MGT 2251 Management Science

Review of Exam 2

Name (Print):_____

ID #:_____

Read each question carefully before you answer. Work at a steady pace, and you should have ample time to finish. **Good Luck!!!**

My signature *certifies* that I have taken this exam in accordance with the Georgia Tech Honor Code.

Signature_____

I. Multiple-Choice Questions from Q1 to Q12 (2 points each, total 24 points)

1. A technique that allows a researcher to determine the greatest amount of material that can move through a network is called
   A) maximal-flow.
   B) maximal-spanning.
   C) shortest-route.
   D) maximal-tree.

2. Which of the following is false?
   A) Maximal-flow technique can be used to study traffic congestion problem between two points on a road network.
   B) Internet services providers (such as Comcast) typically employ minimal-spanning tree technique to provide cable/internet connections to houses.
   C) Package delivery companies (such as UPS) use shortest-route techniques to deliver packages.
   D) Water supply companies would employ the shortest-route technique to lay out the pipes connecting individual houses.

3. When formulating a transportation problem with 2 sources and 4 destinations as a linear programming problem, which of the following statements is true?
   A) There are typically 6 decision variables and 8 constraints (excluding non-negativity constraints).
   B) There are typically 6 decision variables and 4 constraints (excluding non-negativity constraints).
   C) There are typically 8 decision variables and 6 constraints (excluding non-negativity constraints).
   D) There are typically 4 decision variables and 6 constraints (excluding non-negativity constraints).

4. About an unbalanced transportation problem, which of the following is false?
   A) Supply is not equal to demand.
   B) To balance an unbalanced problem, if the demand is less than supply, a dummy destination is created.
   C) To balance an unbalanced problem, if the supply is more than demand, a dummy source is created.
   D) To balance an unbalanced problem, we assume zero unit transportation cost in each cell of dummy rows or columns.

5. Which of the following statements concerning the transshipment problem are false?
   A) The number of units shipped into a transshipment point should be equal to the number of units shipped out.
   B) There can be constraints on the number of units shipped out of an origin point.
   C) Any units shipped from one origin point must all go to the same destination point.
   D) There can be constraints on the number of units shipped into a destination point.
   E) The transshipment problem can be solved with linear programming.

6. The original or beginning node in a network is called a(n)
   A) arc.
   B) branch.
   C) source.
   D) mouth.
   E) sink.

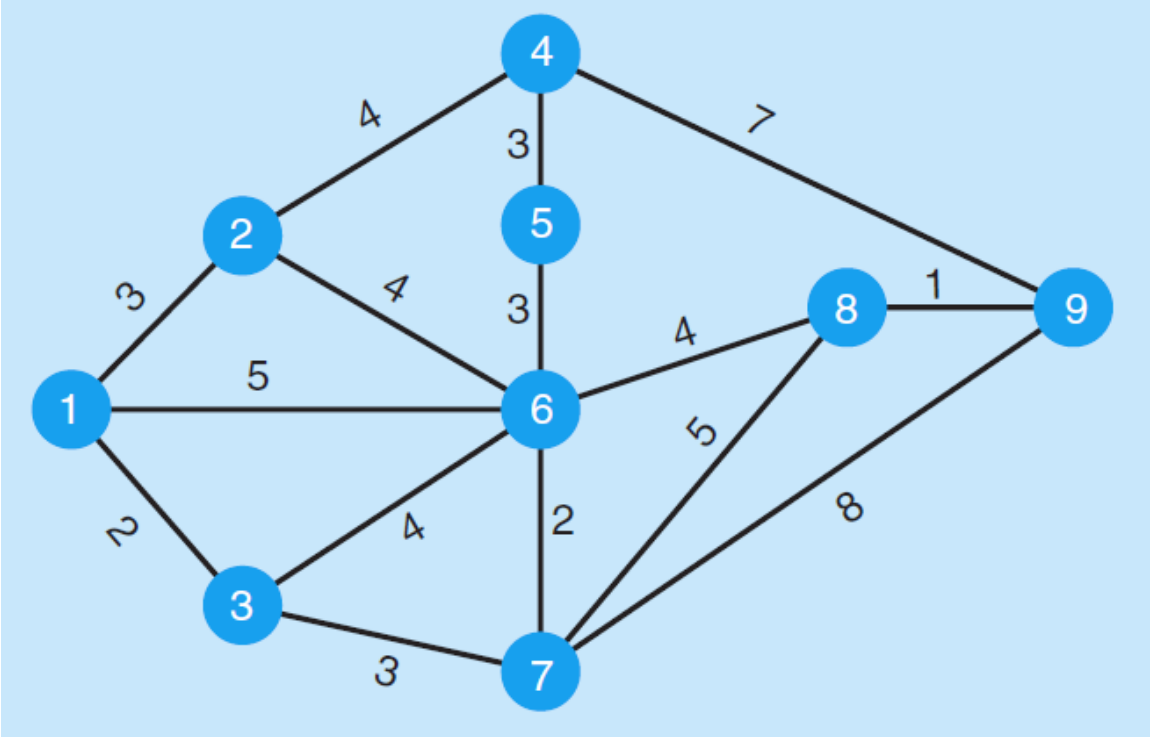
7. The first step of the minimal-spanning tree technique is to
   A) select the node with the highest distance between it and any other node.
   B) select the node that is closest to the origin.
   C) select any node.
   D) select any arc that connects two nodes.

