MGT 2251 Management Science

Exam 2

Professor Chang

October 9, 2012

Your Name (Print):______________________________________

IDN:____

Read each question carefully before you answer. Work at a steady pace, and you should have ample time to finish. Answer the multiple choice questions on the Scantron form. Good Luck!!!

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

Signature____

I. Multiple Choice Questions

Choose the best answer for the following questions. (3 points each)

c_____1. When you use www.MAPQUEST.com to search the direction from a place to another place, the underneath model to solve the problem is

a. transportation model
b. minimal spanning tree model
c. shortest path/route model
d. assignment model

b_____2. A telecommunication company tries to install a system of cables to connect all possible customers with the goal of minimizing the total usage of cables. The appropriate network model to build the possible connection system would most likely be:

a. transportation model
b. minimal spanning tree model
c. shortest path/route model
d. maximal flow model

Use the following data to answer questions 3-10

The Tru-Rainbow Company produces a variety of paint products for both commercial and private use. The demand for paint is highly seasonal, peaking in the third quarter. Current inventory is 350,000 gallons, and the annual ending inventory should be 400,000 gallons.

Tru-Rainbow's manufacturing manager wants to determine the best production plan using the following demand requirements and capacity plans. Demands and capacities below are expressed in thousands of gallons. The manager knows that the regular-time cost is $1.00 per gallon, overtime cost is $1.50 per gallon, subcontracting cost is $1.90 per gallon, and inventory holding cost is $0.30 per gallon per quarter.

	Quarter				
	1	2	3	4	Total
Demand	500	850	1,500	350	3,200
Capacities:					
Regular time	450	450	750	450	2100
Overtime	150	150	150	90	540
Subcontracting	200	200	200	200	800
Total	740	740	1,100	740	3,440

Demand can be satisfied by regular time production, overtime production, subcontracting, or inventory held from the previous quarter. The excess production will be held in inventory for future periods. No backorders or stock-outs are permitted.

a_____3. Let's assume that Xij (i=r1, r2, r3, r4, o1, o2, o3, o4, s1, s2, s3, s4; j=q1, q2, q3, q4) is the production and shipping from supply node i to demand node j. What is the appropriate constraint for the regular production of quarter 2?

a. Xr2q2+Xr2q3+Xr2q4<=450000
b. Xr3q2+Xr2q3+Xr3q4<=450000
c. Xr3q1+Xr3q2+Xr3q3+Xr3q4>=450000
d. Xr1q1+Xr2q2+Xr3q3+Xr4q4=450000

d_____4. Following the last question, let's assume that Xij (i=r1, r2, r3, r4, o1, o2, o3, o4, s1, s2, s3, s4; j=q1, q2, q3, q4) is the production and shipping from supply node i to demand node j. What is the appropriate constraint for the <u>demand</u> of <u>quarter 4</u> (note that the quarter 4 demand needs to include ending inventory)?

a. Xr1q4+Xr2q4+ Xr3q4+Xr4q4+Xo1q4+Xo2q4+ Xo3q4+Xo4q4+Xs1q4+Xs2q4+ Xs3q4+Xs4q4=350000
b. Xr1q4+Xr2q4+Xo1q4+Xo4q4+Xs1q4+Xs4q4<=750000
c. Xr1q4+Xr2q4+Xr3q4+Xr4q4+Xo1q4+Xo2q4=850000
d. Xr1q4+Xr2q4+ Xr3q4+Xr4q4+Xo1q4+Xo2q4+ Xo3q4+Xo4q4+Xs1q4+Xs2q4+ Xs3q4+Xs4q4=750000

Assume that the problem has been formulated as a transportation problem and solved by the Excel Solver. The following tables show the printouts from Excel reports including input, optimal solution output, and sensitivity analysis (partial).

d_____5. Based on the optimal solution, what is the total overtime production for all four quarters?

a. 3,440,000
b. 750,000
c. 610,000
d. 540,000

c_____6. Based on the optimal solution, what is the percentage of total production by subcontracting?

a. 64.6%
b. 16.6%
c. 18.8%
d. 24.5%

b_____7. Based on the following reports, if the demand in quarter 1 increases by 10,000 gallons, how much will the total cost change for the optimal solution?

a. reduce by $19,000
b. increase by $19,000
c. reduce by $22,000
d. increase by $9,000

d_____8. If you have an option to increase the regular time capacity by 5000 gallons in any of the four quarters. Which quarter will be the best choice from the reducing cost point of view?

a. quarter 1
b. quarter 2

c. quarter 3
d. quarter 4

a_____9. If you have an option to increase the regular time capacity by 10000 gallons in quarter 3, how much is the maximum cost you are willing to pay for this capacity increase?

a. $15,000
b. $12,000
c. $1,000
d. $6,000

c_____10. Now assume that the backorders are allowed and the backorder cost is $0.50 per gallon per quarter. That means Tru-Rainbow can produce in later quarters to satisfy earlier quarter demand. For example, it can produce by using regular time capacity in quarter 3 to satisfy the demand in quarter 1. What is the unit cost you should enter in the INPUT table for producing by using regular time capacity in quarter 3 to satisfy the demand in quarter 1? (It is 1000000, a big cost, when backorder is not allowed.)

a. $1.5
b. $2.5
c. $2.0
d. $0.5

INPUT	Demand	150000	850000	1500000	750000
Supply	Nodes	Q1	Q2	Q3	Q4
450000	Q1 Reg	1	1.3	1.6	1.9
150000	Q1 O/T	1.5	1.8	2.1	2.4
200000	Q1 Sub	1.9	2.2	2.5	2.8
450000	Q2 Reg	1000000	1	1.3	1.6
150000	Q2 O/T	1000000	1.5	1.8	2.1
200000	Q2 Sub	1000000	1.9	2.2	2.5
750000	Q3 Reg	1000000	1000000	1	1.3
150000	Q3 O/T	1000000	1000000	1.5	1.8
200000	Q3 Sub	1000000	1000000	1.9	2.2
450000	Q4 Reg	1000000	1000000	1000000	1
90000	Q4 O/T	1000000	1000000	1000000	1.5
200000	Q4 Sub	1000000	1000000	1000000	1.9

SOLUTION	TOTAL COST = 4333000				
OUTPUT	Received	150000	850000	1500000	750000
Shipped	Nodes	Q1	Q2	Q3	Q4
450000	Q1 Reg		450000		
150000	Q1 O/T	140000		10000	
10000	Q1 Sub	10000			
450000	Q2 Reg		400000	50000	
150000	Q2 O/T			150000	
200000	Q2 Sub			200000	
750000	Q3 Reg			750000	
150000	Q3 O/T			150000	
200000	Q3 Sub			190000	10000
450000	Q4 Reg				450000
90000	Q4 O/T				90000
200000	Q4 Sub				200000

Microsoft Excel 12.0 Sensitivity Report
Worksheet: [Tru-Rainbow for Exam 2.xlsx]No Backorder
Report Created: 10/6/2010 8:56:15 AM

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
C21	Q1 Reg Q1	0	0	1	1E+30	0
D21	Q1 Reg Q2	450000	0	1.3	0	1E+30
E21	Q1 Reg Q3	0	0	1.6	1E+30	0
F21	Q1 Reg Q4	0	0	1.9	1E+30	0
C22	Q1 O/T Q1	140000	0	1.5	0	0
D22	Q1 O/T Q2	0	0	1.8	1E+30	0
E22	Q1 O/T Q3	10000	0	2.1	0	0
F22	Q1 O/T Q4	0	0	2.4	1E+30	0
C23	Q1 Sub Q1	10000	0	1.9	0	0.3
D23	Q1 Sub Q2	0	0	2.2	1E+30	0
E23	Q1 Sub Q3	0	0	2.5	1E+30	0
F23	Q1 Sub Q4	0	0	2.8	1E+30	0
C24	Q2 Reg Q1	0	999999.3	1000000	1E+30	999999.3
D24	Q2 Reg Q2	400000	0	1	0	0
E24	Q2 Reg Q3	50000	0	1.3	0	0
F24	Q2 Reg Q4	0	0	1.6	1E+30	0
C25	Q2 O/T Q1	0	999998.8	1000000	1E+30	999998.8
D25	Q2 O/T Q2	0	0	1.5	1E+30	0
E25	Q2 O/T Q3	150000	0	1.8	0	1E+30
F25	Q2 O/T Q4	0	0	2.1	1E+30	0
C26	Q2 Sub Q1	0	999998.4	1000000	1E+30	999998.4
D26	Q2 Sub Q2	0	0	1.9	1E+30	0
E26	Q2 Sub Q3	200000	0	2.2	0	1E+30
F26	Q2 Sub Q4	0	0	2.5	1E+30	0
C27	Q3 Reg Q1	0	999999.6	1000000	1E+30	999999.6
D27	Q3 Reg Q2	0	999999.3	1000000	1E+30	999999.3
E27	Q3 Reg Q3	750000	0	1	0	1E+30
F27	Q3 Reg Q4	0	0	1.3	1E+30	0
C28	Q3 O/T Q1	0	999999.1	1000000	1E+30	999999.1
D28	Q3 O/T Q2	0	999998.8	1000000	1E+30	999998.8
E28	Q3 O/T Q3	150000	0	1.5	0	1E+30
F28	Q3 O/T Q4	0	0	1.8	1E+30	0
C29	Q3 Sub Q1	0	999998.7	1000000	1E+30	999998.7
D29	Q3 Sub Q2	0	999998.4	1000000	1E+30	999998.4
E29	Q3 Sub Q3	190000	0	1.9	0.3	0
F29	Q3 Sub Q4	10000	0	2.2	0	0.3
C30	Q4 Reg Q1	0	999999.9	1000000	1E+30	999999.9
D30	Q4 Reg Q2	0	999999.6	1000000	1E+30	999999.6
E30	Q4 Reg Q3	0	999999.3	1000000	1E+30	999999.3
F30	Q4 Reg Q4	450000	0	1	1.8	1E+30
C31	Q4 O/T Q1	0	999999.4	1000000	1E+30	999999.4
D31	Q4 O/T Q2	0	999999.1	1000000	1E+30	999999.1
E31	Q4 O/T Q3	0	999998.8	1000000	1E+30	999998.8
F31	Q4 O/T Q4	90000	0	1.5	1.3	1E+30
C32	Q4 Sub Q1	0	999999	1000000	1E+30	999999
D32	Q4 Sub Q2	0	999998.7	1000000	1E+30	999998.7
E32	Q4 Sub Q3	0	999998.4	1000000	1E+30	999998.4
F32	Q4 Sub Q4	200000	0	1.9	0.9	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
A21	Shipped Q1 Reg	450000	-0.9	450000	10000	50000
A22	Shipped Q1 O/T	150000	-0.4	150000	10000	140000
A23	Shipped Q1 Sub	10000	0	200000	1E+30	190000
A24	Shipped Q2 Reg	450000	-1.2	450000	10000	50000
A25	Shipped Q2 O/T	150000	-0.7	150000	10000	140000
A26	Shipped Q2 Sub	200000	-0.3	200000	10000	140000
A27	Shipped Q3 Reg	750000	-1.5	750000	10000	140000
A28	Shipped Q3 O/T	150000	-1	150000	10000	140000
A29	Shipped Q3 Sub	200000	-0.6	200000	10000	140000
A30	Shipped Q4 Reg	450000	-1.8	450000	10000	140000
A31	Shipped Q4 O/T	90000	-1.3	90000	10000	90000
A32	Shipped Q4 Sub	200000	-0.9	200000	10000	140000
C19	Received Q1	150000	1.9	150000	190000	10000
D19	Received Q2	850000	2.2	850000	50000	10000
E19	Received Q3	1500000	2.5	1500000	140000	10000
F19	Received Q4	750000	2.8	750000	140000	10000

