MGT 2251 Management Science

Exam 1

Professor Chang

September 11, 2012

Name (Print):_____

ID #:_____

Read each question carefully before you answer. Work at a steady pace, and you should have ample time to finish. Answer the multiple 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 (1-20)
Choose the best answer for the following questions. (3 points each)

c_____1. A typical quantitative analysis or management science process includes: (I) Developing a solution; (II) Acquiring input data; (III) Communicating and implementing the results; (IV) Defining problem; (V) Developing a model; (VI) Testing the solution; (VII) Analyzing the results. The above steps are not in the right sequence. Which of the following is the first in sequence?
a. II
b. I
c. IV
d. III
e. V

a_____2. Katherine D'Ann is planning to finance her college education by selling programs at the football games for State University. There is a fixed cost of $400 for printing these programs, and the variable cost is $3 each program. There is also a $1,000 fixed fee that is paid to the University for the right to sell these programs. If Katherine is able to sell each program for $5, how many would she have to sell in order to break even?
a. 700
b. 200
c. 500
d. 1000

c_____3. Following the above problem, if Katherine D'Ann has printed 1200 programs and sold out all copies, how much net profit can Katherine make for her sale?
a. $3600
b. $6000
c. $1000
d. $2400

b_____4. A solution that satisfies all the constraints and has the best objective function value in an LP problem is called
a. a feasible solution
b. an optimal solution
c. an unbounded region
d. the feasible area

a_____5. At the optimal solution for an LP problem, the constraint that has the left-hand-side value not equal to the right-hand-side value is called
a. a non-binding constraint
b. a corner point
c. an infeasible constraint
d. a binding constraint

Use the following case to answer questions 6-12.

Valley Chassis produces fine-quality polished steel and aluminum sheeting and two lines of industrial chassis for the rack mounting of Internet routers, modems, and other telecommunications equipment into six-foot high bays. For the metal sheeting sold, the company earns a profit of $0.60 per pound for steel and $0.70 per pound for aluminum. For example, the $0.60 per pound for steel sheeting consists of the sales price (per pound) less direct labor and materials, including the cost of the raw unfinished steel. On the sale of Standard chassis rack $16.00 contribution is earned while a Deluxe chassis rack yields $18.00.

For the month of January the company can buy and use up to 30,000 pounds of raw unfinished steel either in sheeting or in chassis. Similarly, 25,000 pounds of aluminum are available. One Standard chassis rack requires 12 pounds of steel and 8 pounds of aluminum. A Deluxe chassis rack requires 10 pounds of steel and 12 pounds of aluminum.

The output of metal sheeting is restricted only by the capacity of the polisher. For January the polisher can handle any mix of the two metals up to 5,000 pounds of metal sheeting.

Chassis manufacture is restricted by either metal stamping or assembly operations. No polishing is required for chassis racks. During the month no more than 3,000 total chassis can be stamped. There are 1500 hours of assembly time available each month. Valley's efficient operations manager has reduced the assembly time to 36 minutes for the Standard chassis rack and 48 minutes for the Deluxe chassis rack.

Market conditions limit the number of chassis racks sold to no more than 1,200 Standard and no more than 1,000 Deluxe. Any quantities of metal sheeting can be sold.

Use the following decision variables to formulate the problem as an LP model:

SS = pounds of steel sheeting produced and sold
AS = pounds of aluminum sheeting produced and sold
SC = number of Standard chassis racks produced and sold
DC = number of Deluxe chassis racks produced and sold

Optimize the LP model with Excel Solver and the following reports show the LP spreadsheet model, the answer and the sensitivity reports. Answer the following questions based on these reports.