8. In a minimal-spanning tree problem, the optimal solution has been found when
   A) all nodes have been connected and are a part of the tree.
   B) the start node and the finish node are connected by a continuous path.
   C) the flow from the start node is equal to the flow into the finish node.
   D) all arcs have been selected to be a part of the tree.

9. Transportation models can be used for which of the following decisions?
   A) production mix
   B) facility location
   C) media selection
   D) portfolio selection
   E) employee shift scheduling

10. In solving a facility location problem in which there are two possible locations being considered, the transportation algorithm may be used. In doing this,
   A) two sources would be added to the existing rows and the enlarged problem would be solved.
   B) two separate transportation problems would be solved.
   C) costs of zero would be used for each of the new facilities.
   D) the problem would be a transshipment problem.

For questions 11 to 12, use the following figure (Minimal-Spanning Tree Problem).

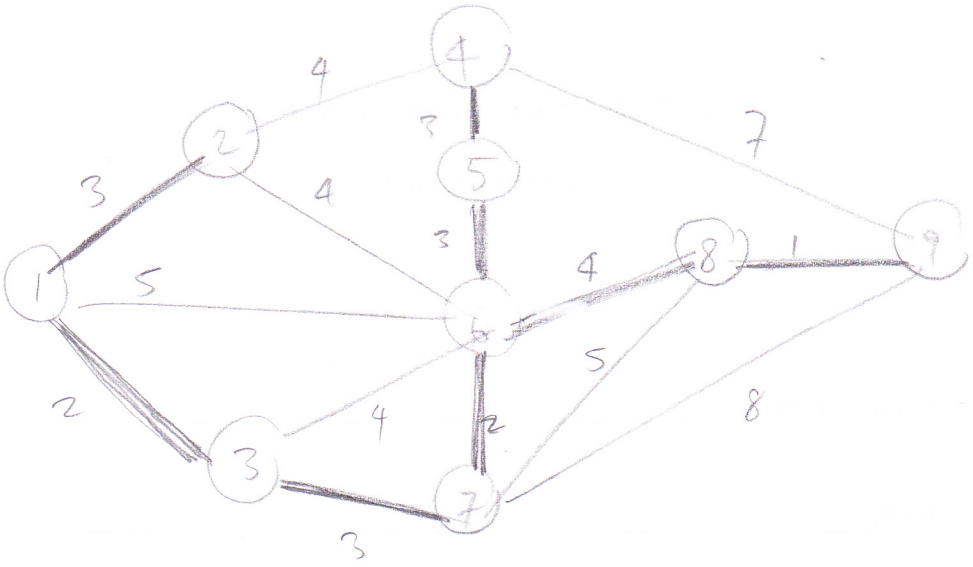


11. Given the distances between different nodes, what is the total length of pipes required to connect all the nodes? SEE HANDWRITTEN SOLUTION
    A) 18
    B) 19
    C) 21
    D) 22