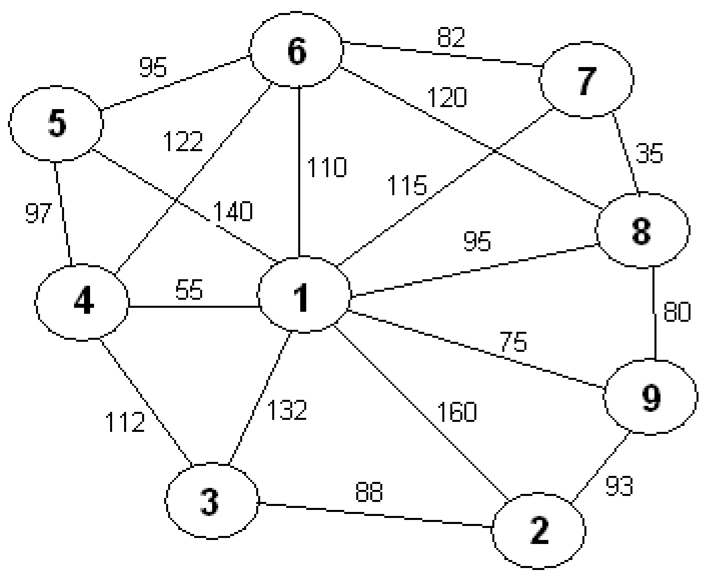
b_____11. In a job shop operation, four jobs: A12, A15, B2, and B9, need to be performed on any of the four machines: W, X, Y, and Z. The hours required for each job on each machine are presented in the following input table. The plant supervisor has arbitrarily made the following assignments: A12-W, A15-X, B2-Y, and B9-Z. However, you disagreed and used the assignment model to solve the optimal solution by Excel Solver shown below (Solution INPUT/OUTPUT). How much improvement has your optimal solution over the plant supervisor assignment?

a. 10 hours
b. 4 hours
c. 2 hours
d. 23 hours

INPUT					
	Nodes	W	X	Y	Z
	A12	10	14	16	13
	A15	12	13	15	12
	B2	9	12	17	11
	B9	14	16	18	16
SOLUTION		TOTAL COST =	52		
OUTPUT	PERFORMED	1	1	1	1
ASSIGNED	Nodes	W	X	Y	Z
1	A12	1			
1	A15				1
1	B2		1		
1	B9			1	

b_____12. A recent tragic fire in Carbonville, Illinois, has prompted the City Council to draft a new ordinance requiring all building to have fully operational sprinkler systems installed by the end of the year. The Talcon Building is affected by the ordinance. From the original blueprints, engineers have designed positions for the location of eight powerful sprinkler heads that are to be connected to the sprinkler controller (node 1). The feasible connections between these eight sprinkler heads and the controller with distance shown in feet are depicted in the following figure. What is the minimum amount of pipe required to connect all sprinkler heads and controller? (Note that the sprinkler head does not need to connect to the controller directly. It can connect to other head that is connected directly or indirectly to the controller.)

a. 459 feet
b. 603 feet
c. 605 feet
d. 711 feet



Use the following data to answer questions 13-18.

Jake Nguyen runs a nervous hand through his once finely combed hair. He loosens his once perfectly knotted silk tie. And he rubs his sweaty hands across his once immaculately pressed trousers. Today has certainly not been a good day.

Over the past few months, Jake had heard whispers circulating from Wall Street—whispers from the lips of investment bankers and stockbrokers famous for their outspokenness. They had whispered about a coming Japanese economic collapse—whispered because they had believed that publicly vocalizing their fears would hasten the collapse.

And, today, their very fears have come true. Jake and his colleagues gather around a small television dedicated exclusively to the Bloomberg channel. Jake stares in disbelief as he listens to the horrors taking place in the Japanese market. And the Japanese market is taking the financial markets in all other East Asian countries with it on its tailspin. He goes numb. As manager of Asian foreign investment for Grant Hill Associates, a small West Coast investment boutique specializing in currency trading, Jake bears personal responsibility for any negative impacts of the collapse. And Grant Hill Associates will experience negative impacts.

Jake had not heeded the whispered warnings of a Japanese collapse. Instead, he had greatly increased the stake Grant Hill Associates held in the Japanese market. Because the Japanese market had performed better than expected over the past year, Jake had increased investments in Japan from $2.5 million to $25 million only one month ago. At that time, one dollar was worth 80 yen.

No longer, Jake realizes that today's devaluation of the yen means that one-dollar is worth 125 yen. He will be able to liquidate these investments without any loss in yen, but now the dollar loss when converting back into U.S. currency would be huge. He takes a deep breath, closes his eyes, and mentally prepares himself for serious damage control.

Jake's meditation is interrupted by a booming voice calling for him from a large, corner office. Grant Hill, the president of Grant Hill Associates, yells, "Nguyen, get the hell in here!"

Jake jumps and looks reluctantly toward the corner office hiding the furious Grant Hill. He smoothens his hair, tightens his tie, and walks briskly into the office.

Grant Hill meets Jake's eyes upon his entrance and continues yelling, "I don't want one word out of you, Nguyen! No excuses; just fix this debacle! Get all of our money out of Japan! My gut tells me this is only the beginning! Get the money into safe U.S. bonds! Now! And don't forget to get our cash positions out of Indonesia and Malaysia ASAP with it!"

Jake has enough common sense to say nothing. He nods his head, turns on his heels, and practically runs out of the office.

Safely back at his desk, Jake begins formulating a plan to move the investment out of Japan, Indonesia, and Malaysia. His experiences investing in foreign markets have taught him that when playing with millions of dollars, how he gets money out of a foreign market is almost as important as when he gets money out of the market. The banking partners of Grant Hill Associates charge different transaction fees for converting one currency into another one and wiring large sums of money around the globe.

And now, to make matters worse, the governments in East Asia have imposed very tight limits on the amount of money an individual or a company can exchange from the domestic currency into a particular foreign currency and withdraw it from the country. The goal of this dramatic measure is to reduce the outflow of foreign investments out of those countries to prevent a complete collapse of the economies in the region. Because of Grant Hill Associates' cash holdings of 15 billion Indonesia rupiahs and 40 million Malaysia ringgits, along with the holding in yen it is not clear how these holdings should be converted back into dollars.

Jake wants to find the most cost-effective method to convert these holdings into dollars. On his company's Web site, he always can find on-the-minute exchange rates for most currencies in the world (see Table 1).

TABLE 1 Currency Exchange Rates

From/To	Yen	Rupiah	Ringgit	U.S. Dollar	Canadian Dollar	Euro	Pound	Peso

Japanese yen	1	50	0.04	0.008	0.01	0.0064	0.0048	0.0768
Indonesia rupiah		1	0.0008	0.00016	0.0002	0.000128	0.000096	0.001536
Malaysian ringgit			1	0.2	0.25	0.16	0.12	1.92
U.S. dollar				1	1.25	0.8	0.6	9.6
Canadian dollar					1	0.64	0.48	7.68
European euro						1	0.75	12
English pound							1	16
Mexican peso								1

The table states that, for example, 1 Japanese yen equals 0.008 U.S. dollar. By making a few phone calls, he discovers the transaction costs his company must pay for large currency transactions during these critical times (see Table 2).

TABLE 2 Transaction Cost (Percent)

From/To	Yen	Rupiah	Ringgit	U.S. Dollar	Canadian Dollar	Euro	Pound	Peso
Yen	–	0.5	0.5	0.4	0.4	0.4	0.25	0.5
Rupiah		–	0.7	0.5	0.3	0.3	0.75	0.75
Ringgit			–	0.7	0.7	0.4	0.45	0.5
U.S. dollar				–	0.05	0.1	0.1	0.1
Canadian dollar					–	0.2	0.1	0.1
Euro						–	0.05	0.5
Pound							–	0.5
Peso								–

Jake notes that exchanging one currency for another one results in the same transaction cost as a reverse conversion. Finally, Jake finds out the maximum amounts of domestic currencies his company is allowed to convert into other currencies in Japan, Indonesia, and Malaysia (see Table 3).

TABLE 3 Transaction Limits in Equivalent of 1,000 Dollars

From/To	Yen	Rupiah	Ringgit	U.S. Dollar	Canadian Dollar	Euro	Pound	Peso
Yen	–	5,000	5,000	4,000	4,000	4,000	4,000	5,000
Rupiah	5,000	–	4,000	2,000	2,000	2,000	5,000	2,000
Ringgit	3,000	4,500	–	2,500	2,500	3,500	2,000	2,000

Assume that the problem has been formulated and entered into the template and solved by Excel Solver. The following tables show the Excel input, output and most sensitivity analysis for the problem.

NODE INPUT				ARC INPUT				SOLUTION	TOTAL COST=	120600
NODE NAME	NODE #	SUPPLY	DEMAND	FROM	TO	COST	CAPACITY	FROM	TO	FLOW
Yen	1	16000000		1	2	0.005	5000000	1	2	
Rupiah	2	2400000		1	3	0.005	5000000	1	3	
Ringgit	3	8000000		1	4	0.004	4000000	1	4	4000000
Canadian	4			1	5	0.004	4000000	1	5	4000000
Eruo	5			1	6	0.0025	4000000	1	6	4000000
Pound	6			1	7	0.005	5000000	1	7	
Peso	7			1	8	0.004	4000000	1	8	4000000
US	8		26400000	2	1	0.005	5000000	2	1	
				2	3	0.007	4000000	2	3	
				2	4	0.003	2000000	2	4	2000000
				2	5	0.003	2000000	2	5	400000
				2	6	0.0075	5000000	2	6	
				2	7	0.0075	2000000	2	7	
				2	8	0.005	2000000	2	8	
				3	1	0.005	3000000	3	1	
				3	2	0.007	4500000	3	2	
				3	4	0.007	2500000	3	4	
				3	5	0.004	3500000	3	5	3500000
				3	6	0.0045	2000000	3	6	2000000
				3	7	0.005	2000000	3	7	2000000
				3	8	0.007	2500000	3	8	500000
				4	5	0.002	1000000000	4	5	
				4	6	0.001	1000000000	4	6	
				4	7	0.001	1000000000	4	7	
				4	8	0.0005	1000000000	4	8	6000000
				5	4	0.002	1000000000	5	4	
				5	6	0.0005	1000000000	5	6	
				5	7	0.005	1000000000	5	7	
				5	8	0.001	1000000000	5	8	7900000
				6	4	0.001	1000000000	6	4	
				6	5	0.0005	1000000000	6	5	
				6	7	0.005	1000000000	6	7	
				6	8	0.001	1000000000	6	8	6000000
				7	4	0.001	1000000000	7	4	
				7	5	0.005	1000000000	7	5	
				7	6	0.005	1000000000	7	6	
				7	8	0.001	1000000000	7	8	2000000

Constraints

	Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
	T4	Yen OUT-IN	16000000	0.005	16000000	5000000	0
	T5	Rupiah OUT-IN	2400000	0.003	2400000	1600000	0
	T6	Ringgit OUT-IN	8000000	0.006	8000000	2000000	0
	T7	Canadian OUT-IN	0	-0.0005	0	2000000	0
	T8	Eruo OUT-IN	0	0	0	2000000	0
	T9	Pound OUT-IN	0	0	0	2000000	0
	T10	Peso OUT-IN	0	0	0	0	1E+30
	T11	US OUT-IN	-26400000	-0.001	-26400000	2000000	0

d_____13. As shown in the table above from the template, what network model was used to formulate the problem for Jake?

a. transportation model
b. minimal spanning tree model
c. shortest path/route model
d. transshipment model

b_____14. Let's assume that Xij, i and j are the node numbers defined in the Excel INPUT table, is the shipping quantity (amount of money converted) from node i to node j. What is the appropriate constraint for the Euro currency node?

a. X14+X24+X34+X54+X64+X74+X84=X41+ X42+ X43+ X45+ X46+ X47+ X48
b. X15+X25+X35+X45+X65+X75+X85=X51+ X52+ X53+ X54+ X56+ X57+ X58
c. X16+X26+X36+X46+X56+X76+X86=X61+ X62+ X63+ X64+ X65+ X67+ X68
d. X15+X25+X35=X51+ X52+ X53

c_____15. Based on the Excel solution how much the Rupiah is directly exchanged to Euro in US dollar?

a. 7,900,000
b. 2,000,000
c. 400,000
d. 3,500,000

a_____16. Based on the Excel solution, how much all currencies are transferred into Pound in US dollar?

a. 6,000,000
b. 500,000
c. 2,000,000
d. 7,900,000

b_____17. By using the sensitivity analysis information, if there is $1,000,000 value of more Yen needs to be transferred, what will the extra cost be?

