UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2016/2017 Academic Session

June 2017

MAT251 - Introduction to Operations Research
[Pengantar Penyelidikan Operasi]

Duration : 3 hours
[Masa : 3 jam]

Please check that this examination paper consists of EIGHT pages of printed material before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi LAPAN muka surat yang bercetak sebelum anda memulakan peperiksaan ini.]

Instructions: Answer **all four** [4] questions.

*[**Arahan:** Jawab **semua empat** [4] soalan.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai].

Question 1

(a) Table Tsar Sdn. Bhd. manufactures 2 models of tables with 4 legs. Both models use the same tabletop, but model A has shorter legs (1.5 feet) while model B has longer legs (2.5 feet). It takes 0.10 labour hours to cut and shape a short leg from stock, 0.15 labour hours to do the same for a long leg, and 0.50 labour hours to produce a tabletop. An additional 0.30 labour hours is needed to attach a set of legs to a tabletop for either model. The estimated profit is RM30 for each model A sold and RM45 for each model B sold. Table Tsar has access to unlimited material for tabletops but only have 500 feet of leg stock and 80 labour hours at their disposal. Help Table Tsar formulate a Linear Program that maximises profit, assuming that they sell all tables made and there are zero leftover table legs or tabletops.

[13 marks]

(b) Solve the following Linear Program:

$$\text{maximise} \quad z = 2x_1 + x_2 + x_3$$

subject to

$$\begin{aligned} x_1 + x_2 + 2x_3 &= 8 \\ -3x_1 + 2x_2 + 5x_3 &\geq 16 \\ x_1, \quad x_2, \quad x_3 &\geq 0. \end{aligned}$$

[12 marks]

Soalan 1

(a) *Table Tsar Sdn. Bhd. membuat 2 jenis meja berkaki 4. Kedua-dua jenis meja menggunakan 'tabletop' yang sama, tetapi model A berkaki pendek (1.5 kaki) manakala model B berkaki panjang (2.5 kaki). Kerja memotong dan mengukir satu kaki pendek mengambil masa sebanyak 0.10 jam, kerja yang sama untuk satu kaki panjang mengambil masa 0.15 jam, dan kerja penghasilan satu 'tabletop' mengambil masa sebanyak 0.50 jam. Kerja penyambungan kaki-kaki meja pada satu 'tabletop' pula mengambil masa sebanyak 0.30 jam. Anggaran keuntungan bagi setiap model A dijual adalah RM 30, dan RM 45 bagi setiap model B dijual. Table Tsar boleh mendapatkan bahan yang tidak terhad untuk membuat 'tabletop', tetapi hanya boleh memperoleh stok bahan kaki meja sebanyak 500 kaki, dan 80 jam bekerja. Bantu Table Tsar merangka suatu model Pengaturcaraan Linear yang memaksimumkan keuntungan, dengan anggapan bahawa mereka menjual semua meja yang dibuat dan tiada lebihan kaki meja dan 'tabletop' dibuat.*

[13 markah]

(b) *Selesaikan model Pengaturcaraan Linear berikut:*

$$\textit{memaksimumkan} \quad z = 2x_1 + x_2 + x_3$$

terhadap

$$\begin{aligned} x_1 + x_2 + 2x_3 &= 8 \\ -3x_1 + 2x_2 + 5x_3 &\geq 16 \\ x_1, \quad x_2, \quad x_3 &\geq 0. \end{aligned}$$

[12 marks]

Question 2

Chick Chick Boom Sdn. Bhd. manufactures organic chicken feed and duck feed from corn, wheat and oats. Currently, 40kg of corn, 30kg of wheat and 40kg of oats are available. A sack of chicken feed sells for RM40 and requires 1kg of corn, 1kg of wheat and 2kg of oats. A sack of duck feed sells for RM50 and requires 2kg of corn, 1kg of wheat and 1kg of oats. Chick Chick Boom knows they can sell all feed produced. Chick Chick Boom's Linear Program that maximises revenue is as follows:

Let:

$$x_1 = \text{Sacks of chicken feed produced.}$$
$$x_2 = \text{Sacks of duck feed produced.}$$

The Linear Program:

$$\text{maximise} \quad z = 40x_1 + 50x_2 \quad \text{(Revenue)}$$

subject to

$$\begin{aligned} x_1 + 2x_2 &\leq 40 \quad \text{(Corn)} \\ x_1 + x_2 &\leq 30 \quad \text{(Wheat)} \\ 2x_1 + x_2 &\leq 40 \quad \text{(Oats)} \\ x_1, \quad x_2 &\geq 0. \end{aligned}$$

The optimal Simplex tableau for this Linear Program is as follows:

Basic	x_1	x_2	s_1	s_2	s_3	Solution
z	0	0	20	0	10	1200
x_2	0	1	$^2/_3$	0	$-^1/_3$	$^{40}/_3$
s_2	0	0	$-^1/_3$	1	$-^1/_3$	$^{10}/_3$
x_1	1	0	$-^1/_3$	0	$^2/_3$	$^{40}/_3$

...**4/-**

(a) Based on the optimal tableau given, how much chicken and duck feed should Chick Chick Boom produce? What is the revenue if they sell those quantities of feed?