12. Given the distances between different nodes, which of the following arcs is not used to connect the nodes?
    A) 3-6
    B) 1-2
    C) 6-8
    D) 1-3

Review

Q11)



1) Arbitrary: Select node 1

2) Connect 1 to 3 (nearest) (2) ✓

3) " 3 to 7 (3)

4) " 7 to 6 (2)

5) " 6 to 5 (3)

6) " 5 to 4 (3)

7) " 1 to 2 (3) ✓

8) " 6 to 8 (4) ✓

9) " 8 to 9 (1)

21

II. Problem Solving (64 Points)

1. The air traffic system passing through the United States can handle aircraft flows with capacities in hundreds of planes per hour as shown in the table below. United States is trying to find the maximum number of planes that can flow through City 5 to City 1.

	To	To	To	To	To
From	1	2	3	4	5
City 1	-	2	-	4	-
City 2	1	-	2	3	3
City 3	2	2	-	5	2
City 4	-	-	-	-	3
City 5	-	2	2	1	-

A) What type of network problem this is? (4 points)

Maximal Flow Problem

B) Draw the network presentation of the problem. (Make sure you clearly show the nodes, arcs and the values on the arcs. (6 points)

See next page

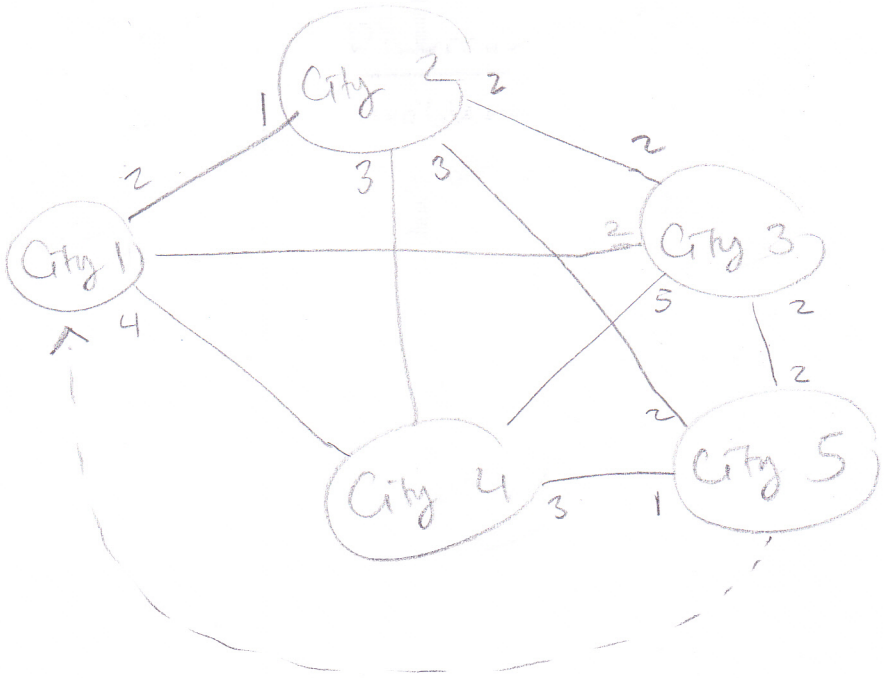
C) Formulate this problem into a linear programming model (including decision variables, objective function, and constraints). Don't forget to label the constraints (6 points)

See next page

Review Exam 2 Problem Solutions

(Q13) A) Maximal flow problem

B)



C) Decision var: X_{ij}: Flow from node i to node j

$i = 1, 2, 3, 4, 5$

$j = 1, 2, 3, 4, 5$

$\max X_{51}$

s.t. $X_{12} \le 2$, $X_{14} \le 4$ (Cap 1)

$X_{21} \le 1$, $X_{24} \le 3$, $X_{25} \le 3$, $X_{23} \le 3$ (Cap 2)

$X_{32} \le 2$, $X_{31} \le 2$, $X_{34} \le 5$, $X_{35} \le 2$ (Cap 3)

$X_{45} \le 3$ (Cap 4)

