Make sure to follow the submission and grading instructions listed with the homework.

1. True/False: For each of the transportation problem, state whether it is true or false.
   a. Transportation problems can only be feasible if the supply is at most equal to the demand.
   b. Network is a graphical representation of the transportation problem using the nodes and arcs.
   c. Dummy origin is added when the supply is more than the demand.
   d. Transportation problems can only have minimization as objective.

2. Valence Pharmaceuticals has three manufacturing facilities in the US where they produce an anti-cancer drug. The drug is shipped from the plants to four distribution centers. Plants 1, 2, and 3 produce 12, 17, and 11 shipments per month, respectively. The distribution centers, A, B, C, and D, each needs to receive 10 shipments per month. The distance (in miles) from each plant to each distribution center is shown in the following table

	Distribution Center			
Plant	A	B	C	D
1	800	1300	400	700
2	1100	1400	600	1000
3	600	1200	800	900

   The freight cost for each shipment is $1.00 per mile.
   (a) Draw a network diagram representing the problem.
   (b) Formulate a linear optimization model that can be used to determine the shipping plan that will minimize total distribution costs. Make sure to follow the mathematical formulation steps clearly (Remember that to formulate a model means to write it out mathematically. Do not set up your model in Excel.)
   (c) Is the capacity of the plants equal to the demand at the distribution centers?

3. Michael would like to drink 3 pints of home-brewed craft beer today and an additional 4 pints tomorrow. There are two neighbors on his block who brew beer. Louise is able to sell up to 5 pints of her beer. She's charging $3.00 a pint today and will charge $2.70 a pint tomorrow. Serge is able to sell up to 4 pints of his beer, at $2.90 a pint today and at $2.80 a pint tomorrow.
   Transportation models are quite flexible. The "origins" and "destinations" don't necessarily need to be physical plants or warehouses. In this problem, there is a time component that can be modeled as different destinations – consider the beer that Michael receives today as one destination and the beer he receives tomorrow as the second destination.
   (a) Draw a network diagram representing the problem.
   (b) Formulate a linear optimization model that can be used to help Michael decide how much beer to purchase from each neighbor and when. Make sure to follow the mathematical formulation steps clearly (You do not need to set your model up in Excel and you do not need to solve it.)

4. A manufacturer produces printers at plants in New Orleans, Albuquerque, and Nashville. These are sent to regional distributors in Jacksonville, Boise, and Charlotte. The shipping costs vary, and the

company would like to find the least-cost way to meet the demands at each of the distribution centers.

Jacksonville needs to receive 800 printers per month, Boise needs 600, and Charlotte needs 200. New Orleans has 750 printers available each month, Albuquerque has 550, and Nashville has 300. The shipping cost per unit from New Orleans to Jacksonville is $8, to Boise is $12, and to Charlotte is $10. Due to truck capacity limits, no more than 50 printers can be shipped between New Orleans and Charlotte each month.

The cost per unit from Albuquerque to Jacksonville is $10, and to Charlotte is $9. Printers from Albuquerque are never shipped to Boise.

The cost per unit from Nashville to Jacksonville is $11, to Boise is $8, and to Charlotte is $12.

(a) Formulate a linear optimization model to determine how many units should be shipped from each plant to each regional distribution center.

(b) Is the capacity of the plants equal to the demand at the distribution centers?

(c) Enter your model in Excel and use Solver to find the optimal distribution plan. Include your spreadsheet in your homework submission.

(d) What is the optimal distribution plan?

(e) What is the cost of the optimal distribution plan?

5. Jefferson Rubber manufactures heavy-duty truck tires. The tires are manufactured in St. Louis and Detroit and shipped to warehouses in Oakland, Miami, Minneapolis, Cleveland, and Boston. The following table shows the number of tires available at each plant, the number of tires required by each warehouse, and the shipping costs (in dollars per tire).

Warehouses

Plant	Oakland	Miami	Minneapolis	Cleveland	Boston	Tires available
St. Louis	10	29	5	9	10	9000
Detroit	1	20	7	10	4	8000
Tires required	3000	5000	4000	6000	3000	

(a) Draw a network diagram of the problem.

(b) Are supply and demand equal to each other?

(c) Formulate a linear optimization model to determine the distribution plan that will minimize cost while meeting as much demand as possible.

(d) Enter the model in Excel and solve for the optimal distribution plan. Include your spreadsheet in your homework submission.

(e) What is the optimal distribution plan?

(f) What is the cost of the optimal distribution plan?

(g) Which warehouse will have a shortage and how big will the shortage be?