Valley Chassis							
	SS	AS	SC	DC	Max. OBJ		
Unit profit	0.6	0.7	16	18			
Production (DV)					0		
Subject to					LHS		RHS
Raw Steel	1		12	10	0	<=	30000
Aluminum		1	8	12	0	<=	25000
Polishing	1	1			0	<=	5000
Stamping			1	1	0	<=	3000
Assembly			0.6	0.8	0	<=	1500
SC Market			1		0	<=	1200
DC Market				1	0	<=	1000

Microsoft Excel 10.0 Answer Report

Target Cell (Max)

Cell	Name	Original Value	Final Value
$F$4	Production Max. OBJ	40120	40120

Adjustable Cells

Cell	Name	Original Value	Final Value
$B$4	Production SS	1300	1300
$C$4	Production AS	3700	3700
$D$4	Production SC	1200	1200
$E$4	Production DC	975	975

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$F$7	Raw Steel LHS	25450	$F$7<=$H$7	Not Binding	4550
$F$8	Aluminum LHS	25000	$F$8<=$H$8	Binding	0
$F$9	Polishing LHS	5000	$F$9<=$H$9	Binding	0
$F$10	Stamping LHS	2175	$F$10<=$H$10	Not Binding	825
$F$11	Assembly LHS	1500	$F$11<=$H$11	Binding	0
$F$12	SC Market LHS	1200	$F$12<=$H$12	Binding	0
$F$13	DC Market LHS	975	$F$13<=$H$13	Not Binding	25

Microsoft Excel 10.0 Sensitivity Report

Adjustable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$B$4	Production SS	1300	0	0.6	0.1	0.6
$C$4	Production AS	3700	0	0.7	1.4	0.1
$D$4	Production SC	1200	0	16	1E+30	2.6
$E$4	Production DC	975	0	18	3.466666667	16.8

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$F$7	Raw Steel LHS	25450	0	30000	1E+30	4550
$F$8	Aluminum LHS	25000	0.1	25000	1300	3700
$F$9	Polishing LHS	5000	0.6	5000	4550	1300
$F$10	Stamping LHS	2175	0	3000	1E+30	825
$F$11	Assembly LHS	1500	21	1500	20	86.66666667
$F$12	SC Market LHS	1200	2.6	1200	1300	33.33333333
$F$13	DC Market LHS	975	0	1000	1E+30	25

d_____6. In the Excel spreadsheet model input, if the first column is A and the first row is 1, the decision variables will be columns B-E of row 4 and the constraints will be in rows 7-13. Which of the followings defines the LHS of the constraint for the aluminum usage and capacity?
a. SUMPRODUCT(B4:F4, B7:F7)
b. SUMPRODUCT(B4:E4, B2:E7)
c. SUMPRODUCT(B4:E4, B10:E10)
d. SUMPRODUCT(B4:E4, B8:E8)

d_____7. What is the total optimal production of standard and deluxe chasses?
a. 1800
b. 1200
c. 975
d. 2175

a_____8. What is the incremental contribution associated with adding an hour of assembly time?
a. $21
b. $2.6
c. $2
d. $0.6

b_____9. Which of the following resource constraints is a non-binding constraint, i.e., not using all available?
a. Aluminum
b. Raw steel
c. Assembly
d. Polishing

c_____10. If Valley Chassis considers increasing the profit contribution per pound of steel sheeting, what is the maximum increase in order to maintain the current optimal production?
a. 2.6
b. 1.4
c. 0.1
d. 0.6

b_____11. The advertising agency of Phillips, West, and Thornton has devised a marketing plan for the Valley Chassis. The plan will increase demand by 50 Standard Chassis per month. What is the maximum price VC will pay to adopt the plan?
a. $5
b. $130
c. $30
d. $1050

a_____12. A third type of chassis rack has been proposed as a very lightweight, "top-of-the-line" item. Such a chassis would require 8 pounds of steel and 16 pounds of aluminum. In addition, one unit of stamping capacity and 48 minutes of assembly would be required. What is the minimum contribution (profit) VC should charge in order to make up the use of these resources?
a. $18.4
b. $16
c. $21
d. $1.6

Use the following case to answer questions 13-17.

Mexican Wire Works

Ron Garcia felt good about his first week as a management trainee at Mexican Wire Winding, Inc. He had not yet developed any technical knowledge about the manufacturing process, but he had toured the entire facility, located in the suburbs of Mexico City, and had met many people in various area of the operation.

