**MGT 2251 Management Science**

**Exam 1**

**NOTE THAT THE DURATION OF THIS EXAM IS 50 MINUTES. THE DURATION OF OUR EXAM WILL BE 80 MINUTES**

**Name (Print):\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

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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 (Q1- Q16)**

**Choose the best answer for the following questions.**  (2.5 points each)

1. A solution that satisfies all the constraints in an LP minimization problem and gives lowest value of the objective function is called
2. the unbounded solution
3. **the optimal solution**
4. the infeasible solution
5. the feasible solution
6. At the optimal solution for an LP problem, if a constraint has the left-hand-side value **not equal** to the right-hand-side values, then which of the following is **false?**
7. the constraint is nonbinding
8. the constraint has positive slack or surplus
9. the constraint has zero shadow price
10. **an infinitesimal change in the right-hand side of the constraint changes optimal objective function value. (false because non-binding)**
11. Which of the following does **not** change the feasible region?
12. **increasing an objective function coefficient in a maximization problem**
13. adding a new constraint
14. increasing the right-hand side of a constraint
15. changing a coefficient of a constraint
16. When more than one optimal solutions exist in an LP problem, then
17. one of the constraints will be redundant
18. **the objective function will be parallel to one of the constraints**
19. two constraints will be parallel
20. the problem will also be unbounded
21. What is limitation of graphical method over “excel solver” method
22. graphical method is not suitable when the number of constraints is more than 2
23. graphical method is not suitable when the number of constraints is more than 4
24. **graphical method is not suitable when the number of decision variables is more than 2**
25. graphical method is not suitable when either the number of constraints is more than 2 or the number of decision variables is more than 2

**Use the following data to answer questions Q6-Q16.**

“Personal Mini Warehouses” is planning to expand its successful Orlando business into Tampa. In doing so, the company must determine how many storage rooms of large and small size to build. Its objective and constraints are as follows:

Maximize monthly earnings = 50X + 20Y

Subject to 2X + 4Y ≤ 400 (monthly advertising budget available)

100X + 50Y ≤ 8,000 (storage space)

X ≤ 60 (rental limit expected)

X, Y ≥0

Where X =number of large rooms developed

Y=number of small rooms developed

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Variable Cells | | |  |  |  |  |  |
|  |  |  | **Final** | **Reduced** | **Objective** | **Allowable** | **Allowable** |
|  | **Cell** | **Name** | **Value** | **Cost** | **Coefficient** | **Increase** | **Decrease** |
|  | $B$3 | Large Rooms | 60 | 0 | 50 | 1E+30 | 10 |
|  | $C$3 | Small Rooms | 40 | 0 | 20 | 5 | 20 |
|  |  |  |  |  |  |  |  |
| Constraints | | |  |  |  |  |  |
|  |  |  | **Final** | **Shadow** | **Constraint** | **Allowable** | **Allowable** |
|  | **Cell** | **Name** | **Value** | **Price** | **R.H. Side** | **Increase** | **Decrease** |
|  | $D$6 | Advertising Budget | 280 | 0 | 400 | 1E+30 | 120 |
|  | $D$7 | Storage Space | 8000 | 0.4 | 8000 | 1500 | 2000 |
|  | $D$8 | Rental Limit | 60 | 10 | 60 | 20 | 20 |

1. Based on the optimal solution, what is the optimal monthly earnings?
2. $3000

50X + 20 Y

50(60) + 20(40)

= $3800

1. **$3800**
2. $2000
3. $800
4. Which of the constraints is nonbinding?
5. **Advertising Budget**
6. Storage Space

shadow price = 0 🡪 nonbinding

1. Rental Limit
2. None
3. Assuming all other parameters remain unchanged, if the objective function coefficient associated with “**Small Rooms**” decreases by $10, what will be the change in the objective function?

within allowable decrease?

Yes! Optimal solution won’t change

$10 decrease/unit \* 40 units = $400 decrease

1. increases by $200
2. decreases by $200
3. increases by $400
4. **decreases by $400**
5. Assuming all other parameters remain unchanged, if the objective function coefficient associated with “**Large Rooms**” increases by $20, what will be the change in the objective function?

