

This question paper consists of THREE (3) sections. Answer ALL questions in the answer booklet provided. [100 MARKS]

SECTION A

(50 Marks)

There are TEN (10) questions in this section. Answer ALL questions.

Case study: A Transportation Problem

CompanyA is a leading grower and distributor of fresh citrus products with three large citrus groves around central Florida in the cities of Grove1, Grove2 and Grove3.

CompanyA currently has 275,000 bushels of citrus at the grove in Grove1, 400,000 bushels at the grove in Grove2, and 300,000 bushels at the grove in Grove3.

CompanyA has citrus processing plants in Plant1, Plant2 and Plant3 with processing capacities to handle 200,000, 600,000 and 225,000 bushels, respectively.

CompanyA contracts with a local trucking company to transport its fruit from the groves to the processing plants. The trucking company charges a flat rate for every mile for transporting each bushel of fruit.

Each mile a bushel of fruit travel is known as a bushel-mile. The following are the distances between the groves and the processing plants:

- Grove1 to Plant1: 21 miles
- Grove1 to Plant2: 50 miles
- Grove1 to Plant3: 40 miles
- Grove2 to Plant1: 35 miles
- Grove2 to Plant2: 30 miles
- Grove2 to Plant3: 22 miles
- Grove3 to Plant1: 55 miles
- Grove3 to Plant2: 20 miles
- Grove3 to Plant3: 25 miles

CompanyA wants to determine how many bushels to ship from each grove to each processing plant to process all the fruit while minimizing the total number of bushel-miles the fruit must be shipped.

Use the nine decision variables below to answer the questions:

- X14: Number of bushels to ship from Grove1 to Plant1
- X15: Number of bushels to ship from Grove1 to Plant2
- X16: Number of bushels to ship from Grove1 to Plant3
- X24: Number of bushels to ship from Grove2 to Plant1
- X25: Number of bushels to ship from Grove2 to Plant2
- X26: Number of bushels to ship from Grove2 to Plant3
- X34: Number of bushels to ship from Grove3 to Plant1
- X35: Number of bushels to ship from Grove3 to Plant2
- X36: Number of bushels to ship from Grove3 to Plant3

1. How many non-negativity conditions must you set for this optimization problem?
 - A. 3, for the number of bushels to ship from Grove1 to Plant1, Plant2 and Plant3
 - B. 3, for the objective function, constraints, and decision variables
 - C. 6, for all the six constraints
 - D. 9, for all the nine decision variables

2. How do you set the constraint that indicates all supply available at Grove2 has to be shipped to the processing plants?
 - A. $X_{24} + X_{25} + X_{26} = 400,000$
 - B. $X_{24} + X_{25} + X_{26} = 300,000$
 - C. $X_{15} + X_{25} + X_{35} \leq 600,000$
 - D. $X_{16} + X_{26} + X_{36} \leq 225,000$

3. How do you set the constraint that indicates the capacity restriction for Plant1?
 - A. $X_{15} + X_{25} + X_{35} \leq 200,000$
 - B. $X_{14} + X_{24} + X_{34} \leq 200,000$
 - C. $X_{15} + X_{25} + X_{35} = 400,000$
 - D. $X_{14} + X_{24} + X_{34} = 400,000$

4. What is the objective function that you must set for this optimization problem?
 - A. $\text{MIN: } X_{14} + X_{24} + X_{34} + X_{15} + X_{25} + X_{35} + X_{16} + X_{26} + X_{36} \leq 200,000 + 600,000 + 225,000$
 - B. $\text{MAX: } X_{14} + X_{15} + X_{16} + X_{24} + X_{25} + X_{26} + X_{34} + X_{35} + X_{36} = 275,000 + 400,000 + 300,000$
 - C. $\text{MIN: } 21X_{14} + 50X_{15} + 40X_{16} + 35X_{24} + 30X_{25} + 22X_{26} + 55X_{34} + 20X_{35} + 25X_{36}$
 - D. $\text{MAX: } 21X_{14} + 50X_{15} + 40X_{16} + 35X_{24} + 30X_{25} + 22X_{26} + 55X_{34} + 20X_{35} + 25X_{36}$

5. Assume that you use Solver to solve an optimal solution and you also manually compute a feasible solution of this optimization problem. Comparing both solutions, the optimized solution yields equal to or less than the total number of bushel-miles the fruit must be shipped with than the feasible solution.
 - A. True
 - B. False

6. By using Solver to solve this optimization problem, what will be the outcome that Solver produced to update the Excel sheet?
- A. The optimized units of bushels shipped from each plant to each grove
 - B. The optimized units of bushels shipped from each grove to each plant
 - C. The optimized processing capacity that the plants should expand on
 - D. The optimized units of bushels that the groves should grow
7. You should set the upper bound (ceiling limit) of the decision variables as the non-negativity condition to prevent Solver from outputting negative values for its optimization outcome.
- A. True
 - B. False
8. By using Solver to solve this optimization problem, you found out that the unit of bushels shipped to Plant1 is more than its processing capacity (250,000 bushels shipped to Plant1 which only has the capacity to process 200,000 bushels). What could be wrong in your Solver constraint configuration that caused this?
- A. The units of bushels for Grove1, Grove2 and Grove3 were set to be more than or equal to 250,000 bushels
 - B. The unit of bushels for Grove1 was set to be more than or equal to 250,000 bushels
 - C. Plant1 processing capacity was set to be less than or equal to 200,000 bushels
 - D. Plant1 processing capacity was set to be more than or equal to 200,000 bushels
9. By using Solver to solve this optimization problem, you found out that the total sum of bushel-miles from each grove to each plant do not make sense. When you compute the problem manually, you can easily find a better solution with shorter total bushel-miles. What could be wrong in your Solver configuration of the objective function?
- A. There was no configuration available in Solver for the objective function
 - B. There was nothing wrong with the objective function
 - C. The objective function was set to be maximized
 - D. The objective function was set to be minimized
10. Each optimization problem has three main components for computation, which are:
- A. Objective function, decision variables, constraints
 - B. Objective function, constraints, budget allocated
 - C. Decision variables, company policy, constraints
 - D. Deadline restriction, decision variables, budget allocated

SECTION B

(40 Marks)

There are TEN (10) questions in this section. Answer ALL questions.

Case study: Blue Ridge Hot Tubs

An optimization problem was solved using Solver and three reports were generated: an answer report, a limits report, and a sensitivity report.

The following shows the respective answer report (Figure 1), limits report (Figure 2) and sensitivity report (Figure 3) of the optimization problem. Use these figures to answer the questions.

	A	B	C	D	E	F	G	H	I
1	Microsoft Excel 16.0 Answer Report								
2	Worksheet: [W6_1_Demo.xlsx]Production								
3	Report Created: 23/11/2020 14:23:20								
4	Result: Solver found a solution. All Constraints and optimality conditions are satisfied.								
5	Solver Engine								
6	Engine: Simplex LP								
7	Solution Time: 0.094 Seconds.								
8	Iterations: 2 Subproblems: 0								
9	Solver Options								
10	Max Time Unlimited, Iterations Unlimited, Precision 0.000001								
11	Max Subproblems Unlimited, Max Integer Sols Unlimited, Integer Tolerance 1%, Assume NonNegative								
12									
13									
14	Objective Cell (Max)								
15	Cell	Name	Original Value	Final Value					
16	\$D\$6	Unit Profits Total Profit	0	66100					
17									
18									
19	Variable Cells								
20	Cell	Name	Original Value	Final Value	Integer				
21	\$B\$3	Number to Make Aqua-Spas	0	122	Contin				
22	\$C\$5	Number to Make Hydro-Luxes	0	78	Contin				
23									
24									
25	Constraints								
26	Cell	Name	Cell Value	Formula	Status	Slack			
27	\$D\$10	Labour Required Used	1566	\$D\$10<=\$E\$10	Binding	0			
28	\$D\$11	Tubing Required Used	2712	\$D\$11<=\$E\$11	Not Binding	169			
29	\$D\$9	Pumps Required Used	200	\$D\$9<=\$E\$9	Binding	0			
30	\$B\$5	Number to Make Aqua-Spas	122	\$B\$5>=0	Not Binding	122			
31	\$C\$5	Number to Make Hydro-Luxes	78	\$C\$5>=0	Not Binding	78			

Figure 1: An Answer Report.

Microsoft Excel 16.0 Limits Report
Worksheet: [W6_L_Demo.xlsx]Production
Report Created: 23/11/2020 14:23:20

Objective		
Cell	Name	Value
\$D\$6	Unit Profits Total Profit	66100

Variable			Lower Objective		Upper Objective	
Cell	Name	Value	Limit	Result	Limit	Result
\$B\$5	Number to Make Aqua-Spas	122	0	23400	122	66100
\$C\$5	Number to Make Hydro-Luxes	78	0	42700	78	66100

Figure 2: A Limits Report.

A	B	C	D	E	F	G	H
1	Microsoft Excel 16.0 Sensitivity Report						
2	Worksheet: [W6_L_Demo.xlsx]Production						
3	Report Created: 23/11/2020 14:23:20						
4							
5							
6	Variable Cells						
7			Final	Reduced	Objective	Allowable	Allowable
8	Cell	Name	Value	Cost	Coefficient	Increase	Decrease
9	\$B\$5	Number to Make Aqua-Spas	122	0	350	100	50
10	\$C\$5	Number to Make Hydro-Luxes	78	0	300	50	66.66666667
11							
12	Constraints						
13			Final	Shadow	Constraint	Allowable	Allowable
14	Cell	Name	Value	Price	R.H. Side	Increase	Decrease
15	\$D\$10	Labour Required Used	1566	16.66666667	1566	234	126
16	\$D\$11	Tubing Required Used	2712	0	2880	1E+30	168
17	\$D\$9	Pumps Required Used	200	200	200	7	26

Figure 3: A Sensitivity Report.