Mexicana, a subsidiary of Westover Wire Works, a Texas firm, is a medium-sized producer of wire windings used in making electrical transformers, Carlos Alverez, the production control manager, described the windings to Garcia as being of standardized design. Garcia's tour of the plant, laid out by process type (See Figure 7.20), followed the manufacturing sequence for the windings: drawing, extrusion, winding, inspection, and packaging. After inspection, good product is packaged and sent to finished product storage; defective product is stored separately until it can be reworked.

On March 8, Vivian Espania, Mexicana's general manager, stopped by Garcia's office and asked him to attend a staff meeting at 1:00 P.M.

"Let's get started with the business at hand," Vivian said, opening the meeting. "You all have met Ron Garcia, our new management trainee. Ron studied operations management in his college program in southern California, so I think he is competent to help us with a problem we have been discussing for a long time without resolution. I'm sure that each of you on my staff will give Ron your full cooperation."

Vivian turned to José Arroyo, production control manager. "José, why don't you describe the problem we are facing?" "Well," José said, "Business is very good now. We are booking more orders than we can fill. We will have some new equipment on line within the next several months, which will take care of our capacity problems, but that won't help us in April. I have located some retired employees who used to work in the drawing department, and I am planning to bring them in as temporary employees in April to increase capacity there. Because we are planning to refinance some of our long-term debt, Vivian wants our profits to look as good as possible in April. I'm having a hard time figuring out which orders to run and which to back orders so that I can make the bottom line look as good as possible. Can you help me with this?"

Garcia was surprised and apprehensive to receive such an important, high-profile assignment so early in his career. Recovering quickly, he said, "Give me your data and let me work with it for a day or two."

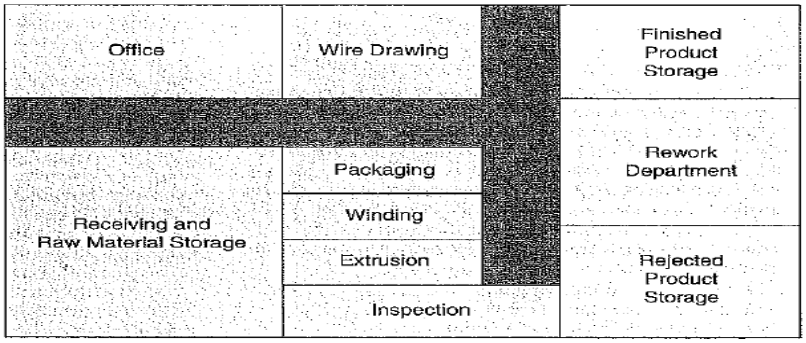


Figure 7-20. Mexican Wire Winding, Inc.

April Order

Product W0075C	1,400 units
Product W0033C	250 units
Product W0005X	1,510 units
Product W0007X	1,116 units

Note: Vivian Espania has given her word to a key customer that we will manufacture 600 units of product W0007X and 150 units of product W0075C for him during April.

Standard Cost

PRODUCT	MATERIAL	FABRIC	OVERHEAD	SELLING PRICE
W0075C	$33.00	$9.90	$23.10	$120.00
W0033C	25.00	7.50	17.50	100.00
W0005X	35.00	10.50	24.50	140.00
W0007X	75.00	11.25	63.75	195.00

Selected Operating Data

Average output per month = 2,400 units

Average machine utilization = 63%

Average percentage of production set to rework department = 5% (mostly from Winding Department)

Average no. of rejected units awaiting rework = 850 (mostly from Winding Department)

Plant Capacity (Hours)

DRAWING	EXTRUSION	WINDING	PACKAGING
4,000	4,200	3,000	2,500

Note: Inspection capacity is not a problem; we can work overtime, as necessary, to accommodate any schedule.

Bill of Labor (Hours/Unit)

PRODUCT	DRAWING	EXTRUSION	WINDING	PACKAGING
W0075C	1.0	1.0	1.0	1.0
W0033C	2.0	1.0	3.0	0.0

W0005X	0.0	4.0	0.0	3.0
W0007X	1.0	1.0	0.0	2.0

The following reports show the Excel LP spreadsheet model, the answer and the sensitivity reports. Answer the following questions based on these reports.

