UNIVERSITI SAINS MALAYSIA

Final Examination
2016/2017 Academic Session

May/June 2017

JIM 316 – Introduction To Operations Research
[Pengantar Penyelidikan Operasi]

Duration : 3 hour
[Masa: 3 jam]

Please ensure that this examination paper contains **TWELVE** printed pages before you begin the examination.

Answer **ALL** questions. You may answer either in Bahasa Malaysia or in English.

Read the instructions carefully before answering.

Each question is worth 100 marks.

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

*Sila pastikan bahawa kertas peperiksaan ini mengandungi **DUA BELAS** muka surat yang bercetak sebelum anda memulakan peperiksaan.*

*Jawab **SEMUA** soalan. Anda dibenarkan menjawab sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.*

Baca arahan dengan teliti sebelum anda menjawab soalan.

Setiap soalan diperuntukkan 100 markah.

Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.

1. (a) A manufacturer produces four different models of wooden television consoles, labelled I, II, III and IV, each of which must be assembled and then decorated. The models require 4, 5, 3 and 5 hours, respectively, for assembling and 2, 1.5, 3 and 3 hours, respectively, for decorating. The profits on the models are RM7, RM7, RM6 and RM9, respectively. The manufacturer has 30,000 hours available for assembling these products and 20,000 hours available for decorating.

Formulate a linear programming model for this problem in order to maximise profit.

(50 marks)

(b) Consider the following linear programming model:

Maximise $Z = 90x_1 + 60x_2$

subject to

$$\begin{aligned} 5x_1 + 8x_2 &\le 2000 && \text{(Raw Material I)} \\ x_1 &\le 175 && \text{(Raw Material II)} \\ x_2 &\le 225 && \text{(Raw Material III)} \\ 7x_1 + 4x_2 &\le 1400 && \text{(Raw Material IV)} \\ x_1,\ x_2 &\ge 0. \end{aligned}$$

Use the graphical method to find

(i) the optimal solution.

(ii) binding, non-binding and redundant contraints.

(iii) raw materials that are in surplus and deficit.

(50 marks)

2. (a) Solve the following problem using the Big M method.

Minimise $Z = 3x_1 + 2.5x_2$

subject to

$$\begin{aligned} 2x_1 + 4x_2 &\ge 40 \\ 5x_1 + 2x_2 &\ge 50 \\ x_1, x_2 &\ge 0. \end{aligned}$$

(50 marks)

(b) A linear programming model was solved using the simplex method. The following is part of the solution tableau.

			Coefficient of					
Iteration	**Basic Variable**	z	x_1	x_2	x_3	x_4	x_5	**Right side**
0	z	1	1	9	1	0	0	
	x_4	0	1	2	3	1	0	9
	x_5	0	3	2	2	0	1	15
⋮	⋮				⋮			⋮
Optimum	z	1	7/2	0	25/2	9/2	0	81/2
	x_2	0	1/2	1	3/2	1/2	0	9/2
	x_5	0	2	0	–1	–1	1	6

Based on the tableau above,

(i) determine the original PL model.

(ii) determine the optimal solution.