[3 marks]

(b) Half of Chick Chick Boom's corn supply was stolen. Would the current basis still be feasible? If yes, what is the new production plan?

[11 marks]

(c) Chick Chick Boom would like to increase the price of duck feed to RM60. Would the current basis still be optimal? If yes, what is the new revenue?

[11 marks]

Soalan 2

Chick Chick Boom Sdn. Bhd. membuat makanan organik untuk ayam dan itik menggunakan jagung, gandum dan oat. Mereka mempunyai stok jagung sebanyak 40kg, gandum sebanyak 30kg dan oat sebanyak 40kg. Seguni makanan ayam dijual dengan harga RM40, dan memerlukan 1kg jagung, 1kg gandum dan 2kg oat. Seguni makanan itik dijual dengan harga RM50, dan memerlukan 2kg jagung, 1kg gandum dan 1kg oat. Chick Chick Boom boleh menjual segala makanan yang mereka keluarkan. Model Pengaturcaraan Linear Chick Chick Boom yang memaksimumkan pulangan adalah seperti berikut:

Biarkan:

$$x_1 = \textit{Bilangan guni makanan ayam dikeluarkan.}$$
$$x_2 = \textit{Bilangan guni makanan itik dikeluarkan.}$$

Model Pengaturcaraan Linear:

$$\textit{memaksimumkan} \quad z = 40x_1 + 50x_2 \qquad \textit{(Pulangan)}$$

terhadap

$$\begin{aligned} x_1 + 2x_2 &\leq 40 \quad \textit{(Jagung)} \\ x_1 + x_2 &\leq 30 \quad \textit{(Gandum)} \\ 2x_1 + x_2 &\leq 40 \quad \textit{(Oat)} \\ x_1, \quad x_2 &\geq 0. \end{aligned}$$

Tablo optimum Simplex bagi model Pengaturcaraan Linear di atas adalah seperti berikut:

Asas	x_1	x_2	s_1	s_2	s_3	*Penyelesaian*
z	0	0	20	0	10	1200
x_2	0	1	$^2/_3$	0	$-^1/_3$	$^{40}/_3$
s_2	0	0	$-^1/_3$	1	$-^1/_3$	$^{10}/_3$
x_1	1	0	$-^1/_3$	0	$^2/_3$	$^{40}/_3$

(a) *Berdasarkan tablo optimum yang diberi, berapa banyakkah makanan ayam dan itik patut Chick Chick Boom hasilkan? Berapakah pulangan yang didapati jika kesemua makanan ayam dan itik dapat dijual?*

[3 markah]

(b) *Separuh daripada stok jagung Chick Chick Boom telah dicuri. Adakah asas semasa masih tersaur? Jika ya, apakah pelan produksi baru?*

[11 markah]

(c) *Chick Chick Boom mahu menaikkan harga makanan itik kepada RM60. Adakah asas semasa masih optimum? Jika ya, berapakah nilai pulangan baru?*

[11 markah]

Question 3

Mooptech Sdn. Bhd. manufactures satellite phones for consumer use. Mooptech has plants in Pulau Pinang, Kulim and Johor Bahru. Currently, there are 30 phones in Pulau Pinang, 40 in Kulim and 30 in Johor Bahru. Mooptech's customers Andy, Sandy, Mandy and Randy have put in their orders of 20, 20, 25 and 35 phones respectively. The delivery costs per phone (in RM) are as follows:

From \To	Andy	Sandy	Mandy	Randy
Pulau Pinang	7	10	14	8
Kulim	7	11	12	6
Johor Bahru	5	8	15	9

(a) Formulate Mooptech's problem as a balanced transportation model.

[3 marks]

(b) Use the North West Corner Rule on the transportation model in (a).

[3 marks]

(c) Solve Mooptech's problem using the Transportation Simplex Method. Use the answer in (b) as the initial Basic Feasible Solution. Report the optimal delivery plan and cost.

[11 marks]

(d) Mooptech has to change couriers for the Pulau Pinang - Mandy delivery, and they **do not** want to recalculate their delivery plan from scratch as this would incur more costs. Which of the following couriers should Mooptech choose and why?

- FedEz (RM20/phone).
- UPZ (RM15/phone).
- SkyZet (RM12/phone).
- GDez (RM8/phone).

