UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
MAY 2023 SEMESTER

COURSE : **FEM3023 - SIMULATION AND OPTIMISATION**
DATE : **7 AUGUST 2023 (MONDAY)**
TIME : **9:00 AM - 12:00 NOON (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.

2. Begin **EACH** answer on a new page in the Answer Booklet.

3. Indicate clearly answers that are cancelled, if any.

4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.

5. **DO NOT** open this Question Booklet until instructed.

Note :

 i. There are **TWELVE (12)** pages in this Question Booklet including the cover page and the appendix.

 ii. **DOUBLE-SIDED** Question Booklet.

1. a. A company is setting the price for one of its products. The marketing department has formulated three pricing schemes, namely, PSX, PSY, and PSZ. The estimated sales volume for three demand levels of high, medium, and low are as shown in the **TABLE Q1** below.

TABLE Q1

Pricing Scheme	High	Medium	Low
PSX	RM20,000	RM18,000	RM14,000
PSY	RM18,000	RM16,500	RM12,000
PSZ	RM16,500	RM16,000	RM10,000

Determine which pricing scheme should be chosen using the following decision criteria.

   i.   Maximin

[2 marks]

   ii. Hurwicz (x = 0.3)

[3 marks]

b.   A house developer, Mr Alex, is still thinking whether to build a bungalow or a medium-cost house or does not proceed with the project based on the current market information. Given a favorable market, he will earn a profit of RM35,000 if he builds a bungalow and RM15,000 if he builds a medium-cost house. However, with an unfavorable market, Mr Alex will lose RM45,000 with the bungalow and RM25,000 with medium-cost house. It is known that the probability of a favorable market is 0.7. Prior to the decision, Mr Alex can get additional information from market research analyst at a cost of RM8,000 and the probability that the result will be positive is 0.5. A positive result from the study will increase the probability of a favorable market to 0.9 and a negative result from the study will decrease the probability of a favorable market to 0.4.

i.   Construct a decision tree for this problem.

[10 Marks]

ii.   Analyze the decision tree and advise Mr Alex for the best decision.

[3 Marks]

iii.   If the cost to gather the additional information is reduced to RM 3,000, what will be the best advice to Mr Alex.

[2 Marks]

2. a. Given the following linear programs:

Maximize $Z = 12x_1 + 16x_2$

Subject to:

$$3x_1 + 4x_2 \leq 15$$
$$2x_1 + 5x_2 \leq 14$$
$$x_1, x_2 \geq 0$$

Construct the linear programming graph and identify the optimum value.

[7 marks]

b. Alice Bakery is preparing for the coming Christmas festival. The bakery plans to bake and sell its favorite cookies, such as butter cookies, chocolate cookies and almond cookies. Each cookie will be packed in half kilogram weight. Butter cookies require 3 cups of flour, one cup each for special ingredient and choc chip respectively. Chocolate cookies require one cup of special ingredient added to 5 cups of flour and 3 cups of choc chip. To make almond cookies, it requires at least 4 cups of flour, one cup of special ingredient and 2 cups of choc chip. The bakery wishes to maximize its daily profit during this festival. However, each day, the bakery can only allocate at most 410 cups of flour, 110 cups of special ingredient and 220 cups of choc chip to bake the cookies. Formulate the linear programming model for this problem.

[5 marks]

c. **TABLE Q2** is the final simplex tableau for the given problem in **Q2(b)**.

TABLE Q2

C_j	Solution	10	20	15				
	Mix	X_1	X_2	X_3	S_1	S_2	S_3	Quantity
	X_1	1	0	1/2	3/4	0	-5/4	32.5
	S_2	0	0	0	-1/2	1	1/2	15
	X_2	0	1	1/2	-1/4	0	3/4	62.5
	Z							
	Cj – Zj							

S_1, S_2 and S_3 are the slack variables for flour, special ingredients, and choc chip respectively. Based on information in **TABLE Q2**, determine

i.   how many kilograms of each cookie should be baked?

[3 marks]

ii.   the value of profit obtained.

[2 marks]

iii.   any ingredient that is not fully utilized. State the amount unused.

[3 marks]

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3. a. An IT company has three teams, each led by Ahmad, Azman and Awang. **TABLE Q3(a)** shows the estimated time in months that each team will take to complete a project.