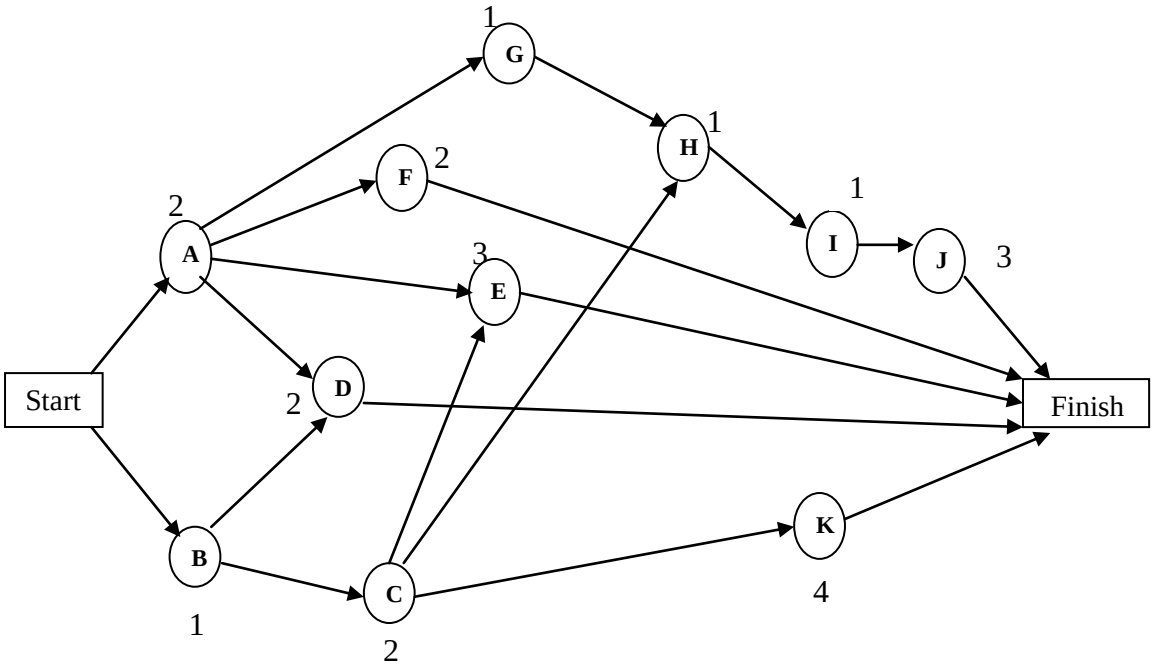
(iii) determine the unit value of each resource.

(iv) determine the amount that can be deducted from surplus resources.

(v) if additional capital is made available to increase the raw material, which resource (s) should be given priority? Why?

(50 marks)

3. (a) Given below is a project network with estimated duration (in weeks) of all activities.



(i) List the immediate predecessors of each activity.

(ii) Find all the paths and path lengths through this project network.

(iii) If no delay occurs, what is the project earliest completion time?

(iv) Find ES, EF, LS, LF and slack of each activity.

(v) Which of the paths is a critical path?

(vi) Determine the duration of the project if activity E is delayed by 2 weeks.

(50 marks)

(b) Table below shows the estimates of the duration of each activity, using the PERT three-estimate approach.

Activity	Duration		
	Optimistic Estimate	Most Likely Estimate	Pessimistic Estimate
A	4	3	6
B	8	6	10
C	5	3	8
D	3	2	5
E	7	6	9
F	4	3	5
G	3	2	5
H	2	2	2
I	6	5	7
J	3	3	3

Find the

(i) estimate of the mean and variance of the duration of each activity.

(ii) probability that activities G and H will complete before the beginning of the 14^{th} week.

(iii) probability that activity B will complete no later than the beginning of the 10^{th} week.

(iv) probability that the project will finish within 18 weeks.

(50 marks)

4. (a) List the three assumptions of the basic economic order quantity (EOQ) model.

(15 marks)

(b) Give a brief definition of the following terms:

(i) Inventory

(ii) Lead time

(iii) Reorder point

(iv) Holding cost

(v) Shortage cost

(25 marks)

…6/-

(c) Precision Tools Inc. sells pistons to Best Motor Co. as per following price list:

Order quantity	Price per unit
1 – 299	RM2.50
300 – 619	RM2.30
620+	RM2.00

The annual demand is estimated to be 15000 pistons per year. The holding costs are 25% of the unit price and the setup costs are RM6.50. Assume instantaneous delivery. Find

(i) optimum order quantity.

(ii) optimum total cost.

(iii) time between orders.

