09:29 AM

PackageID: 19, Address: 177 W Price Ave, Deadline: 04:00 PM, Status: delivered 09:35 AM

PackageID: 20, Address: 3595 Main St, Deadline: 10:30 AM, Status: delivered 09:37 AM

PackageID: 21, Address: 3595 Main St, Deadline: 04:00 PM, Status: delivered 09:37 AM

Truck 2:
truckId: 1, Departure Time: 09:05 AM, Miles Driven: 31.00
PackageID: 25, Address: 5383 South 900 East #104, Deadline: 10:30 AM, Status: delivered 09:13 AM

PackageID: 26, Address: 5383 South 900 East #104, Deadline: 04:00 PM, Status: delivered 09:13 AM

PackageID: 18, Address: 1488 4800 S, Deadline: 04:00 PM, Status: delivered 09:34 AM

PackageID: 36, Address: 2300 Parkway Blvd, Deadline: 04:00 PM, Status: delivered 09:47 AM

PackageID: 6, Address: 3060 Lester St, Deadline: 10:30 AM, Status: delivered 09:53 AM

PackageID: 32, Address: 3365 S 900 W, Deadline: 04:00 PM, Status: delivered 09:58 AM

PackageID: 28, Address: 2835 Main St, Deadline: 04:00 PM, Status: delivered 10:07 AM

PackageID: 3, Address: 233 Canyon Rd, Deadline: 04:00 PM, Status: delivered 10:23 AM

PackageID: 38, Address: 410 S State St, Deadline: 04:00 PM, Status: delivered 10:26 AM
```

All Packages on Each Truck

Time: 1:11 PM

Total Miles Driven = 108.40 mi

```
Truck 3:
truckId: 2, Departure Time: 10:20 AM, Miles Driven: 46.20
PackageID: 22, Address: 6351 South 900 East, Deadline: 04:00 PM, Status: delivered 10:32 AM

PackageID: 24, Address: 5025 State St, Deadline: 04:00 PM, Status: delivered 10:42 AM

PackageID: 11, Address: 2600 Taylorsville Blvd, Deadline: 04:00 PM, Status: delivered 10:56 AM

PackageID: 23, Address: 5100 South 2700 West, Deadline: 04:00 PM, Status: delivered 10:57 AM

PackageID: 12, Address: 3575 W Valley Central Station bus loop, Deadline: 04:00 PM, Status: delivered 11:22 AM

PackageID: 7, Address: 1330 2100 S, Deadline: 04:00 PM, Status: delivered 11:41 AM

PackageID: 10, Address: 600 E 900 South, Deadline: 04:00 PM, Status: delivered 11:50 AM

PackageID: 9, Address: 410 S State St, Deadline: 04:00 PM, Status: delivered 11:56 AM

PackageID: 5, Address: 410 S State St, Deadline: 04:00 PM, Status: delivered 11:56 AM

PackageID: 8, Address: 300 State St, Deadline: 04:00 PM, Status: delivered 12:00 PM

PackageID: 27, Address: 1060 Dalton Ave S, Deadline: 04:00 PM, Status: delivered 12:16 PM

PackageID: 35, Address: 1060 Dalton Ave S, Deadline: 04:00 PM, Status: delivered 12:16 PM

PackageID: 17, Address: 3148 S 1100 W, Deadline: 04:00 PM, Status: delivered 12:31 PM

PackageID: 4, Address: 380 W 2880 S, Deadline: 04:00 PM, Status: delivered 12:38 PM

PackageID: 2, Address: 2530 S 500 E, Deadline: 04:00 PM, Status: delivered 12:44 PM

PackageID: 33, Address: 2530 S 500 E, Deadline: 04:00 PM, Status: delivered 12:44 PM
```