TABLE Q3(a)

Team Leader	Projects			
	A	B	C	D
Ahmad	13	14	12	14
Azman	12	14	10	11
Awang	11	12	11	13

Determine,

i. an optimal assignment of each team leader to each project so that the total project completion time is minimized.

[4 marks]

ii. the minimum total project completion time.

[1 mark]

b.   Syarikat Mindah Jaya has three factories that produce computer tables. These factories are in Ipoh, Sepang and Banting respectively. These computer tables are distributed to three major outlets in Seremban, Kajang, and Taiping. The cost of producing one computer table varies from one factory to the others due to different production technologies. The demands from three locations are given in **TABLE Q3(b)(i)**.

TABLE Q3(b)(i)

Location	Demand(units)
Seremban	200
Kajang	300
Taiping	400

The production capacities at the factories are given in **TABLE Q3(b)(ii)**.

TABLE Q3(b)(ii)

Factory	Capacity(units)
Ipoh	350
Sepang	250
Banting	300

The costs per unit (in RM) of producing and distributing the computer tables from the factories to the outlets are given in **TABLE Q3(b)(iii)**.

TABLE Q3(b)(iii)

Factory	Outlet		
	Seremban	Kajang	Taiping
Ipoh	34	54	47
Sepang	46	28	60
Banting	57	49	75

i. Obtain the initial solution using North-West Corner method and optimal solution using MODI method to minimize the total production and distribution cost respectively, and determine the minimum total cost. Is there any alternative optimal solution? Explain.

[13 marks]

ii. Calculate the total profit if the computer tables are sold at RM 500 each to the outlets.
[2 marks]

4. The Sungai Bakap Food Company was inspected by the Environmental and Protection Agency (EPA) and found to be violating several safety regulations. The EPA inspectors ordered the company to alter some of the existing machineries to make them safer, purchase some new machineries to replace the older and dangerous machineries; and install water pollution control equipment. The agency gave the factory only 24 weeks to make the changes; if the changes are not done by then, the company would be fined by RM300,000. The company has to determine the activities that need to be completed and then estimate the activity times as summarized in **TABLE Q4**.

TABLE Q4

Activity	Immediate Predecessors	Optimistic (a)	Most Probable (m)	Pessimistic (b)
A	-	1	2	3
B	-	2	5	8
C	-	1	3	5
D	A	4	5.5	10
E	A	3	4.75	8
F	B	5	5.5	9
G	C	5	9	13
H	D, E	4	5	6
I	D, E, F	1	4	7
J	H, I	2	5	8
K	G	6	6	6

(Time (weeks) spans the Optimistic, Most Probable, and Pessimistic columns.)

From **TABLE Q4**,

a. construct the project network.

[10 marks]

b. find the critical path, the expected project duration, and the project standard deviation.

[7 marks]

c. calculate the probability that the company will be fined by RM300,000?

[3 marks]

5.   Polystone Company is a manufacturer of radial tire. A main element in the production process is rubber, which is supplied by West Rubber on a contractual weekly basis. The probability distribution for quantity delivered when Polystone Company places an order for rubber is as given in **TABLE Q5(i).**

TABLE Q5(i).

Quantity Delivered (tons)	Probability
9,000	0.40
12,000	0.60

The quantity of rubber needed by Polystone Company every week follows the probability distribution as in **TABLE Q5(ii).**

TABLE Q5(ii)

Quantity Needed per Week (tons)	Probability
7,000	0.05
8,000	0.15
9,000	0.20
10,000	0.30
11,000	0.20
12,000	0.10

Polystone Company has the capacity to store not more than 18,000 ton of rubber at any time. Because of the contract, orders for rubber must be placed every week regardless of the on-hand supply. Use the following random numbers for quantity of rubber delivered and needed.

Quantity delivered: 84 40 17 50 63 46 01 04 99 44 36 53 79 59 10
Quantity needed: 91 18 59 62 83 40 55 71 37 60 56 97 81 57 93

a.   Simulate the quantity delivered and needed for 15 weeks.

[15 marks]

b.   Suggest whether Polystone Company needs to add more storage area to cater the demand, justify your answer.

[2 marks]

c.   Calculate the probability that Polystone Company may have rubber more than it needs per week.

[3 marks]

– END OF PAPER –