$20 increase/unit

within allowable decrease

$20 increase/unit \* 60 units = $1200 increase

1. increase by $1000
2. decrease by $1000
3. **increases by $1200**
4. decrease by $1200
5. Assuming all other parameters remain unchanged, if the objective function coefficient associated with “**Large Rooms**” increases by $20, what will be the change in the **optimal solution**?
6. The optimal number of Large Rooms decreases
7. **The optimal number of Large Rooms remains the same**
8. The optimal number of Large Rooms increases
9. The optimal number of Large Rooms can either decrease or increases
10. Assuming all other parameters remain unchanged, what is the range of the objective function coefficient associated with **Small Rooms** for which the current optimal solution still remains optimal?

max allowed: 20 + 5 = 25

min allowed: 20 - 20 = 0

0 🡪 25

1. Between 20 and 25
2. Between 15 and 40
3. **Between 0 and 25**
4. Between 40 and plus infinity
5. If the “**Rental Limit**” constraint’s right-hand side were 75, what would have been optimal profit of the Personal Mini Warehouses?
6. $3800

Rental Limit = binding

15 unit increase \* 10 shadow price = $150 increase

3800 + 150 = 3950

1. **$3950**
2. $4100
3. $3650
4. If the “Advertising Budget” available were only $300, what would have been optimal profit of the Personal Mini Warehouses?
5. **$3800**

AB = non-binding

nonbinding constraint = no change in profit

1. $3700
2. $3500
3. $3600
4. Assuming all other parameters remain unchanged, if another firm is ready to provide loan for **Advertising Budget** to Personal Mini Warehouses at interest rate of **1% per month**,should Personal Mini Warehouses accept the offer?
5. Yes

AB = nonbinding (shadow price = 0)

never accept offer for nonbinding constraint

1. **No**
2. Can’t say
3. Assuming all other parameters remain unchanged, if another firm is ready to lease its **Storage Space** to Personal Mini Warehouses,what is the maximum monthly rental per unit of storage space below which Personal Mini Warehouses should accept the offer?
4. $0

shadow price = $0.40

1. **$0.4**
2. $9500
3. $10
4. Assuming all other parameters remain unchanged, if another firm leases 400 units its **Storage Space** to Personal Mini Warehouses at monthly rental **$20 per 100 units** of storage space, what is total profit to Personal Mini Warehouses in this new setting?
5. $3800
6. **$3880**

$20 per 100 units (400 units)

SS = binding

$20 / 100 units = $0.20 / unit < 0.40

Take! lower than shadow price

.40 - .20 = 0.20 / unit

.20 \* 400 = $80

$3800 + 80 = $3880

1. $3720
2. $3960

**II. Problem (30 points for each question)**

1. MSA Computer Corporation manufactures three models of computers: Netbook, Notebook and Desktop. The firm employs five technicians, working 160 hours each per month, on its assembly line. It requires 10 labor hours to assemble each Netbook, 15 labor hours to assemble each Notebook and 8 labor hours to assemble each Desktop. Each computer model requires data storage space. However, the supply of data storage space available is only 10000 GB per month. Each Netbook requires 200 GB, each Notebook requires 300 GB and each Desktop requires 100 GB data storage space. MSA wants at least 6 Netbooks and at most 10 Desktops to be produced each month. Furthermore, the number of Notebooks must be at least twice as the number of netbooks.

Netbooks generate $800 profit per unit, Notebooks generate $1000 profit per unit and Desktops generate $600 profit per unit. MSA aims to maximize its profit by choosing how many computers of each model to manufacture. Formulate this as linear programming problem. (30 points)

(a). Define the decision variables for MSA Computer Corporation. Write the symbol or notation and its plain description for each decision variable. (3 points)

x = # netbooks to be manufactured

y = # notebooks to be manufactured

z = # desktops to be manufactured

(b). If MSA Computer Corporation’s goal is to maximize its profit, formulate its objective function. (7 points)

max profit

max 800x + 1000y + 600z

(c). Formulate the constraints including non-negativity for MSA Computer Corporation. Label each constraint in parenthesis. (20 points)

1. 10x + 15y + 8z ≤ 800
2. 200x + 300y + 100z ≤ 10,000
3. x ≥ 6
4. z ≤ 10
5. -2x + y ≥ 0
6. x,y,z ≥ 0

2. Consider the following linear programming problem: (30 points)

Maximize 30X + 40Y (OBJ)

Subject to 2X + Y  8 (1)

2X - Y ≥ 2 (2)

Y  2 (3)

X, Y ≥ 0

Solve the problem graphically and answer the following:

(a). Clearly plot and label the constraints. (8 points)

(b). Identify and shade the feasible region. (3 points)

(c). Identify all the corner points or extreme points and their coordinates (i.e. the values of X and Y). (8 points)

(d). Compute the objective function values on all the corner points. (3 points)

(e). Determine the optimal solution (i.e. the values of X and Y), and also compute the value of the objective function at the optimal solution. (2 points)

(f). Identify the non-binding constraint(s). (2 points)

(g). Is coordinate (4, 1) feasible solution? Is (1, 3) feasible? (4 points)

**NOTE: Graph paper follows on the next page. You may answer all the parts of the question using the graph provided on the next page.**

Optimal:

x = 3

y = 2

max profit = $170

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