Mexicana April Production

	W0075C	W0033C	W0005X	W0007X	LHS	Direction	RHS	Slack
DV	1300	250	0	600	109700			
OBJ	54	50	70	45				
S.T								
Drawing	1	2		1	2400	<=	4000	1600
Extrusion	1	1	4	1	2150	<=	4200	2050
Winding	1	3			2050	<=	3000	950
Packaging	1		3	2	2500	<=	2500	0
W0075C Order	1				1300	<=	1400	100
W0033C Order		1			250	<=	250	0
W0005X Order			1		0	<=	1510	1510
W0007X Order				1	600	<=	1116	516
W0007X Promise				1	600	>=	600	0
W0075C Promise	1				1300	>=	150	1150

Result: Solver found a solution. All Constraints and optimality conditions are satisfied.

Objective Cell (Max)

Cell	Name	Original Value	Final Value
$G$5	DV LHS	0	109700

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$C$5	DV W0075C	0	1300	Contin
$D$5	DV W0033C	0	250	Contin
$E$5	DV W0005X	0	0	Contin
$F$5	DV W0007X	0	600	Contin

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$G$8	Drawing LHS	2400	$G$8<=$I$8	Not Binding	1600
$G$9	Extrusion LHS	2150	$G$9<=$I$9	Not Binding	2050
$G$10	Winding LHS	2050	$G$10<=$I$10	Not Binding	950
$G$11	Packaging LHS	2500	$G$11<=$I$11	Binding	0
$G$12	W0075C Order LHS	1300	$G$12<=$I$12	Not Binding	100
$G$13	W0033C Order LHS	250	$G$13<=$I$13	Binding	0
$G$14	W0005X Order LHS	0	$G$14<=$I$14	Not Binding	1510
$G$15	W0007X Order LHS	600	$G$15<=$I$15	Not Binding	516
$G$16	W0007X Promise LHS	600	$G$16>=$I$16	Binding	0
$G$17	W0075C Promise LHS	1300	$G$17>=$I$17	Not Binding	1150

Microsoft Excel 14.0 Sensitivity Report

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$C$5	DV W0075C	1300	0	54	1E+30	30.66666667
$D$5	DV W0033C	250	0	50	1E+30	50
$E$5	DV W0005X	0	-92	70	92	1E+30
$F$5	DV W0007X	600	0	45	63	1E+30

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$G$8	Drawing LHS	2400	0	4000	1E+30	1600
$G$9	Extrusion LHS	2150	0	4200	1E+30	2050
$G$10	Winding LHS	2050	0	3000	1E+30	950
$G$11	Packaging LHS	2500	54	2500	100	1150
$G$12	W0075C Order LHS	1300	0	1400	1E+30	100
$G$13	W0033C Order LHS	250	50	250	316.6666667	250
$G$14	W0005X Order LHS	0	0	1510	1E+30	1510
$G$15	W0007X Order LHS	600	0	1116	1E+30	516
$G$16	W0007X Promise LHS	600	-63	600	516	50
$G$17	W0075C Promise LHS	1300	0	150	1150	1E+30

c_____13. The selling price of W0005X is $140 and its profit is $70 but the solution shows no production for this product. What is the lowest price for W0005X to be considered for production, i.e., its solution becomes positive?
a. $162
b. $210
c. $232
d. $92

b_____14. Based on the optimal solution, what is the total production quantity of all products?
a. 1300
b. 2150
c. 600
d. 250

d_____15. If Mexicana is planning to add capacities to its production departments, which department should be considered first?
a. Drawing
b. Extrusion
c. Winding
d. Packaging

c_____16. If the Drawing department has an option to add additional 100 hours capacity by bringing back some newly retired workers, how much will the net profit increase for this capacity increase?
a. $2,400
b. $3,400
c. $0
d. $6,000

a_____17. Based on the above sensitivity analysis for the constraints, the final value represents the LHS (left-hand-side) of the constraint at the optimal solution. Use this information to compute the overall utilization for the four departments (drawing, extrusion, winding, and packaging) in April if the optimal solution is adopted. What is the overall utilization rate?
a. 66.42%
b. 59.56%
c. 48.25%
d. 75.34%

Use the following case to answer questions 18-20.

