School of Computer Sciences

CMT426/CMM426 Business Intelligence and Analytics

Academic Session: Semester 2, 2023/2024

Assignment 02

Question 1 (15 marks):

Consider the following linear programming model:

Maximize profit, $Z = 7x_1 + 5x_2$,

subject to

$$8x_2 - 5x_1 \leq 445 \qquad \text{(resource 1 constraint)}$$

$$4x_1 - 0.5x_2 \geq 40 \qquad \text{(resource 2 constraint)}$$

$$5x_1 + 2x_2 \leq 250 \qquad \text{(resource 3 constraint)}$$

$$2x_1 - x_2 \leq 5 \qquad \text{(resource 4 constraint)}$$

and
$$x_1 \geq 0, \ x_2 \geq 0$$

a. Solve this model using graphical method.
b. Use a software package based on the simplex method (e.g., Excel Solver) to solve the problem and then to generate sensitivity analysis. Explain the allowable range for each objective function coefficient, and the allowable range for each right-hand side. Give appropriate examples in your explanation.
c. Based on the shadow prices obtained from Question 2(b), if you only can perform additional investment in one of the four resources, which resource that you want to invest in? Explain your answer using an appropriate example.

Question 2 (15 marks):

Consider the following linear programming model:

Maximize $\quad P = 365(A + B + C) + 400(D + E + F) + 360(G + H + I) + 290(J + K + L)$

subject to

$A - 0.5D + G + 3J \leq 12$ $\qquad\qquad$ (Constraint 1)

$2B + E + H + K \geq 18$ $\qquad\qquad$ (Constraint 2)

$C + 2F + I + 4L \leq 10$ $\qquad\qquad$ (Constraint 3)

$2A + 3B + C \geq 20$ $\qquad\qquad$ (Constraint 4)

$D + E + 0.25F \geq 6$ $\qquad\qquad$ (Constraint 5)

$G + 3H + I \geq 50$ $\qquad\qquad$ (Constraint 6)

$-0.8J + K - 0.3L \leq 5$ $\qquad\qquad$ (Constraint 7)

$500A + 700D + 600G + 400J \leq 6400$ $\qquad\qquad$ (Constraint 8)

$250B + 520E + 300H + 200K \leq 6120$ $\qquad\qquad$ (Constraint 9)

$550C + 450F + 200I + 100L \leq 2100$ $\qquad\qquad$ (Constraint 10)

$\frac{1}{12}(A + D + G + J) - \frac{1}{18}(B + E + H + K) = 0$ $\qquad$ (Constraint 11)

$\frac{1}{12}(A + D + G + J) - \frac{1}{10}(C + F + I + L) = 0$ $\qquad$ (Constraint 12)

and
$\qquad A, B, C, D, E, F, G, H, I, J, K, L \geq 0$

Use a software package based on the simplex method (e.g., Excel Solver) to solve the problem and answer the following questions. All the values stated in the values must be rounded to 4 decimal places.
   a. What are the values for all the decision variables that maximize P.
   b. Identify the non-binding constraints. For each of the identified non-binding constraints, explain the slack/surplus value.

Question 3 (20 marks):

Company 99 Speed Courier provides delivery service of large parcels across the three states in the northern region of Peninsular Malaysia, i.e., Perlis, Kedah, Pulau Pinang. At each collection center, the parcels that have arrived are consolidated and loaded onto several trucks for delivery throughout the area. The parcels are normally divided among the trucks based on their geographical destinations to minimize the average time needed to make the deliveries.

The dispatch manager of Company 99 Speed Courier, Ali, needs to determine a delivery plan for 20 parcels. These parcels will be delivered to 20 distinct addresses which all at locations many kilometers apart. Ali has already identified a considerable number of attractive possible routes for individual delivery trucks. These routes are presented in the following table, where the numbers in each column indicate the order/sequence of the deliveries, along with the estimated time required to traverse the route.

Delivery Location	Attractive Possible Route																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Location 1	1	1		2							1									
Location 2							1	2									1		2	
Location 3			1							1					1					
Location 4		2				1		1									2	1		
Location 5												2								
Location 6	2											2								
Location 7						2							3							1
Location 8			2							2						1				
Location 9			3						3						3					
Location 10						4								1				4		
Location 11			4					3											1	
Location 12											3									
Location 13						3			2				2							
Location 14				1								1								2
Location 15					1			1												
Location 16				2			2											2		
Location 17		3											1			2				
Location 18														2				3		
Location 19				3												3	3			
Location 20					3										2					
Time (in hours)	6	8	6	6	7	5	7	8	9	9	8	9	6	5	7	5	5	8	7	5

Use a software package based on the simplex method (e.g., Excel Solver) to help Ali to determine the minimum number of trucks needed that minimize the total traveling while including each delivery location on exactly one route.