$X_{54} \le 1$, $X_{52} \le 2$, $X_{53} \le 2$ (Cap 5)

$X_{51} + X_{21} = X_{12} + X_{14}$ (In = Out 1)

$X_{12} + X_{32} + X_{52} = X_{21} + X_{23} + X_{24} + X_{25}$ (" 2)

$X_{23} + X_{53} = X_{31} + X_{32} + X_{34} + X_{35}$ (" 3)

$X_{14} + X_{24} + X_{34} + X_{54} = X_{45}$ (" 4)

$X_{25} + X_{35} + X_{45} = X_{54} + X_{52} + X_{53}$ (" 5)

$X_{ij} \ge 0$

14. The hospital administrator at St. Charles General must appoint head nurses to four newly established departments: urology, cardiology, orthopedics, and obstetrics. In anticipation of this staffing problem, she had hired four nurses: Hawkins, Condriac, Bar-dot, and Hoolihan. Believing in the quantitative analysis approach to problem solving, the administrator has interviewed each nurse, considered his or her background, personality, and talents, and developed a cost scale ranging from 0 to 100 to be used in the assignment. A 0 for Nurse Bardot being assigned to the cardiology unit implies that she would be perfectly suited to that task. A value close to 100, on the other hand, would imply that she is not at all suited to head that unit. The accompanying table gives the complete set of cost figures that the hospital administrator felt represented all possible assignments.

	DEPARTMENT			
Nurse	**Urology**	**Cardiology**	**Orthopedics**	**Obstetrics**
Hawkins	28	18	15	75
Condriac	32	48	23	38
Bardot	51	36	24	36
Hoolihan	25	38	55	12

A) Identify the type of network problem for St Charles. (4 point)

Assignment Problem

B) Draw the network diagram including all the nodes and all the possible connections. Also include all supply and demand quantities and the costs on the diagram. (6 points)

See next page

C) Formulate this problem into a linear programming model (including decision variables, objective function, and constraints) Don't forget to label the constraints (6 points)

Number the nurses 1, 2, 3, and 4 for Hawkins, Condriac, Bardot, and Hoolihan respectively, and number the departments similarly with 1, 2, 3, and 4 for urology, cardiology, orthopedics, and obstetrics respectively.

Let $X_{ij} = 1$ if nurse i is assigned to department j, and . $X_{ij} = 0$ otherwise. The linear program is

Minimize cost scale = $28X_{11} + 18X_{12} + 15X_{13} + 75X_{14} + 32X_{21} + 48X_{22} + 23X_{23} + 38X_{24} + 51X_{31} + 36X_{32} + 24X_{33} + 36X_{34} + 25X_{41} + 38X_{42} + 55X_{43} + 12X_{44}$