Galaxy Industries is an emerging toy manufacturing company that produces two "space age" water guns that are marketed nationwide, primarily to discount toy stores. The two models, the Space Ray and the Zapper, are produced in units of one-dozen each and are made exclusively from a special plastic compound. Two of the resources are the 3000 pounds of the special plastic compound and the 100 hours of production time that are available each week.

Galaxy's marketing department is more concerned with building a strong customer demand base for the fledgling company's products than with meeting high production quotas. Two of its recommendations, which Galaxy's management has accepted, are to limit total weekly production to at most 1500 dozen units and to prevent weekly production of Space Rays from exceeding that of Zappers by more than 400 dozens. The following table summarizes the per-dozen resource requirements and profit values (calculated by subtracting variable production costs from their wholesale selling prices).

Resource	Space Ray	Zapper	Total Available
Special Plastic (pounds)	3	2	3000 lbs.
Production Time	2 minutes	3 minutes	100 hours
Profit per-dozen	$18	$11	

The following reports show the Excel LP spreadsheet model, the answer and the sensitivity reports. Answer the following questions based on these reports.

		Space Ray	Zapper			
DV		760	360	OBJ/TP		
Profit		18	11	17640		
S.T.				LHS	Dir/Sign	RHS
Plastic		3	2	3000	<=	3000
Production Time		2	3	2600	<=	6000
Total Production		1	1	1120	<=	1500
Marketing Mix		1	-1	400	<=	400

Microsoft Excel 14.0 Answer Report

Objective Cell (Max)

Cell	Name	Original Value	Final Value
$F$6	Profit OBJ/TP	0	17640

Variable Cells

Cell	Name	Original Value	Final Value	Integer
$D$5	DV Space Ray	0	760	Contin
$E$5	DV Zapper	0	360	Contin

Constraints

Cell	Name	Cell Value	Formula	Status	Slack
$F$8	Plastic LHS	3000	$F$8<=$H$8	Binding	0
$F$9	Production Time LHS	2600	$F$9<=$H$9	Not Binding	3400
$F$10	Total Production LHS	1120	$F$10<=$H$10	Not Binding	380
$F$11	Marketing Mix LHS	400	$F$11<=$H$11	Binding	0

Microsoft Excel 14.0 Sensitivity Report

Variable Cells

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
$D$5	DV Space Ray	760	0	18	1E+30	1.5
$E$5	DV Zapper	360	0	11	1	29

Constraints

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
$F$8	Plastic LHS	3000	5.8	3000	950	1800
$F$9	Production Time LHS	2600	0	6000	1E+30	3400
$F$10	Total Production LHS	1120	0	1500	1E+30	380
$F$11	Marketing Mix LHS	400	0.6	400	600	1900

c_____18. If Galaxy can obtain 450 pounds of additional plastic compound, how much is the maximum total price Galaxy should pay for this additional resource?
a. $3,000
b. $950
c. $2,610

d. $1800

b_____19. What is the maximum profit per dozen for Zapper for the current optimal solution holds?
a. $18
b. $12
c. $29
d. $11

d_____20. For Galaxy's production, if some less-than or equal-to (≤) constraints become more restricted by reducing the right hand side values, for example, less plastic compound available, which of the following results is typically or most likely correct for the new situation?
a. The optimal solution (production) will have fractional values.
b. The optimal objective function value (weekly profit) will improve.
c. The optimal solution (production) will not change.
d. The optimal objective function value (weekly profit) will decrease.

II. Problem:

1. A winner of the Texas Lotto has decided to invest $500,000 in the stock market. Under consideration are stocks for a petrochemical firm and a public utility. Although a long-range goal is to get the highest possible return, some consideration is given to the risk involved with stocks. A risk index on a scale of 1-10 (with 10 being the most risky) is assigned to each of the two stocks. The total risk of the portfolio is found by multiplying the risk index of each stock by the dollars invested in that stock.

The following table provides a summary of the return and risk:

Stock	Estimated Return	Risk Index
Petrochemical	12%	9
Utility	7%	4

The investor would like to maximize the return on the investment, but the average risk index of the investment should not be higher than 6. Formulate this investment problem by finishing the following elements.

(a). Define the decision variables for the investment situation. Write the symbol or notation and its plain description for each decision variable. (2 points)

X_1 = Dollars invested in petrochemical firm
X_2 = Dollars invested in public utility

(b). Label and formulate the investor's objective function. (2 points)

Maximize $0.12X_1 + 0.07X_2$ (return on the investment)

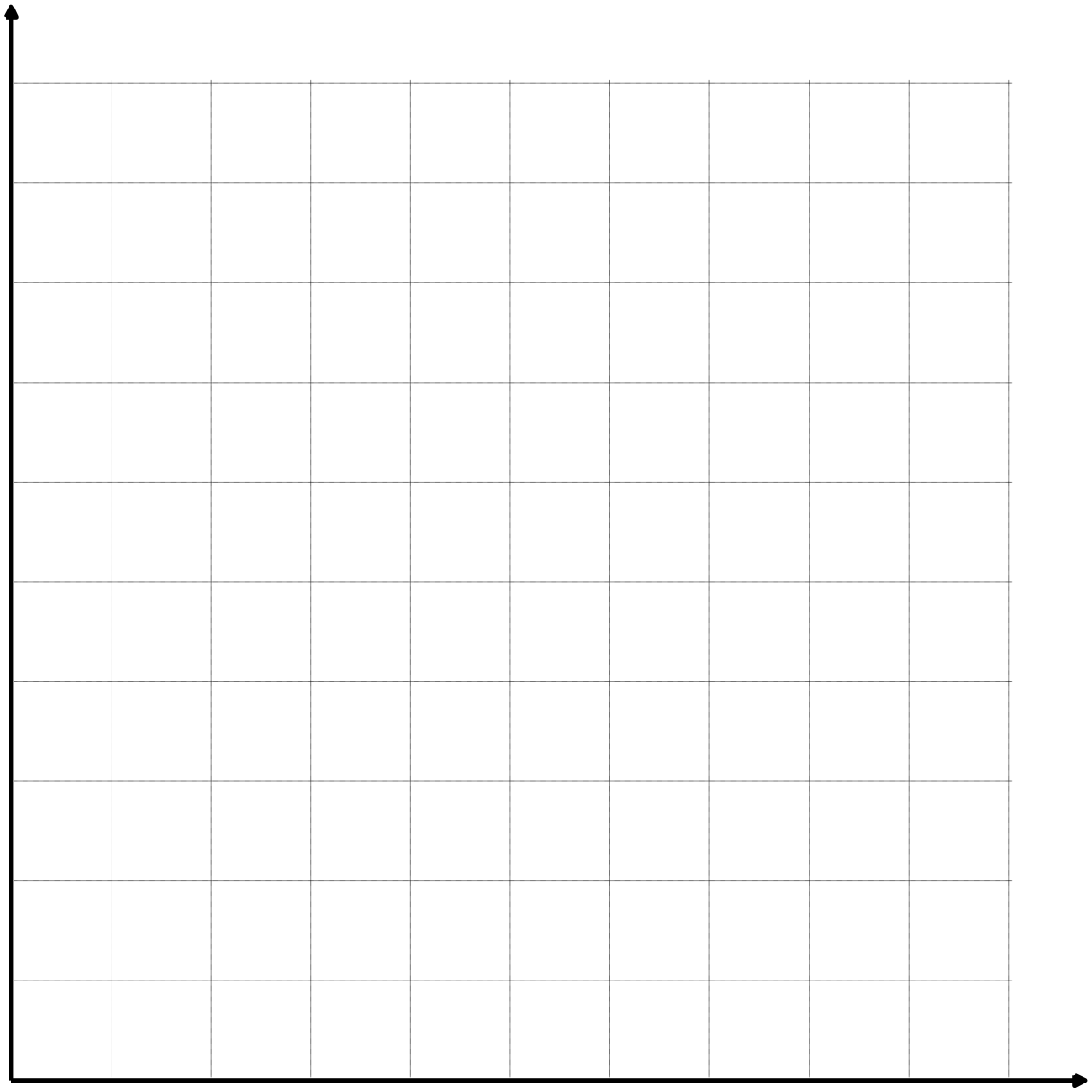
(c). Formulate the constraints for the investment situation. Label each constraint in parenthesis. (6 points)

