Illustrative Exam 2[1] Solutions
BUAD311T – Operations Management for Accounting Majors

Section A: Multiple Choices [No partial credits]. Circle only one.

1. Of the following five expressions, how many are linear?
   $x^2 - 3y$
   $\log x + y/3$
   $5x - 2y$
   $5x - y/2$
   $5x + 2^y$
   a) Only one expression. The other four are non-linear.
   b) Exactly two of them. The other three are non-linear.
   c) Exactly three. The other two are non-linear.
   d) Exactly four. The other is non-linear.
   e) All the five are.

b) Hint: only $5x - 2y$ and $5x - y/2$ are linear.

2. Which of the following is (are) true?
   I: A linear program always has a feasible solution.
   II: A linear program always has some decision variable(s)
   III: A linear program always has a unique optimal solution
   IV: A linear program always has an objective function.
   a) I and II are true. The others are false.
   b) I and III are true. The others are false.
   c) III and IV are true. The others are false.
   d) II and IV are true. The others are false.
   e) II and III are true. The others are false.

d) Hint: I—may not have feasible solutions.
III—may have multiple optimal solutions, or may not have optimal solution (if does not have feasible solutions).

3. Our company produces two products, product X and product Y, using three inputs: labor, raw material A, and raw material B. One unit of product X requires 8 hours of labor, 5 pounds of A, and 7.5 pounds of B. One unit of product Y requires 6 hours of labor, 10 pounds of A, and 4.5 pounds of B. The demand of each product is so large that the company can sell as many as it can produce. The firm earns a profit of \$3 per unit of X and \$4 per unit of Y. However, only 1200 labor hours, 900 pounds of A, and 675 pounds of B are available to the firm each day. You formulated the problem as a linear program.

Decision variables:	x: #units of product X we produce	
	y: #units of product Y we produce	
Objective:	Max $3x + 4y$	Maximize the profit function
Constraints (subject to):	$8x + 6y \le 1200$	Labor hours constraint
	$5x + 10y \le 900$	Raw Material A constraint
	$7.5x + 4.5y \le 675$	Raw Material B constraint
	$x \ge 0, y \ge 0$	Non-negativity constraints

The optimal decision variables turned out: x = 51.4285 and y = 64.2857. The sensitivity report created by Excel Solver is as follows.

[1] These are all actual questions that appeared in past exams. Note we may be covering slightly different materials this semester.

Adjustable Cells						
Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
B1	x	51.4285	0	3	3.666666667	1
B2	y	64.2857	0	4	2	2.2
Constraints						
Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
E3		797.1428571	0	1200	1E+30	402.8571429
F3		900	0.314285714	900	600	1E+30
G3		675	0.19047619	675	423	270

Which of the following statements is true?

a) If the coefficient of y in the objective function is 1.5 instead of 4, the optimal decision variables remain the same: x = 51.4285 and y = 64.2857.

b) It makes sense to pay $10 for an additional hour of labor.

c) Suppose we have 500 pounds of extra raw material A, we can use this Excel Solver output to calculate the increase in the optimal objective value.

d) Suppose we have 500 pounds of extra raw material B, we can use this Excel Solver output to calculate the increase in the optimal objective value.

e) None of the above.

c) Hint: a)—in the 2nd row of Table "Adjustable Cells", when the Objective Coefficient decreases from 4 to 1.5, the decrease is 2.5, exceeding the Allowable Decrease. Therefore, the optimal decision variables (Final Value) will change.
b)—in the 1st row of Table "Constraints", since the Shadow Price is 0, labor is not a binding constraint. That is, increasing labor does not change the optimal solution.
c)—in the 2nd row of Table "Constraints", since the extra A in less than the Allowable Increase, we can use the Shadow Price to calculate the increase to the optimal objective value.
d)—in the 3rd row of Table "Constraints", since the extra B is more than the Allowable Increase, we cannot use the Shadow Price to calculate the increase to the optimal objective value.