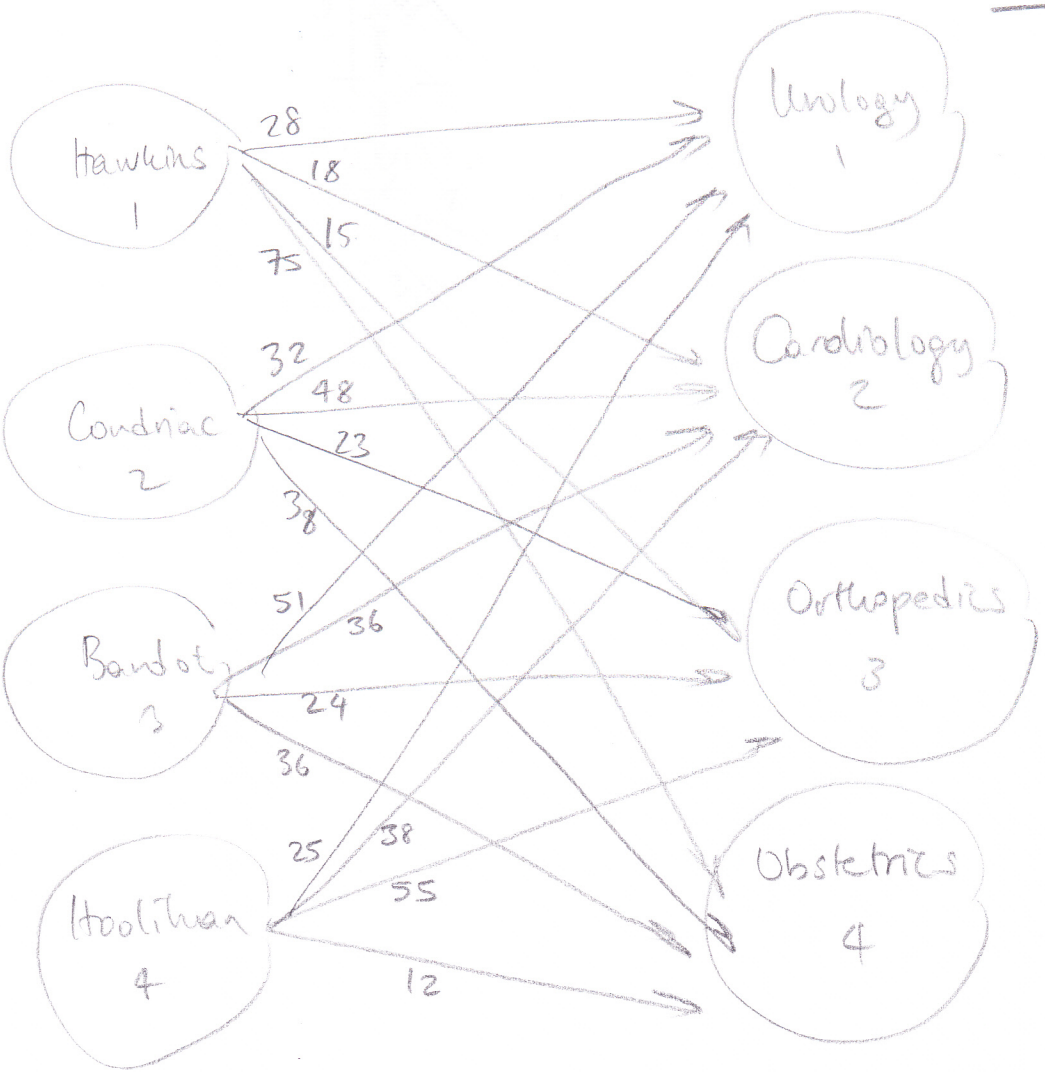
Subject to

$X_{11} + X_{21} + X_{31} + X_{41} = 1$
$X_{11} + X_{22} + X_{32} + X_{42} = 1$
$X_{13} + X_{23} + X_{33} + X_{43} = 1$
$X_{14} + X_{24} + X_{34} + X_{44} = 1$
$X_{11} + X_{12} + X_{13} + X_{14} = 1$
$X_{21} + X_{22} + X_{23} + X_{24} = 1$
$X_{31} + X_{32} + X_{33} + X_{34} = 1$
$X_{41} + X_{42} + X_{43} + X_{44} = 1$
All variables = 0 or 1

Q 14 B)

Supply

Demand



15. Neki Sports Company manufactures treadmills in factories located in Pittsburgh and Kansas City. These are shipped to regional distribution centers in Chicago, Phoenix, and Philadelphia. Ultimately they are delivered to supply houses in New York and Los Angeles. The available supplies at the factories, demands at the final destinations, and shipping costs are illustrated in the table below. Neki's goal is to minimize the total costs.

	To					
From	Chicago	Phoenix	Philadelphia	New York	Los Angeles	Supply
Pittsburgh	$4	$8	$2	--	--	1500
Kansas City	$3	$6	$5	--	--	1000
Chicago	--	--	--	5	7	--
Phoenix	--	--	--	8	3	--
Philadelphia	--	--	--	2	9	--
Demand	--	--	--	1200	800	--

A) Identify the type of network problem for Neki Sports. (4 points)

Transshipment Problem

B) Draw the network diagram including all the nodes and all the possible connections. Also include all supply and demand quantities and the costs on the diagram. (6 points)

See next page

C) Formulate this problem into a linear programming model (including decision variables, objective function, and constraints) Don't forget to label the constraints (6 points)

Let (1) = Pittsburgh, (2) = Kansas City, (3) = Chicago, (4) = Phoenix, (5) = Philadelphia, (6) = New York, and (7) = Los Angeles