[8 marks]

Soalan 3

Mooptech Sdn. Bhd. membuat telefon satelit untuk pengguna akhir. Mooptech mempunyai kilang di Pulau Pinang, Kulim dan Johor Bahru. Kini, terdapat 30 telefon di Pulau Pinang, 40 di Kulim dan 30 di Johor Bahru. Pelanggan-pelanggan Mooptech, Andy, Sandy, Mandy dan Randy telah membuat tempahan sebanyak 20, 20, 25 dan 35 telefon masing-masing. Kos penghantaran bagi setiap telefon (dalam RM) adalah seperti berikut:

Dari \ Ke	*Andy*	*Sandy*	*Mandy*	*Randy*
Pulau Pinang	7	10	14	8
Kulim	7	11	12	6
Johor Bahru	5	8	15	9

(a) *Rangkakan suatu model pengangkutan seimbang bagi masalah Mooptech.*

[3 markah]

(b) *Gunakan Petua Sudut Barat Laut pada model pengangkutan dalam (a).*

[3 markah]

(c) *Selesaikan masalah Mooptech menggunakan Kaedah Simplex Pengangkutan. Gunakan penyelesaian dalam (b) sebagai penyelesaian asas permulaan tersaur. Laporkan pelan penghantaran optimum dan kos.*

[11 markah]

(d) *Mooptech perlu menukar syarikat penghantaran bagi penghantaran Pulau Pinang - Mandy, dan mereka* ***tidak mahu*** *membuat semula pelan penghantaran kerana ia akan menyebabkan penambahan kos. Syarikat yang manakah patut Mooptech pilih dan kenapa?*

- *FedEz (RM20/telefon).*
- *UPZ (RM15/telefon).*
- *SkyZet (RM12/telefon).*
- *GDez (RM8/telefon).*

[8 markah]

Question 4

Action Comics Studios is about to begin production on its most important movie this year, Condiment Man. Production begins this week, and the producer Kenneth Feike has decided to use CPM/PERT to plan his project. Kenneth has identified the activities necessary to occur before the movie can be released. The activities, their precedence relations, durations and costs are as follows:

Activity	A	B	C	D	E	F	G	H
Preceding Activities	-	-	A	A	B	B	C, E	D, F
Duration (weeks)	5	3	4	6	5	7	9	8
Cost ($million)	20	10	16	25	22	30	25	30

(a) Construct an arrow diagram for this project. Show the earliest and latest event times on the diagram.

[5 marks]

(b) What is the cost (in $million) of producing Condiment Man? How long (in weeks) before Condiment Man can be released when production starts? Which activities are in the critical path?

[3 marks]

(c) Kenneth recently learned that Action Comics Studios' rival BS Comics Studios are also releasing a movie when Condiment Man is scheduled to be released. After a long discussion with Action Comics boss Stan Zee, the project duration has been changed to 15 weeks. Given the following information, help Kenneth determine the least costly way of crashing his project.

Activity	A	B	C	D	E	F	G	H
Crash Time (week)	3	2	2	3	4	4	5	6
Crash Cost ($million)	30	20	24	43	30	48	45	44

Report the list of activities crashed and their reduction in number of weeks, along with the new cost to produce Condiment Man.

[17 marks]

Soalan 4

Dalam masa terdekat, Action Comics Studios akan memulakan proses penghasilan filem terpenting tahun ini buat mereka, Condiment Man. Proses tersebut bermula minggu ini dan penerbit filem Kenneth Feike telah membuat keputusan untuk menggunakan CPM/PERT untuk merancang projeknya. Kenneth telahpun mengenal pasti aktiviti-aktiviti yang perlu dijalankan sebelum filemnya boleh ditayang di pawagam. Aktiviti-aktiviti tersebut, aktiviti-aktiviti pendahulu, tempoh dan kos adalah seperti berikut:

Aktiviti	A	B	C	D	E	F	G	H
Aktiviti Dahulu	-	-	A	A	B	B	C, E	D, F
Tempoh (minggu)	5	3	4	6	5	7	9	8
Kos ($juta)	20	10	16	25	22	30	25	30

(a) *Lakarkan gambarajah aliran projek ini. Tunjukkan masa terawal and terlewat buat setiap acara di atas gambarajah.*

[5 markah]

(b) *Berapakah kos (dalam $juta) untuk menghasilkan Condiment Man? Berapa lamakah (dalam minggu) sebelum Condiment Man boleh ditayangkan di pawagam? Apakah aktiviti-aktiviti yang genting?*

[3 markah]

(c) *Kenneth mendapat tahu bahawa pesaing Action Comics Studios, BS Comics Studios juga akan mengeluarkan suatu filem pada masa yang sama dengan Condiment Man. Setelah berbincang panjang dengan bos Action Comics, Stan Zee, tempoh projek diubah kepada 15 minggu. Diberi maklumat di bawah, bantu Kenneth mengenalpasti cara memampatkan projeknya dengan kos terendah.*

Aktiviti	A	B	C	D	E	F	G	H
Tempoh Mampat (minggu)	3	2	2	3	4	4	5	6
Kos Mampat ($juta)	30	20	24	43	30	48	45	44

Laporkan senarai aktiviti yang dimampat berserta tempoh pengurangan dalam minggu, dan kos penghasilan baru buat Condiment Man.

[17 markah]