(60 marks)

1. (a) Satu pengilang menghasilkan empat model konsol kayu televisyen yang berbeza, dilabel I, II, III dan IV, setiap satu mesti dipasang dan kemudian dihiasi. Model-model tersebut memerlukan 4, 5, 3 dan 5 jam, masing-masing, untuk memasang dan 2, 1. 5, 3 dan 3 jam, masing-masing, untuk menghias. Keuntungan setiap model masing-masing adalah RM7, RM7, RM6 dan RM9. Pengilang mempunyai masa 30,000 jam untuk memasang produk-produk dan 20,000 jam untuk menghias.

Rumuskan model pengaturcaraan linear bagi masalah ini untuk memaksimumkan keuntungan.

(50 markah)

(b) Pertimbangkan model pengaturcaraan linear yang berikut:

Maksimumkan $Z = 90x_1 + 60x_2$

terhadap

$$\begin{aligned} 5x_1 + 8x_2 &\le 2000 && \text{(Bahan Mentah I)} \\ x_1 &\le 175 && \text{(Bahan Mentah II)} \\ x_2 &\le 225 && \text{(Bahan Mentah III)} \\ 7x_1 + 4x_2 &\le 1400 && \text{(Bahan Mentah IV)} \\ x_1,\ x_2 &\ge 0. \end{aligned}$$

Dengan menggunakan penyelesaian secara bergraf, tentukan

(i) penyelesaian optimum bagi masalah ini.

(ii) kekangan terikat, tak terikat dan membazir.

(iii) bahan mentah yang berkurangan dan berlebihan.

(50 markah)

2. (a) Selesaikan masalah berikut dengan menggunakan kaedah Big M.

Minimumkan $Z = 3x_1 + 2.5x_2$

terhadap

$$\begin{aligned} 2x_1 + 4x_2 &\ge 40 \\ 5x_1 + 2x_2 &\ge 50 \\ x_1, x_2 &\ge 0. \end{aligned}$$

(50 markah)

(b) Suatu model pengaturcaraan linear diselesaikan dengan menggunakan kaedah simpleks. Berikut adalah sebahagian daripada tablo penyelesaian.

			Pekali					
Lelaran	**Pembolehubah Asas**	z	x_1	x_2	x_3	x_4	x_5	**Sebelah Kanan**
0	z	1	1	9	1	0	0	
	x_4	0	1	2	3	1	0	9
	x_5	0	3	2	2	0	1	15
⋮	⋮				⋮			⋮
Optimum	z	1	7/2	0	25/2	9/2	0	81/2
	x_2	0	1/2	1	3/2	1/2	0	9/2
	x_5	0	2	0	-1	-1	1	6

Berdasarkan tablo diatas,

(i) tentukan model PL yang asal.

(ii) tentukan penyelesaian optimum.

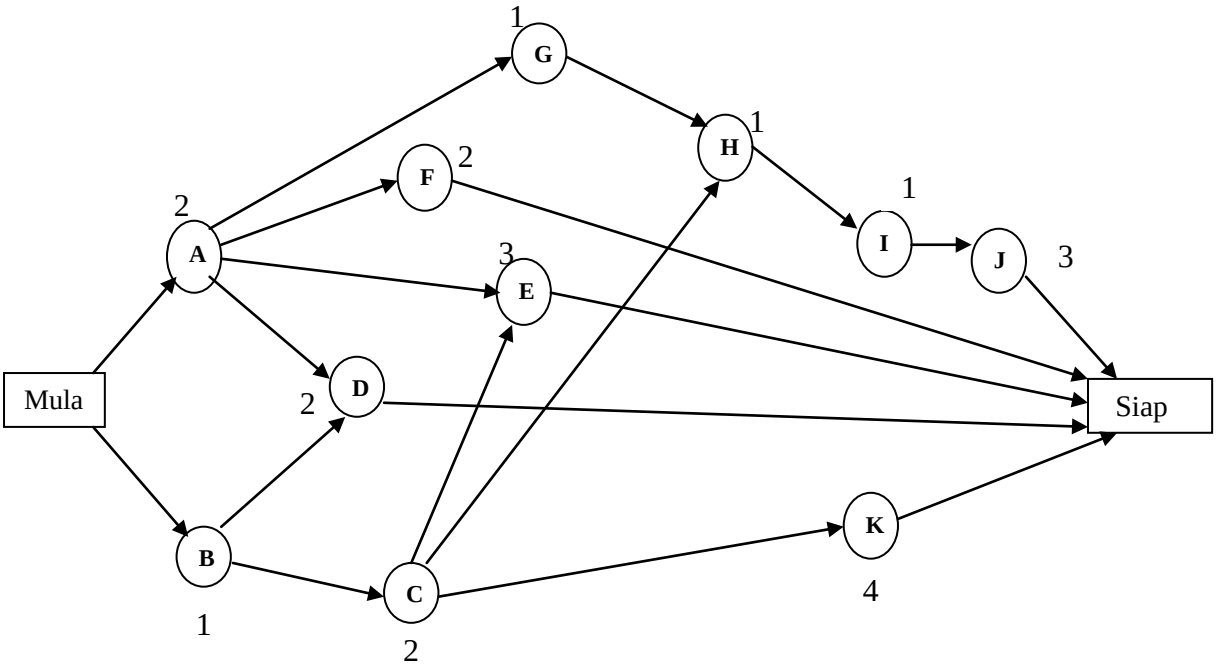
(iii) tentukan nilai unit setiap sumber.