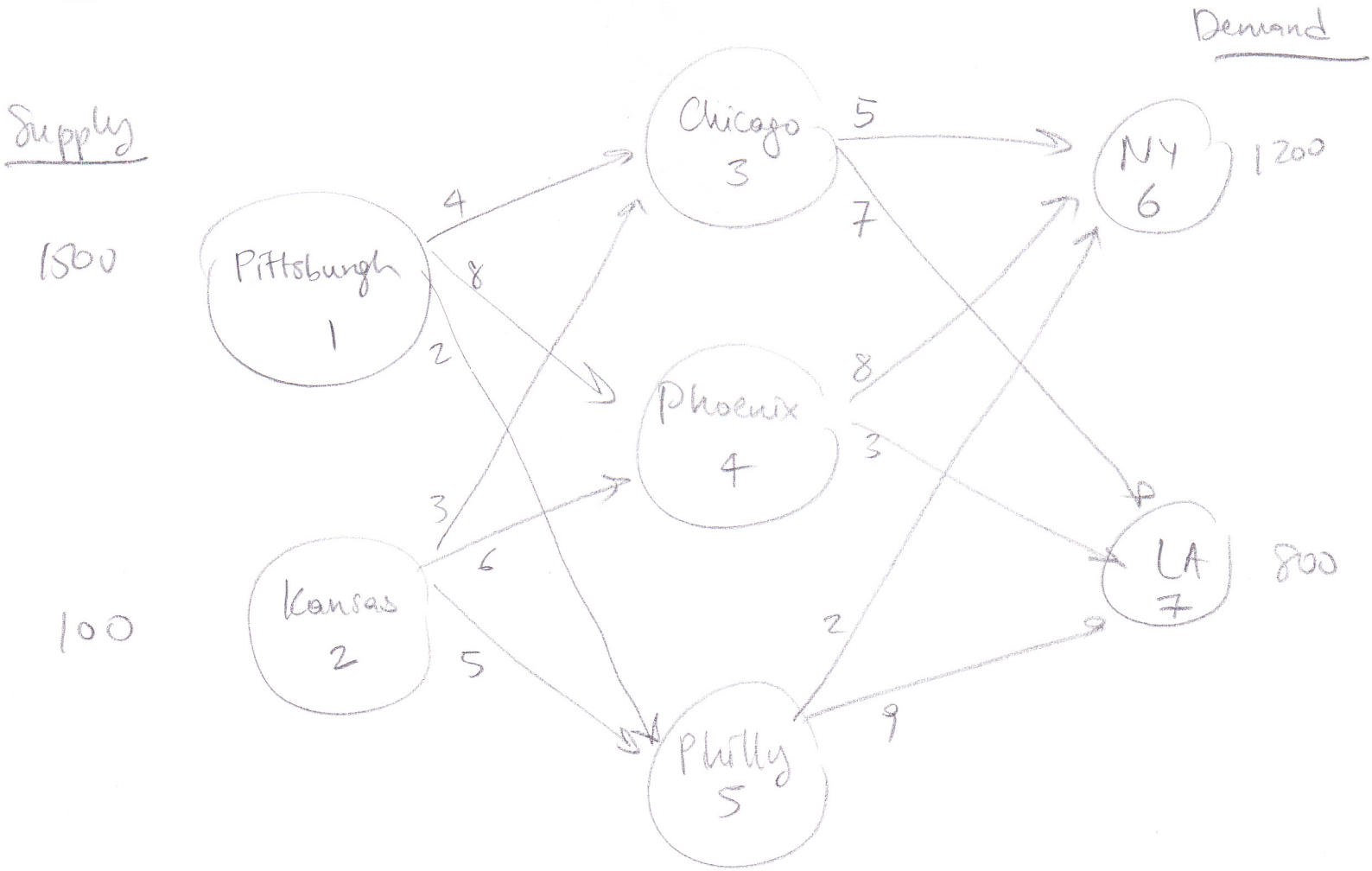
Let x_{ij} = the number of units shipped from location i to location j.

The LP is as follows:

Minimize total cost = $4x_{13} + 3x_{23} + 8x_{14} + 6x_{24} + 2x_{15} + 5x_{25} + 5x_{36} + 8x_{46} + 2x_{56} + 7x_{37} + 3x_{47} + 9x_{57}$

Subject to:
$x_{13} + x_{14} + x_{15} \leq 1500$
$x_{23} + x_{24} + x_{25} \leq 1000$
$x_{13} + x_{23} = x_{36} + x_{37}$
$x_{14} + x_{24} = x_{46} + x_{47}$
$x_{15} + x_{25} = x_{56} + x_{57}$
$x_{36} + x_{46} + x_{56} = 1200$
$x_{37} + x_{47} + x_{57} = 800$
All $x_{ij} \geq 0$

Q 15 B)


Demand
Supply
1500
100
Pittsburgh
1
Kansas
2
Chicago
3
Phoenix
4
Philly
5
NY
6
LA
7
1200
800
4
8
2
3
6
5
7
8
3
2
9

16. Don Levine Corporation has three existing facilities in Decatur, Minneapolis, and Carbondale. From these facilities, the company ships goods to Atlanta, Miami and Tampa. The company is considering adding an additional plant to either St. Louis or Chicago. The transportation costs per unit for existing plants are shown in the table below.

From/To	Atlanta	Miami	Tampa	**Supply**
Decatur	$20	$25	$22	**300**
Minneapolis	17	27	25	**200**
Carbondale	21	20	22	**150**
Demand	250	200	350	

The transportation costs per unit for proposed plants are shown in the table below.

From/To	Atlanta	Miami	Tampa	**Supply**
St. Louis	$29	$30	$30	**150**
Chicago	27	28	31	**170**

A) Identify the type of network problem for Don Levine Corp. (4 points)

Transportation problem

Suppose that Don Levine Corp. is first considering the case where St. Louis location is added. Answer parts B and C according to this assumption.

B) Draw the network diagram that includes St. Louis location, including all the nodes and all the possible connections. Also include all supply and demand quantities and the costs on the diagram. (6 points)

See next page

C) Formulate this problem into a linear programming model (including decision variables, objective function, and constraints. Don't forget to label the constraints.) (6 points)

Let X_{ij} = the number of units produced and shipped from plant i to destination j
where i = 1, 2, 3, 4 for Decatur, Minneapolis, Carbondale, St. Louis
and j = 1, 2, and 3 for Atlanta, Miami and Tampa respectively.
For the St. Louis location, the linear program is

Minimize cost = $20X_{11} + 25X_{12} + 22X_{13} + 17X_{21} + 27X_{22} + 25X_{23} + 21X_{31} + 20X_{32} + 22X_{33} + 29X_{41} + 30X_{42} + 30X_{43}$
Subject to
$X_{11} + X_{21} + X_{31} + X_{41} = 250$ (1)
$X_{12} + X_{22} + X_{32} + X_{42} = 200$ (2)
$X_{13} + X_{23} + X_{33} + X_{43} = 350$ (3)

$X_{11} + X_{12} + X_{13} \leq 300$ (4)
$X_{21} + X_{22} + X_{23} \leq 200$ (5)
$X_{31} + X_{32} + X_{33} \leq 150$ (6)
$X_{41} + X_{42} + X_{43} \leq 150$ (7)
All variables ≥ 0 (8)

Next, suppose that Don Levine Corp. is considering the case where Chicago location is added. Answer parts D, E and F according to this assumption.

D) Which decision variable changes in this case compared to the formulation you wrote in part C? Why? (4 points)

i=4 now defines Chicago. Thus, X41, X42 and X42 now define the arc between Chicago and Atlanta, Miami and Tampa, respectively

