Project: A comprehensive COVID-19 plan

A small town is using part of its funding to organize a comprehensive plan for tackling any COVID-19 outbreak. Their plan includes three steps:

1. Establishing testing centers to satisfy all the residents testing demand.
2. Providing first testing materials to all the testing centers from their trusted supplier companies.
3. Routing to each of the testing center at the end of the day to pick up the tests and bring them to a lab.

Each of the next three subsections describes what the goal of the town is for the three steps. **Work in groups of 2-4 analysts to help the town implement this ambitious plan.**

Step 1: Opening testing centers

In class, we discussed about the **facility location problem** and provided one of its formulations. As established in the Introduction, our town is deciding where to open up their new testing centers. Specifically, they need to pick 4 locations from a set of 10 potential sites. Their goal is to satisfy all 30 of the town's neighborhoods. Each neighborhood has different populations living there. The x and y coordinates of the 30 neighborhoods and their populations are presented in Table 1.

On the other hand, the 10 potential sites for the testing centers (out of which the town will pick 4) are presented in Table 2.

For simplicity, you may assume that the cost of going to a testing center i from a neighborhood j is equal to the Euclidean distance between the two. As a reminder, the Euclidean distance between testing center i with coordinates (x_i, y_i) and neighborhood j with coordinates (x_j, y_j) is:

$$c_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}. \tag{1}$$

Finally, you may assume that each testing center can satisfy at most 25000 residents. That is, at most 25000 people can be assigned to visit a specific testing center. Of course, this can only happen if you decide to open that testing center.

(a) Formulate the problem mathematically. Be careful to define your data, variables, constraints, and objective function, as shown in class.

(b) Use Python or another tool to model and solve the problem (by calling a solver).

Step 2: Providing the testing material

The town has formed an agreement with 6 suppliers of testing materials and other medical equipment. That said, the town wants the providers to send the materials to the individual testing centers themselves. To do so, the town will formulate and solve a **transportation problem**, as discussed in class. The 6 suppliers can send materials to the testing centers with *per unit costs* as in Table 3. Note here that you are only opening 4 of the sites: hence, use your solution from Step 1 to establish which testing centers the suppliers need to reach.

(c) Formulate the problem mathematically. Be careful to define your data, variables, constraints, and objective function, as shown in class.

(d) Use Python or another tool to model and solve the problem (by calling a solver).

Table 1: The x and y coordinates of the 30 neighborhoods of the town, along with their populations.

Neighborhood	x	y	Population
1	94	84	2500
2	15	19	2000
3	95	88	3000
4	3	72	1000
5	33	12	2500
6	37	73	2500
7	60	91	4000
8	67	60	2000
9	49	67	1000
10	87	65	500
11	82	2	2500
12	70	82	2000
13	16	59	3000
14	47	55	5000
15	42	88	2500
16	46	99	2000
17	40	82	1500
18	77	60	1000
19	75	76	1000
20	89	87	2000
21	29	73	3000
22	4	48	1500
23	90	10	2500
24	68	46	3500
25	48	76	3000
26	28	79	2500
27	2	20	2000
28	1	99	1500
29	32	31	1500
30	66	100	3000

Table 2: The x and y coordinates of the 10 sites identified. The town will have to pick 4 of them to open and use as testing centers.

Neighborhood	x	y
1	24	22
2	52	72
3	60	56
4	96	98
5	55	87
6	90	31
7	61	97
8	46	54
9	53	90
10	52	18

Table 3: The costs for each of the 6 suppliers to each of the 10 possible sites. Remember that you are only opening 4 of these sites!

		Suppliers					
		1	2	3	4	5	6
Sites	1	3	3	3	6	4	4
	2	1	2	6	3	2	6
	3	4	3	5	4	2	6
	4	3	2	5	2	2	2
	5	4	2	3	6	2	6
	6	5	2	4	3	4	6
	7	4	3	3	5	4	3
	8	2	3	6	6	3	6
	9	1	3	3	6	3	6
	10	3	3	2	4	4	5

Step 3: Picking up all tests

At the end of the day, the town will pick up all tests performed during the day and return them to a laboratory for processing. The laboratory is located in the center of the town, that is at coordinates $x = 50, y = 50$. The laboratory owns one truck that will travel to each testing center (exactly once), pick up all the tests, and return them for processing to the laboratory. This is the definition of a **traveling salesperson problem**, as we saw it in class!

Once again, you may assume that the distances between any two locations (the laboratory and testing centers, or from testing center to testing center) is the Euclidean distance (see (1)). As a reminder, you only need to visit the four testing centers that you decided to open in the first step of this project!

(e) Formulate the problem mathematically. Be careful to define your data, variables, constraints, and objective function, as shown in class.

(f) Use Python or another tool to model and solve the problem (by calling a solver).

Deliverables: Your final report is due on **May 11th, 2022 at 11:59pm in Compass2g**. The report should be brief and organized in a professional manner. In addition to the answers to each question, at the beginning of the report, you are asked to include an executive summary (max 1 page) that describes:

1. The key points about the problem.
2. The methods used (linear or integer programming) and your coding language.
3. A summary of your findings.

All pages must be numbered. All data and code printouts should be clearly labeled and organized in a logical manner, and tables or figures should have detailed informative captions. It is important that your codes are well documented. Your grade is dependent on the graders' ability to understand what you have done in your codes, so adding 'comments' in your codes is valuable. Examples of Jupyter Notebooks and Python are provided in Prof. Kontou's binder `https://mybinder.org/v2/gh/ekontou/CEE201/master`. An **example of a facility location problem and solution** is provided under the "Spring2020-ProjectSolution" folder for your reference.

Good luck!