- Referring to the answer report, which constraint resources will be completely used up when the optimized solution applies?
 - Available labour hours and number of tubes
 - Available number of tubes and number of pumps
 - Available labour hours and number of pumps
 - Available labour hours, number of tubes and number of pumps

2. Referring to the limits report, what will be the objective function value if the number of Aqua-Spas is set to zero and the number of Hydro-Luxes is set to 78?
 - A. 0
 - B. 42700
 - C. 66100
 - D. 23400

3. Referring to the limits report, the displayed values of the Objective Result columns always assume the Number to Make Aqua-Spas and the Number to Make Hydro-Luxes both change at the same time.
 - A. True
 - B. False

4. Referring to the sensitivity report, which of the following Objective Coefficient values will change the Final Value of Numbers to Make Aqua-Spas from 122 to something else?
 - A. 350
 - B. 250
 - C. 305
 - D. 440

5. Referring to the sensitivity report, which of the stated constraints are binding?
 - A. Labour required used and pumps required used
 - B. Labour required used and tubing required used
 - C. Tubing required used and pumps required used
 - D. Labour required used, tubing required used and pumps required used

6. Referring to the sensitivity report, a unit increase in the Constraint RHS value of Tubing Required Used from 2712 to 2713 did not increase the optimal objective function value.
 - A. True
 - B. False

7. Referring to the sensitivity report and given that the current optimal objective function value is \$66,100. What will be the new optimal objective function value if the Final Value of the Pumps Required Used increases from 200 to 202?
 - A. \$66100
 - B. \$66300
 - C. \$66500
 - D. \$65700

8. Referring to the sensitivity report and given that the current optimal objective function value is \$66,100. What will be the new optimal objective function value if the Final Value of the Tubing Required Used increases from 2712 to 2713?
- A. \$66100
 - B. \$66300
 - C. \$66130
 - D. \$65700
9. Referring to the sensitivity report, if the Labour Required Used value decreases by any amount in the range of zero to 126 hours, the optimal objective function value will increase by \$16.67 for each lost labour hour.
- A. True
 - B. False
10. Referring to the sensitivity report, if the Labour Required Used constraint increases from 1,556 hours to 1,728 hours (162 hours increment), the resulting objective function value will increase from \$66,100 to \$68,800. With that, the optimized solution – Numbers to Make for Aqua-Spas and Hydro-Luxes, will change respectively from 122 and 78 to some other values.
- A. True
 - B. False

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SECTION C

(10 Marks)

There are TWO (2) questions in this section. Answer ALL questions.

Question 1

(5 marks)

Answer the following questions based on the Limits Report below:

Microsoft Excel 16.0 Limits Report
Worksheet: [WS_L Demo.xlsx]Production
Report Created: 23/11/2020 14:23:20

Objective		
Cell	Name	Value
\$D\$6	Unit Profits Total Profit	66100

Variable			Lower Objective		Upper Objective	
Cell	Name	Value	Limit	Result	Limit	Result
\$B\$5	Number to Make Aqua-Spas	122	0	23400	122	66100
\$C\$5	Number to Make Hydro-Luxes	78	0	42700	78	66100

- a) Based on your understanding of the Limits report, what does the Limits Report summarise and indicate? (3 marks)
- b) What does the values in the Lower Limits column indicate? (1 marks)
- c) What does the values in the Upper Limits column indicate? (1 marks)

Question 2

(5 Marks)

Cell	Name	Final Value	Reduced Cost	Objective Coefficient	Allowable Increase	Allowable Decrease
\$B\$5	Number to Make Aqua-Spas	122	0	350	100	50
\$C\$5	Number to Make Hydro-Tubs	78	0	300	50	66.6666667

Cell	Name	Final Value	Shadow Price	Constraint R.H. Side	Allowable Increase	Allowable Decrease
\$D\$10	Labour Required Used	1566	16.66666667	1566	234	126
\$D\$11	Tubing Required Used	2712	0	2880	1E+30	168
\$D\$9	Pumps Required Used	200	200	200	7	26

- a) Based on your understanding of the Sensitivity report, what information does the Sensitivity Report summarize? List -TWO (2) informations. (2 marks)
- b) What does the information that you've listed above evaluate? Answer based on optimal solution and coefficient/values (3 marks)

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*** END OF QUESTION PAPER ***