(iv) tentukan jumlah yang boleh ditolak daripada sumber berlebihan.

(v) jika modal tambahan disediakan untuk tingkatkan bahan mentah, sumber yang mana perlu diberi keutamaan? Mengapa?

(50 markah)

3. (a) Diberi di bawah satu rangkaian projek dengan anggaran tempoh (dalam minggu) untuk semua kegiatan.



(i) Senaraikan kegiatan pendahulu bagi setiap kegiatan.

(ii) Dapatkan kesemua lintasan dan panjang lintasan dalam rangkaian projek ini.

(iii) Jika tiada kelewatan berlaku, apakah masa terawal penyiapan projek?

(iv) Cari ES, EF, LS, LF dan lalai setiap aktiviti.

(v) Lintasan manakah yang merupakan lintasan kritikal?

(vi) Tentukan tempoh projek jika kegiatan E terlewat selama 2 minggu.

(50 markah)

(b) Jadual di bawah menunjukkan anggaran jangka masa bagi setiap kegiatan, menggunakan pendekatan tiga-anggaran PERT.

Kegiatan	Jangka masa		
	Masa optimis	Masa paling boleh jadi	Masa pesimis
A	4	3	6
B	8	6	10
C	5	3	8
D	3	2	5
E	7	6	9
F	4	3	5
G	3	2	5
H	2	2	2
I	6	5	7
J	3	3	3

(i) Dapatkan anggaran min dan varians jangka masa untuk setiap kegiatan.

(ii) Dapatkan kebarangkalian kegiatan G dan H boleh siap sebelum permulaan minggu ke 14.

(iii) Dapatkan kebarangkalian kegiatan B siap tidak lewat daripada permulaan minggu ke 10.

(iv) Dapatkan kebarangkalian projek siap dalam tempoh 18 minggu.

(50 markah)

4. (a) Senaraikan tiga andaian untuk model asas saiz lot ekonomi (EOQ).

(15 markah)

(b) Beri takrifan ringkas bagi istilah berikut:

(i) Inventori

(ii) Masa lopor

(iii) Titik pesanan semula

(iv) Kos penangguhan

(v) Kos kekurangan

(25 markah)

(c) Precision Tools Inc menjual piston kepada Best Motor Co. dengan senarai harga berikut:

Kuantiti pesanan	Harga setiap unit
1 – 299	RM2.50
300 – 619	RM2.30
620+	RM2.00

Permintaan tahunan dianggarkan 15000 piston setahun. Kos penangguhan adalah 25% daripada harga unit dan kos penyediaan adalah RM6.50. Andaikan penghantaran serta-merta. Cari

(i) kuantiti pesanan optimum.