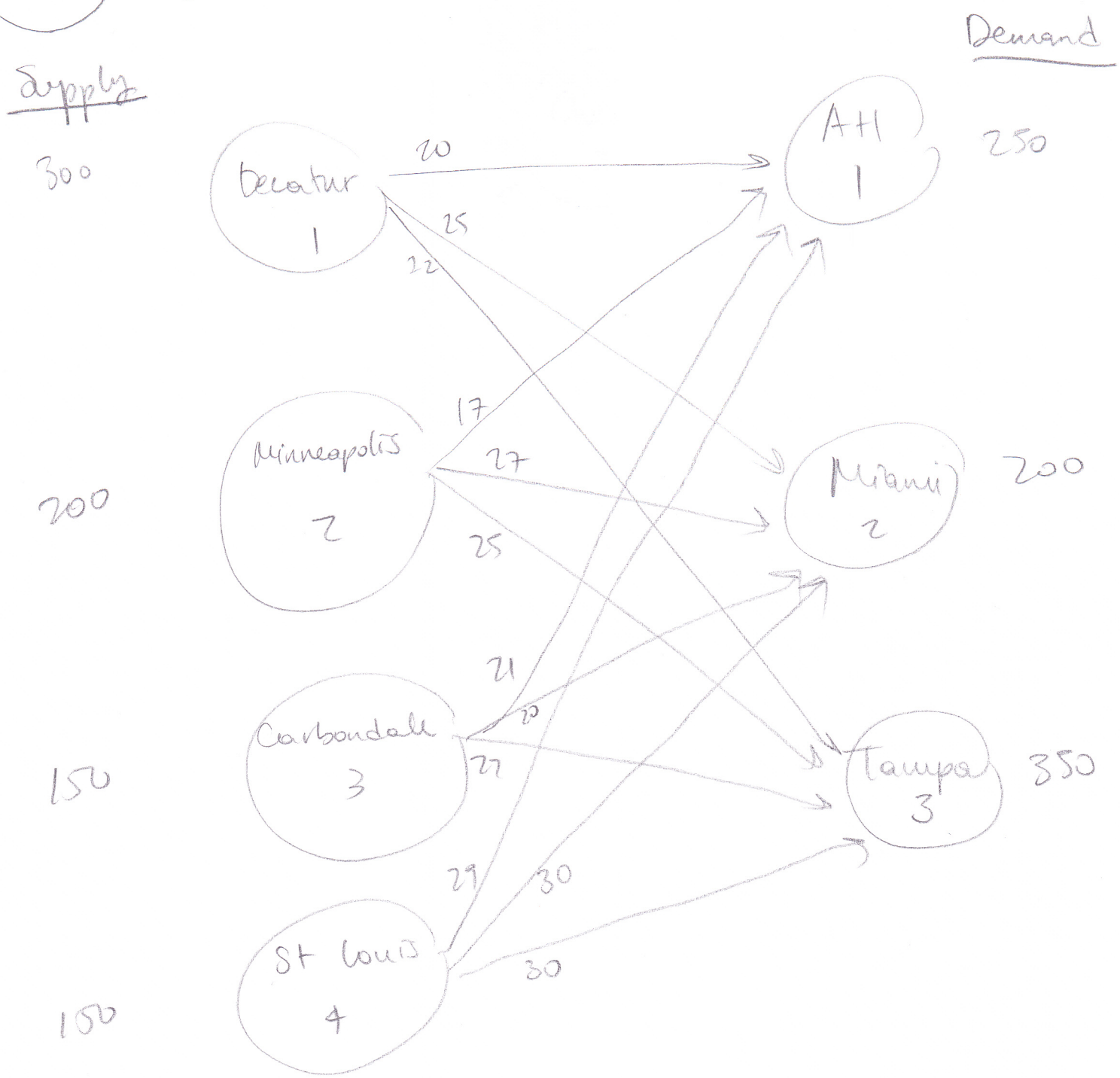
E) What changes in the objective function in this case compared to the formulation you wrote in part C? Why? (4 points)

Last three terms change to + $27X_{41} + 28X_{42} + 31X_{43}$

F) Which constraint(s) change(s) in the objective function in this case compared to the formulation you wrote in part C? Why? (4 points)

Constraint (7) becomes $X_{41} + X_{42} + X_{43} \leq 170$ (7)

Q 16 B)


Supply
Demand
300
200
150
150
Decatur
1
Minneapolis
2
Carbondale
3
St Louis
4
Atl
1
Miami
2
Tampa
3
250
200
350
20
25
22
17
27
25
21
20
27
29
30
30