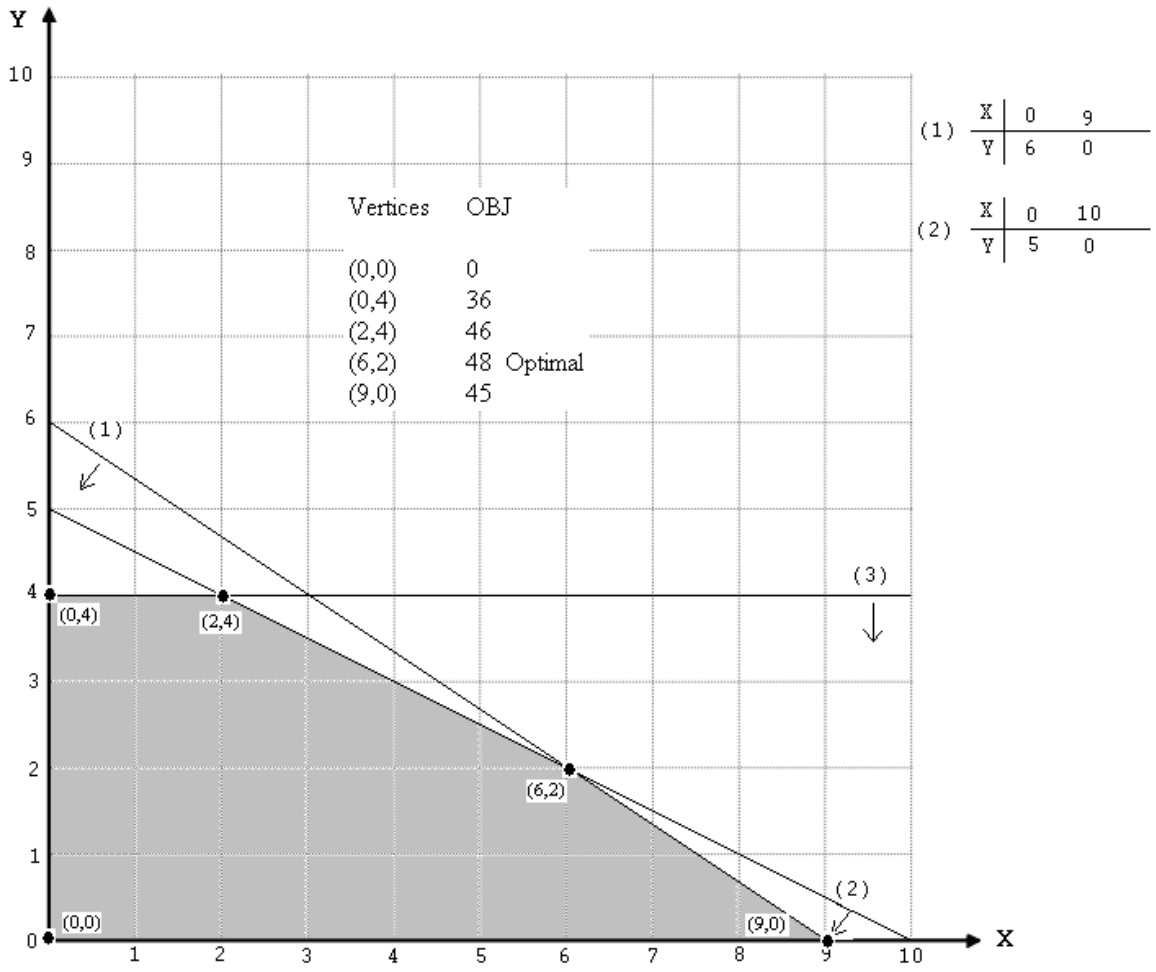
$X_1 + X_2 \leq 500{,}000$ (Total investment)
[Or $X_1 + X_2 = 500{,}000$ (Total investment)]
$9X_1 + 4X_2 \leq 6(500{,}000)$ (Total risk index)
[Or $9X_1 + 4X_2 \leq 3{,}000{,}000$ (Total risk index)]
$X_1, X2 \geq 0$ (Non-negativity)