a. $3,000
b. $5,000
c. $4,000

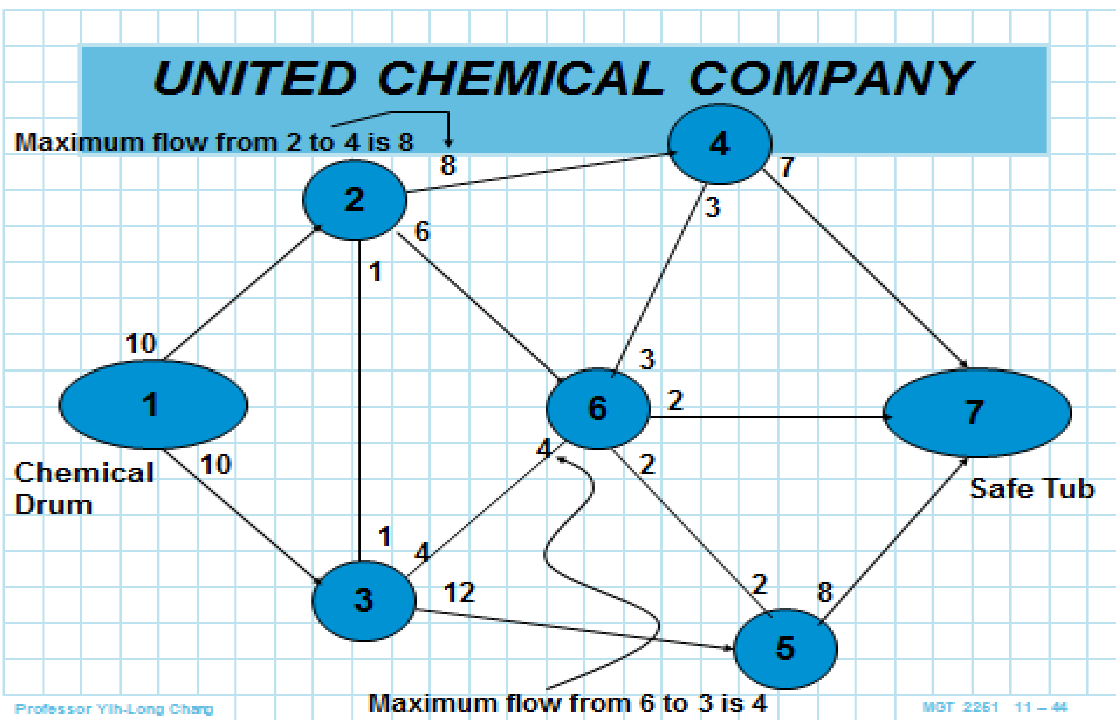
d. $20,000

a_____18. After the money is transferred to US dollar, the transaction fee will be paid from the final pool and the balance will be used to purchase US Treasury Bond. Based on the optimal solution, how much US Treasury Bond will be purchased?

a. 26,279,400
b. 16,796,620
c. 26,400,000
d. 18,400,000

Use the following data to answer questions 19-20

United Chemical produces pesticides and lawn care products. Poisonous chemicals needed for the production process are held in a huge drum. A network of pipes and valves regulates the chemical flow from the drum to different production areas. The safety division must plan a procedure to empty the drum as fast as possible into a safety tub in the disposal area, using a network of pipes and valves. The following network shows the possible pipe connections (arcs) and valve locations (nodes). The number on arc represents the maximum flow capacity in thousand gallons per minute. For example, maximum flow from node 2 to node 4 is 8 thousand gallons per minute.



The problem is modeled as a maximal flow problem and solved by Excel Solver. The following table shows the optimal solution.

NODE INPUT			ARC INPUT			SOLUTION	MAXIMUM FLOW=	17
	NODE NAME	NODE #	FROM	TO	CAPACITY	FROM	TO	FLOW
SOURCE	Chemical Drum	1	1	2	10	1	2	9
SINK	Safe Tub	7	1	3	10	1	3	8
	Area 2	2	2	3	1	2	3	
	Area 3	3	2	4	8	2	4	7
	Area 4	4	2	6	6	2	6	2
	Area 5	5	3	2	1	3	2	
	Area 6	6	3	5	12	3	5	8
			3	6	4	3	6	
			4	6	3	4	6	
			4	7	7	4	7	7
			5	6	2	5	6	
			5	7	8	5	7	8
			6	3	4	6	3	
			6	5	2	6	5	
			6	7	2	6	7	2

a_____19. Based on the optimal solution from Solver, how much does the chemical flow through (in and out) area/valve 6?

a. 2 thousand gallons per minute
b. 9 thousand gallons per minute
c. 8 thousand gallons per minute
d. 7 thousand gallons per minute

b_____20. If the chemical drum has 200 thousand gallons in deposit, what is the shortest time to discharge into safe tub?

a. 15.11 minutes
b. 11.76 minutes
c. 10.00 minutes
d. 5.88 minutes

II. Problems.

1. Consider a capital budgeting problem in which five possible projects are being considered for implementation over the next three years. The expected returns for each project, the annual expenditures, and budgets (all in thousands of dollars) are shown in the table. Assume that each approved project will continue over the entire three-year period.

Project	Expenditures			Expected
	Year 1	Year 2	Year 3	Return
1	5	1	8	27
2	4	7	10	40
3	3	9	2	25

4	7	4	7	19
5	8	6	10	28
Budget	25	30	32	

(a). Formulate an integer linear programming model (including decision variables, objective function, and constraints) to maximize the total expected returns. Assume that unused funds for each year cannot be carried forward. (10 points)

DV (decision variables): (2 points)

Let Xi: 1 if project i is selected; 0 otherwise.

OBJ (objective function): (2 points)

Max 27X1+40X2+25X3+19X4+28X5

Constraints: (6 points)

S.T. 5X1+4X2+3X3+7X4+8X5 <= 25
8X1+7X2+9X3+4X4+6X5 <= 30
8X1+10X2+2X3+7X4+10X5 <= 32
For any Xi=0,1

(b). When project 5 is selected, project 1 must be selected. Add this constraint. (2 points)

Add constraint: X1>=X5 or X1-X5>=0 or X5-X1<=0

(c). No more than 4 projects should be selected. Add this constraint. (2 points)

Add constraint: X1+X2+X3+X4+X5<=4

2. This problem is based on the following case problem: Andrew-Carter, Inc.

Andrew-Carter, Inc. (A-C), is a major Canadian producer and distributor of outdoor lighting fixture. Its fixture is distributed throughout North America and has been in high demand for several years. The company operates three plants that manufacture the fixture and distribute it to five distribution centers (warehouses).