(ii) jumlah kos optimum.

(iii) masa di antara pesanan.

(60 markah)

Lampiran

Table E The Standard Normal Distribution

z	*.00*	*.01*	*.02*	*.03*	*.04*	*.05*	*.06*	*.07*	*.08*	*.09*
0.0	.0000	.0040	.0080	.0120	.0160	.0199	.0239	.0279	.0319	.0359
0.1	.0398	.0438	.0478	.0517	.0557	.0596	.0636	.0675	.0714	.0753
0.2	.0793	.0832	.0871	.0910	.0948	.0987	.1026	.1064	.1103	.1141
0.3	.1179	.1217	.1255	.1293	.1331	.1368	.1406	.1443	.1480	.1517
0.4	.1554	.1591	.1628	.1664	.1700	.1736	.1772	.1808	.1844	.1879
0.5	.1915	.1950	.1985	.2019	.2054	.2088	.2123	.2157	.2190	.2224
0.6	.2257	.2291	.2324	.2357	.2389	.2422	.2454	.2486	.2517	.2549
0.7	.2580	.2611	.2642	.2673	.2704	.2734	.2764	.2794	.2823	.2852
0.8	.2881	.2910	.2939	.2967	.2995	.3023	.3051	.3078	.3106	.3133
0.9	.3159	.3186	.3212	.3238	.3264	.3289	.3315	.3340	.3365	.3389
1.0	.3413	.3438	.3461	.3485	.3508	.3531	.3554	.3577	.3599	.3621
1.1	.3643	.3665	.3686	.3708	.3729	.3749	.3770	.3790	.3810	.3830
1.2	.3849	.3869	.3888	.3907	.3925	.3944	.3962	.3980	.3997	.4015
1.3	.4032	.4049	.4066	.4082	.4099	.4115	.4131	.4147	.4162	.4177
1.4	.4192	.4207	.4222	.4236	.4251	.4265	.4279	.4292	.4306	.4319
1.5	.4332	.4345	.4357	.4370	.4382	.4394	.4406	.4418	.4429	.4441
1.6	.4452	.4463	.4474	.4484	.4495	.4505	.4515	.4525	.4535	.4545
1.7	.4554	.4564	.4573	.4582	.4591	.4599	.4608	.4616	.4625	.4633
1.8	.4641	.4649	.4656	.4664	.4671	.4678	.4686	.4693	.4699	.4706
1.9	.4713	.4719	.4726	.4732	.4738	.4744	.4750	.4756	.4761	.4767
2.0	.4772	.4778	.4783	.4788	.4793	.4798	.4803	.4808	.4812	.4817
2.1	.4821	.4826	.4830	.4834	.4838	.4842	.4846	.4850	.4854	.4857
2.2	.4861	.4864	.4868	.4871	.4875	.4878	.4881	.4884	.4887	.4890
2.3	.4893	.4896	.4898	.4901	.4904	.4906	.4909	.4911	.4913	.4916
2.4	.4918	.4920	.4922	.4925	.4927	.4929	.4931	.4932	.4934	.4936
2.5	.4938	.4940	.4941	.4943	.4945	.4946	.4948	.4949	.4951	.4952
2.6	.4953	.4955	.4956	.4957	.4959	.4960	.4961	.4962	.4963	.4964
2.7	.4965	.4966	.4967	.4968	.4969	.4970	.4971	.4972	.4973	.4974
2.8	.4974	.4975	.4976	.4977	.4977	.4978	.4979	.4979	.4980	.4981
2.9	.4981	.4982	.4982	.4983	.4984	.4984	.4985	.4985	.4986	.4986
3.0	.4987	.4987	.4987	.4988	.4988	.4989	.4989	.4989	.4990	.4990

Note: Use 0.4999 for z values above 3.09.

Source: Frederick Mosteller and Robert E. K. Rourke, *Sturdy Statistics*, Table A–1 (Reading, Mass.: Addison-Wesley, 1973). Reprinted with permission of the copyright owners.