2. Consider the following linear programming problem: (19 points)

Maximize	$5X + 9Y$	(OBJ)
Subject to	$4X + 6Y \leq 36$	(1)
	$X + 2Y \leq 10$	(2)
	$Y \leq 4$	(3)
	$X, Y \geq 0$	

(a). Solve the problem graphically by clearly plotting and labeling the constraints. (5 points)
(b). Identify and shade the feasible region. (2 points)
(c). Identify the vertices or extreme points and their values. (5 points)
(d). Determine the optimal solution (that is the values of X and Y), and also compute the value of the objective function at the optimal solution. (2 points)
(e). Identify the binding and non-binding constraint(s). (3 points)
(f). Is (4, 2) feasible? Is (7, 3) feasible? (2 points)
NOTE: Graph paper follows on the next page. You may answer all the above questions on the graph paper (label clearly).





(d). Optimal solution: (6, 2); Optimal OBJ=48
(e). Constraints (1) and (2) are binding.
(f). (4, 2) is feasible; (7, 3) is infeasible.

3. The Consolidated Company has in the past contracted out the shipment of its products from its factory to its warehouses. The volume of deliveries is measured in ton-miles (tons of product x number of miles over which it is to be delivered). Consolidated has 450,000 ton-miles to be delivered each month.

Currently, Consolidated is paying Speedie Trucking Company 55 cents per ton-mile to deliver the product. Consolidated is considering the purchase of a fleet of trucks to take over all or part of the delivery service. Three types of trucks are under consideration: large trailer trucks, medium sized trucks, and pickup trucks. Details on each type are given below.

Type	Purchase Cost	Operating Cost Per Ton-Mile	Capacity per Month In Ton-Miles
Trailer Truck	$15,000	0.35	10,000
Medium Truck	$8,000	0.375	8,000
Pickup Truck	$5,000	0.45	6,000

Speedie Trucking has indicated that it would be willing to continue to deliver any excess not delivered by Consolidated's own trucks at the rate of 55 cents per ton-mile.

Capital equipment funds are in short supply at Consolidated, and only $500,000 is available to purchase the truck equipment. Because of parking space and dock limitations, not more than 32 truck spaces are available. A trailer or medium truck would use one space, while two pickup trucks can use one space. Also, because of the types and sizes of deliveries, at least two-thirds of the trucks purchased must be either trailers or medium trucks. The objective is to minimize total monthly operating cost.

(a). Define the decision variables for Consolidated's situation. Write the symbol or notation and its plain description for each decision variable. (4 points)

T: number of trailer trucks to purchase
M: number of medium trucks to purchase
P: number of pickups to purchase
LS: monthly load contracted out to Speedie in ton-miles

(b). Label and formulate the objective function. (2 points)

Min 3500T+3000M+2700P+0.55LS (Total monthly operating cost)

(c). Formulate the constraints for the Consolidated's situation. Label each constraint in parenthesis. (5 points)

S.T.	10000T+8000M+6000P+LS=450000	(Delivery demand)
	15000T+8000M+5000P≤500000	(Capital Budget)
	T+M+0.5P≤32	(Parking Space)
	T+M-2P≥0	(Truck Mix)
	[or T+M ≥(2/3)(T+M+2P)]	
	T, M, P, LS≥0	(Non-negativity)