During the present recession, A-C has seen a major drop in demand for its fixture as the housing market has declined. Based on the forecast of interest rates, the head of operations feels that demand for housing and thus for its product will remain depressed for the foreseeable future. A-C is considering closing one of its plants, as it is now operating with a forecasted excess capacity of 34,000 units per week. The forecasted weekly demands for the coming year are

Warehouse 1	9,000 units
Warehouse 2	13,000 units
Warehouse 3	11,000 units
Warehouse 4	15,000 units
Warehouse 5	8,000 units

The plant capacities in units per week are

Plant 1, regular time	27,000 units
Plant 1, on overtime	7,000 units
Plant 2, regular time	20,000 units
Plant 2, on overtime	5,000 units
Plant 3, regular time	25,000 units
Plant 3, on overtime	6,000 units

If A-C shuts down any plants, its weekly costs will change, as fixed costs are lower for a nonoperation plant. Table 1 shows production costs at each plant, both variable at regular time and overtime, and fixed when operating and shut down. Table 2 shows distribution costs from each plant to each warehouse (distribution center).

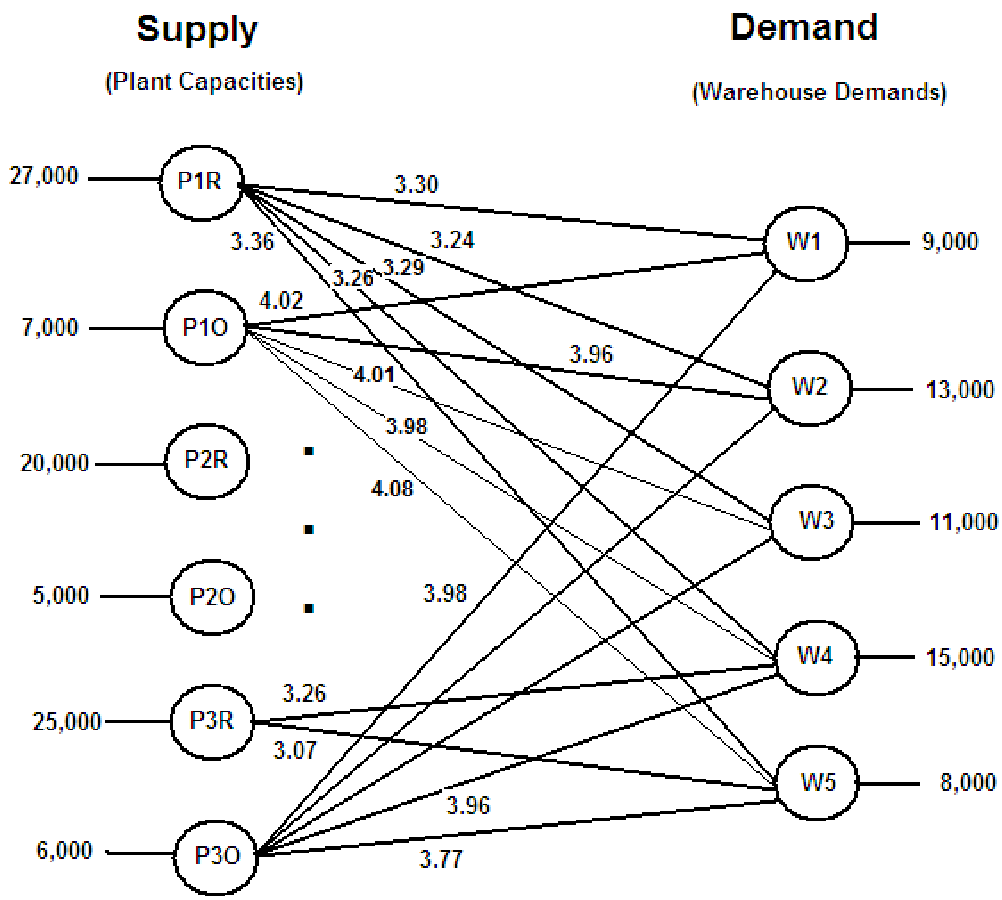
Table 1 Andrew-Carter, Inc., Variable Costs and Fixed Production Costs per week

		FIXED COST PER WEEK	
PLANT	VARIABLE COST	OPERATING	NOT OPERATING
No. 1, regular time	$2.80/units	$14,000	$6,000
No. 1, overtime	3.52		
No. 2, regular time	2.78	12,000	5,000
No. 2, overtime	3.48		
No. 3, regular time	2.72	15,000	7,500
No. 3, overtime	3.42		

Table 2 Andrew-Carter, Inc., Distribution Costs per Unit

	TO DISTRIBUTION CENTER				
FROM PLANT	W1	W2	W3	W4	W5
No. 1	$0.50	$0.44	$0.49	$0.46	$0.56
No. 2	0.40	0.52	0.50	0.56	0.57
No. 3	0.56	0.53	0.51	0.54	0.35

(a). Assume that no plant will be closed. Draw the transportation network diagram including all supply and demand nodes and all the possible connections (i.e., allocations) for AC's weekly production plan. Also include all supply and demand quantities and the unit transportation (i.e., allocation or variable) costs of plant 1 to all distribution centers (including regular and overtime productions). (10 points)



(b). If the optimal solution from Solver has the total cost $179,730 for the production allocation, i. e, the total variable cost, what is the overall cost including <u>variable and fixed</u> costs for no plants are closed? (2 points)

Overall cost = 179730+14000+12000+15000=$220,730.

3. This problem is based on the following case problem: Puyallup Mall (PM)

Jane Rodney, president of the Rodney Development Company, was trying to decide what types of stores to include in her new shopping center at Puyallup Mall. She had already contracted for a supermarket, a drugstore, and a few other stores that she considered essential. However, she had available an additional <u>18,000 square feet</u> of floor space yet to allocate. She drew up a list of the 15 types of stores she might consider (see Table 1) including the floor space required by each. Jane did not think she would have any trouble finding occupants for any type of store.