Question 4 (20 marks):

Ali has three farms that grow Plant A, Plant B, Plant C. Because of different soil conditions, there are differences in the yields and costs of growing crops on these three farms. The yields and costs are as follows:

	Farm 1	Farm 2	Farm 3
Plant A yield/acre (kg)	420	300	500
Cost/acre of plant A (RM)	90	50	45
Plant B yield/acre (kg)	200	250	250
Cost/acre of plant B (RM)	75	80	50
Plant C yield/acre (kg)	300	150	125
Cost/acre of plant C (RM)	25	50	90

Farm 1, Farm 2, and Farm 3 have 100, 50, and 100 acres available for cultivation respectively. 21000kg of Plant A, 25000kg of plant B, and 30000kg of plant C must be grown. Determine a planting plan that will minimize the cost of meeting these demands.

    a. Formulate a linear programming model for this problem.
    b. Use a software package based on the simplex method (e.g. Excel Solver) to solve the problem.
    c. One of the cost-saving ideas for Ali is to expand the area of Farm 1. Is this a true statement?
    d. Analyze the consequence of fully utilizing all the three farms to meet the demands? Is this a wise decision to do so?

Question 5 (30 marks):

Ali owns a manufacturing workshop. He recently received 20 orders from his customers. The respective processing time (in hours) and the due date (in -th hour) of the 20 orders are shown as follows.

Order	Processing Time (hours)	Due Date (-th hour)
1	13	25
2	9	24
3	5	15
4	15	36
5	7	22
6	8	18
7	8	17
8	7	26
9	4	20
10	7	17
11	11	29
12	5	14
13	8	23
14	3	10
15	12	25
16	2	8
17	7	16
18	6	29
19	12	34
20	8	33

The due date is determined from the point of starting of the scheduling process. At the point of Ali would like to perform the scheduling, he has 20 workers. Due to the nature of the manufacturing processes of these 20 orders, the workers must be grouped to run the manufacturing processes. Ali intends to come up with a schedule based on the following groupings:

a. 3 workers in a group, i.e., 7 groups of workers, each group with 3 workers except one group with 2 workers.
b. 4 workers in a group, i.e., 5 groups of workers.
c. 5 workers in a group, i.e., 4 groups of workers.

Based on the past experience, operations cost increases when more groups are formed. For each of the group settings, in what order the job should be scheduled to minimize the makespan (i.e., the time to complete all jobs)? Create an Excel Evolutionary model to help Ali to generate a schedule for each of the group settings. The parameter of the Excel Evolutionary model must be clearly reported. Analyze and evaluate the generated schedules.

Assignment Instructions:

This is a group assignment. The member grouping for Assignment 01 will apply.

For the question which requires you to use a software package based on the simplex method to solve the linear programming problem, **relevant screenshot of the model as well as the sensitivity information must be included in the assignment script**. You are recommended to use Excel Solver in this assignment.

Due date: 05 Jul 2024 (Friday), 23:59 p.m. Failure to submit the assignment will be a disadvantage to you.

Submission Procedure: A zip/rar package which contains an assignment script in PDF and an Excel file in XLSX must be submitted via eLearn@USM. Kindly organize all your Excel models in one Excel file. The Excel file will be submitted via eLearn@USM. Please use a new worksheet for each question and clearly label the worksheets.

The zip/rar package must be named according to the following notation: **CMT423_CMT426_CMM426_GXX_A02**, where the GXX is the group number. For example, for the submission performed by Group 5; the zip/rar package must be named as **CMT423_CMT426_CMM426_G05_A02**.

One of the group members is required to submit the zip/rar package. Kindly communicate with your group members before the submission to avoid any miscommunication.

Assignment evaluation: The total mark for this assignment is 100 marks. The total will be scaled to 10% of your overall grade. Questions 1 – 5 are computational-based questions. Hence, they will be evaluated based on a marking scheme.

Reference: Kindly state any source of reference in your assignment report should you refer to various sources to complete this assignment.

IMPORTANT: Students who copied or plagiarized other's work or let their work be copied or plagiarized will be given an F grade. The student may be barred from sitting for final exam and reported to the university's disciplinary board.

~~END OF ASSIGNMENT 02~~