```
Time: 01:11 PM
Total Miles Driven: 108.40
Packages 13, 14, 15, 16, 19, 20 are all grouped together
Packages 3, 18, 36, 38 are all on truck 2
Packages 6, 25, 28, 32 have left on time
Wrong address for package 9 has been corrected
```

E. Provide screenshots showing successful completion of the code that includes the total mileage traveled by *all* trucks.

Code Execution

Time: 4:00pm aka EOD

Total Miles Driven = 108.40 mi

F. Justify the package delivery algorithm used in the solution as written in the original program by doing the following:
    1. Describe **two or more** strengths of the algorithm used in the solution.

Strengths of bestTour algorithm: It adapts its result depending on the deadline of the packages. It provides optimization of the entire tour used by the truck to deliver its packages by continuing its iterations as long as an improved tour is discovered.

    2. Verify that the algorithm used in the solution meets *all* requirements in the scenario.

The algorithm meets all required specifications.

```
Time: 01:11 PM
Total Miles Driven: 108.40
Packages 13, 14, 15, 16, 19, 20 are all grouped together
Packages 3, 18, 36, 38 are all on truck 2
Packages 6, 25, 28, 32 have left on time
Wrong address for package 9 has been corrected
```

Dijkstra's algorithm or a genetic algorithm could have been used to meet the scenario's requirements

Dijkstra's algorithm is used for finding the shortest path in weighted directed or undirected graph. It will provide the exact shortest path. Although both are deterministic, meaning they will continue searching as long as they find an improvement, two-opt differs in that it is a heuristic algorithm. Meaning, two-opt will find approximate solutions that aren't guaranteed to be as precise as Dijkstra's algorithm (Navone, 2020).

A genetic algorithm has a population of potential solutions that incorporate operators to "evolve" the population with an element of randomness over generations. These generations can be evaluated based on the quality of the solution provided. This is very different from two-opt, which simply checks the distance of two edges and keeps the shortest one. Genetic algorithms can also have lots of variety in their solutions, whereas two-opt iteratively makes small local changes that lack variety (MathWorks, 2019).

One aspect that I would do differently is the distance matrix design. As it is, it seems awkward in the way it chains together multiple functions. Perhaps a dictionary of addresses as keys and tuples of neighboring addresses and their distances would have been a more concise and less space consuming option.

A binary search tree or a trie are 2 possible data structures that could be used.

A binary search tree guarantees that all operations will work in O(log n), whereas with hashing, some operations can be O(n^2). Binary search trees require less memory and computing (Advantages of BST over Hash Table, 2015).

A trie, like a hash table, prioritizes quick retrieval of data. This seems to be a likely choice for this project due to the frequency of looking up different packages for their status. Searching for the existence of a particular string like " wrong address" or "truck 2" would have a much faster time complexity than in the current hash table implementation (Hash Table vs Trie, 2022).

2-opt algorithm to solve the Travelling Salesman Problem in Python. (n.d.).

Stack Overflow. https://stackoverflow.com/questions/53275314/2-opt-algorithm-to-solve-the-travelling-salesman-problem-in-python

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Create an incremental ID in a Python class with subclasses each maintaining their own ID series. (n.d.). Stack Overflow. Retrieved July 22, 2024, from

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　　　　https://www.geeksforgeeks.org/hash-table-vs-trie/

MathWorks. (2019). *What Is the Genetic Algorithm?* Mathworks.com.

　　　　https://www.mathworks.com/help/gads/what-is-the-genetic-
　　　　algorithm.html

Navone, E. C. (2020, September 28). *Dijkstra's Shortest Path Algorithm - A
Detailed and Visual Introduction*. FreeCodeCamp.org.

　　　　https://www.freecodecamp.org/news/dijkstras-shortest-path-
　　　　algorithm-visual-introduction/

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Represent GRAPHS*. YouTube.

　　　　https://www.youtube.com/watch?v=HDUzBEG1GlA&t=486s

PageKey. (2017, November 26). *Hash Tables in Python*. YouTube.

　　　　https://www.youtube.com/watch?v=zHi5v78W1f0&t=628s

J. Demonstrate professional communication in the content and presentation of your
    submission.

Extensive communication is used.