The lease agreements Jane used in her developments included two types of payment. The store had to pay a certain annual rent, depending on the size and type of store. In addition, Jane was to receive a small percentage of the store's sales if the sales exceeded a specified minimum amount. The amount of annual rent from each store is shown in the second column of the table. To estimate the profitability of each type of store, Jane calculated the present value of all future rent and sales percentage payments. These are given in the third column. Jane wants to achieve the highest total *present value* over the set of stores she selects. However, she could not simply pick those stores with the highest present values, for there were several restrictions. The first, of course, was that she has available only 18,000 square feet.

In addition, a condition on the financing of the project required that the total annual rent should be at least as much as the annual fixed costs (taxes, management fees, debt service, and so forth). These annual costs were $150,000 for this part of the project. Finally, the total funds available for construction of this part of the project were $800,000, and each type of store required different construction costs depending on the size and type of store (fourth column in the table).

In addition, Jane had certain requirements in terms of the mix of stores that she considered best. She wanted at least one store from each of the clothing, hard goods, and miscellaneous groups, and at least two from the restaurant category. She wanted no more than two from the clothing group. Furthermore, the number of stores in the miscellaneous group should not exceed the total number of stores in the clothing and hard goods groups combined.

TABLE 1 Characteristics of Possible Leases for Puyallup Mall Shopping Center

TYPE OF STORE	SIZE OF STORE (1,000s of Sq. Ft.)	ANNUAL RENT ($1,000s)	PRESENT VALUE ($1,000s)	CONSTRUCTION COST ($1,000s)
Clothing				
1. Men's	1.0	$4.4	$38.1	$24.6
2. Women's	1.6	6.1	44.6	32.0
3. Variety (both)	2.0	8.3	60.0	41.4
Restaurants				
4. Fancy restaurant	3.2	24.0	162.0	124.4
5. Lunchroom	1.8	19.5	77.8	64.8
6. Cocktail lounge	2.1	20.7	100.4	79.8
7. Candy and ice cream shop	1.2	7.7	45.2	38.6
Hard Goods				
8. Hardware store	2.4	19.4	80.2	66.8
9. Cutlery and variety	1.6	11.7	51.4	45.1
10. Luggage and leather	2.0	15.2	62.5	54.3
Miscellaneous				
11. Travel agency	0.6	3.9	18.0	15.0
12. Tobacco shop	0.5	3.2	11.6	13.4
13. Camera store	1.4	11.3	50.4	42.0
14. Toys	2.0	16.0	73.6	63.7
15. Beauty parlor	1.0	9.6	71.2	40.0

Let's define the following decision variables:

X_i = 1 if store i is selected; 0, otherwise ($i = 1, \ldots, 15$).

(a). The goal is to maximize the total NPV of all store selection. Formulate the objective function (goal). (2 points)

Maximize
$38.1X_1+44.6X_2+60X_3+162X_4+77.8X_5+100.4X_6+45.2X_7+80.2X_8+51.4X_9+62.5X_{10}$
$+18X_{11}+11.6X_{12}+50.4X_{13}+73.6X_{14}+71.2X_{15}$

(b). Formulate the constraints for space limit, rent requirement, and construction fund limit. Name and label each constraint. (6 points) subject to the space constraint

$$1.0X_1 + 1.6X_2 + 2.0X_3 + 3.2X_4 + 1.8X_5 + 2.1X_6 + 1.2X_7 + 2.4X_8 + 1.6X_9 + 2.0X_{10} + 0.6X_{11} + 0.5X_{12} + 1.4X_{13} + 2.0X_{14} + 1.0X_{15} \leqslant 18$$

the annual rent constraint

$$4.4X_1 + 6.1X_2 + 8.3X_3 + 24.0X_4 + 19.5X_5 + 20.7X_6 + 7.7X_7 + 19.4X_8 + 11.7X_9 + 15.2X_{10} + 3.9X_{11} + 3.2X_{12} + 11.3X_{13} + 16.0X_{14} + 9.6X_{15} \geqslant 150$$

the construction cost constraint

$$24.6X_1 + 32.0X_2 + 41.4X_3 + 124.4X_4 + 64.8X_5 + 79.8X_6 + 38.6X_7 + 66.8X_8 + 45.1X_9 + 54.3X_{10} + 15.0X_{11} + 13.4X_{12} + 42.0X_{13} + 63.7X_{14} + 40.0X_{15} \leqslant 800$$

(c). Formulate the requirements from Jane in the last paragraph? Name and label each constraint. (6 points)

at least one clothing store

$$X_1 + X_2 + X_3 \geqslant 1$$

at least one hard goods store

$$X_8 + X_9 + X_{10} \geqslant 1$$

at least one miscellaneous-type store

$$X_{11} + X_{12} + X_{13} + X_{14} + X_{15} \geqslant 1$$

at least two restaurants

$$X_4 + X_5 + X_6 + X_7 \geqslant 2$$

no more than two clothing stores

$$X_1 + X_2 + X_3 \leqslant 2$$

miscellaneous types cannot exceed total of clothing and hard goods

$$X_1 + X_2 + X_3 + X_8 + X_9 + X_{10} - X_{11} - X_{12} - X_{13} - X_{14} - X_{15} \geqslant 0$$