

- c) Heuristic model
- d) Stochastic model
- e) (5p - Bonus) What is the difference between model created in **Q1.1** and **Q1.2**. Explain by using a few sentences.

Q2 (60 pts)- Application Part

Implementation of a mathematical model

YTU Manufacturing Company produces book and sends these products different areas. It has four different warehouses, which are called TonoZ, White Kiosk, Quarterage, and Middle Yard. Each Warehouse has capacity and these capacities are 3000, 5000, 10000, and 7000 books, respectively. The company sends its product from these warehouses either to distribution centres or to stores. This means that, in this transportation system, direct shipment from warehouses to stores is allowed. The number of distribution centres to which the books are sent is three and their names are Atlas, Nebulae and Azure respectively. The last chain in the supply chain, on the other hand, is the stores. Here, there are five different stores which are located on the different sides of the city. Each store has a book demand. The required information about the stores is given in Table 4.

Table 4: The Stores and Their Capacities

Store Name	Demand
Venus	5500
Minerva	4750
Neptunus	6550
Mars	4000
Ceres	4200

The company wants to send the books directly from its own warehouse or through distribution centres. While meeting the demands, the aim is to ensure that this distribution is made with minimum cost. However, shipping costs are defined according to the identity of the Engineer who made the calculation. For this reason, the Engineer should calculate the relevant cost values before shipping. For this, cost values should be generated by entering the information of the Engineer in the field whose code is displayed on the screen and indicated in yellow in the code given on the Jupyter Notebook page Figure 1. Note that, the information of the Engineer includes the student ID of the student who will do the assignment. If there are characters in your Student ID such as C21506050, you must remove the letters and use only numbers as 21506050. As a result of the random number generation process, the Engineer will be able to obtain cost values according to her/his own number. The resulting output should be in the following format given in Figure 2. However, we would like to remind you again that since the numbers are generated randomly, the values in the table will be different and the results obtained will also be different. Moreover, **the following values given in Figure 2 is not used in your assignment calculation.**

```

1 import pandas as pd
2 import numpy as np
3 import math
4 # the seed number should be your student ID.
5 # If it has letter, please ignore it and use only numbers in the ID
6 np.random.seed(21506050)
7
8 # Shipment cost from factory to distribution center
9 RandomFtoD1 = np.round(np.random.uniform(low = 1, high = 10, size = 12),0).astype(int)
10 RandomFtoD2 = np.reshape(RandomFtoD1, (4,3))
11 CostFtoD = pd.DataFrame(RandomFtoD2, columns=['Atlas', 'Nebule', 'Azure'],
12 index=["Tonoz", "White Kiosk", "Quarterage", "Middle Yard"])
13 #CostFtoD # gives the shipment cost from factory to distribution center
14
15 # Shipment cost from distribution center to store
16 RandomDtoS1 = np.round(np.random.uniform(low = 1, high = 10, size = 15),0).astype(int)
17 RandomDtoS2 = np.reshape(RandomDtoS1, (3,5))
18 CostDtoS = pd.DataFrame(RandomDtoS2, columns=["Venus", "Minerva", "Neptunus", "Mars", "Ceres"],
19 index=['Atlas', 'Nebule', 'Azure'])
20 #CostDtoS # gives the shipment cost from distribution center to store
21
22 # Shipment cost from factory to store
23 RandomFtoS1 = np.round(np.random.uniform(low = 1, high = 10, size = 20),0).astype(int)
24 RandomFtoS2 = np.reshape(RandomFtoS1, (4,5))
25 CostFtoS = pd.DataFrame(RandomFtoS2, columns=["Venus", "Minerva", "Neptunus", "Mars", "Ceres"],
26 index=["Tonoz", "White Kiosk", "Quarterage", "Middle Yard"])
27 #CostFtoS # gives the shipment cost from distribution center to store
28
29 # Your Required Information About Shipment Cost
30 print("The shipment cost from factory to distribution center")
31 print(CostFtoD)
32 print("\n The shipment cost from distribution center to store")
33 print(CostDtoS)
34 print("\n The shipment cost from distribution center to store")
35 print(CostFtoS)

```

Figure 1: Shipment Cost Calculation Process

```

The shipment cost from factory to distribution center
      Atlas  Nebule  Azure
Tonoz      10      4      9
White Kiosk 10      2      7
Quarterage   7      8      1
Middle Yard   9      8      6

The shipment cost from distribution center to store
      Venus  Minerva  Neptunus  Mars  Ceres
Atlas      5      7      10      3      1
Nebule      7      5      4      5      10
Azure       3      8      1      9      8

The shipment cost from factory to store
      Venus  Minerva  Neptunus  Mars  Ceres
Tonoz      8      9      9      7      10
White Kiosk 9      7      4      1      4
Quarterage 10      5      3      9      2
Middle Yard 2      7      8      5      6

```

Figure 2: Example of the Shipment Cost

To obtain shipment schedule,

- Construct the mathematical model,
- Create your own shipment cost values by using Python code given in jupyter notebook,
- Code your mathematical model with parameters,
- Solve the model (The model will be coded by using python programming language and then the model will be solved via open solver CBC).

Then, create your technical report to present management unit.

Code your mathematical model by using python programming language with Jupyter interface (30p).

- a) (10p) What is your mathematical model?
- b) (3p) What is value of the objective function?
- c) (3p) What is the value of decision variables? According to this values, evaluate the supply chain and flow in this supply chain?
- d) (3p) If we change the capacity of warehouse **Quarterage** from 10000 to 7500, and the demand of Ceres from 4200 to 1700, how do the objective value and the values of the decision variables change?
- e) (4p) If we change the shipment cost from warehouse **Tono**z to distribution center **Atlas** as 10 and **Azure** to **Minerva** as 5, how the objective function is affected. Give new objective value and number of shipments, and then explain your answer with few sentences.
- f) (7p) If we change the capacity of the warehouse **Middle Yard** from 7000 to 5000, what should we expect? Can we obtain optimal solution? Please explain your conclusion clearly. If it is necessary make some arrangement and give the results with explanations.

Report Format and Submission

1) Report File:

- a) The answers of the questions should be written into shared technical report file and used instructions to write this report.
- b) Your answers and explanations should be written clearly. After the completion of the report preparation, the report should be submitted as PDF file. The file name should be "**StudentID**", for example, "13061004.pdf".

2) Code File:

- a) The code should be written in the Jupyter and this file should be submitted

b) The code file name must be **StudentID**, i.e., For Jupyter file "13061004.ipynb".

Two file must be prepared and submitted separately.

Different file name can cause some loss of points.

The submission link will be announced as soon as possible.