For questions 4 and 5, consider the following linear program.

Max $6(9x1 + 5x2) + 9(7x1 + 9x2)$

Subject to: $9x1 + 5x2 \geq 500$

$7x1 + 9x2 \geq 300$

$5x1 + 3x2 \leq 1500$

$7x1 + 9x2 \leq 1900$

$2x1 + 4x2 \leq 1000$

$x1 \geq 0, x2 \geq 0$

The associated Solver sensitivity report is shown below.

Adjustable Cells						
Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
C4	x1	271.42857	0	117	1E+30	30.66666667
C5	x2	0	-39.42857143	111	39.42857143	1E+30
Constraints						
Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
C11	9x1+5x2 >= 500	2443	0	500	1942.857143	1E+30
C12	7x1+9x2 >= 300	1900	0	300	1600	1E+30
C15	2x1+4x2 <= 1000	543	0	1000	1E+30	457.1428571
C13	5x1+3x2 <= 1500	1357	0	1500	1E+30	142.8571429
C14	7x1+9x2 <= 1900	1900	16.71428571	1900	200	1511.111111

4. Suppose the 1000 in the constraint "$2x1 + 4x2 \leq 1000$" is changed to 900. By how much does the optimal objective function value change?

a) 0
b) 16.71
c) -16.71
d) 1671
e) -1671

a) Hint: In the 3rd row of Table "Constraints", the decreases is 100, which is within the Allowable Decrease. The Shadow Price is 0, so the change to the optimal objective function is 0*(-100) = 0.

5. Which of the following statements is true?
   a) If the coefficient multiplying x1 changes, the optimal objective function value will change.
   b) If the coefficient multiplying x2 changes, the optimal objective function value will change.
   c) If the 500 in the first constraint changes to 600, the optimal objective function value will change.
   d) More than one of (a), (b), or (c) is true.
   e) None of the above.

a) Hint: a)—the optimal value (Final Value) of x1 is non-zero, then if the change to the coefficient multiplying x1 changes, the optimal objective function value will change.
b)—the optimal value (Final Value) of x2 is zero, then if the change to the coefficient multiplying x2 changes within the Allowable Increase/Decrease, the optimal objective function value will not change.
c)—in the 1st row of Table "Constraints", the increase is 100, with in the Allowable Increase. Therefore, the change to the optimal objective function is 0*100 = 0.

6. Which of the following is true?
   I: The shadow price for a non-binding constraint is positive
   II: The shadow price for a non-binding constraint is zero
   III: The shadow price for a binding constraint is always zero
   IV: The shadow price for a binding constraint is always positive
   a) II only
   b) II and III
   c) I and III
   d) II and IV
   e) I and IV

a) Hint: The shadow price for a non-binding constraint is zero, for a binding one could be positive or zero

7. Trojan Trends Inc. makes several lines of skirts, dresses and sport coats. Each product requires the same fabric and must pass through the cutting and sewing departments. The cutting department has 100 hours of capacity, the sewing department has 180 hours of capacity, and 60 yards of fabric are available. Each skirt contributes \$5 to profits, each dress, \$17, and each sport coat, \$30. Let x_1, x_2, and x_3 denote the number of skirts, dresses and sport coats respectively that the firm produces. The problem facing by the firm can be formulated as follows.

Maximize $5x_1 + 17x_2 + 30x_3$

Subject to: $x_1 + 3x_2 + 4x_3 <= 100$ (Cutting Department capacity constraint)
$x_1 + 4x_2 + 6x_3 <= 180$ (Sewing Department capacity constraint)
$x_1 + x_2 + 4x_3 <= 60$ (Fabric availability constraint)
$x_1 >= 0, x_2 >= 0, x_3 >= 0$ (Non-negativity constraints)

Consider the following Sensitivity Report generated when the above problem was solved and answer questions on the next page.

Adjustable Cells						
Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease