UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2006/2007

April 2007

MSG 265 – Design and Analysis of Experiments
[Rekabentuk Dan Analisis Ujikaji]

Duration : 3 hours
[Masa : 3 jam]

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

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

Instructions : Answer **all five** [5] questions.

[Arahan **:** *Jawab **semua lima** [5] soalan.]*

...2/-

1. (a) Consider the cell sums of the experimental units of a temperature × type of material factorial experiment.

	Type of Material			Orthogonal Contrast Coefficients (c_{ij})	
Temperature (°F)	1 ($y_{1j.}$)	2 ($y_{2j.}$)	3 ($y_{3j.}$)	Linear	Quadratic
50	404	172	192	-1	+1
65	428	377	135	0	-2
80	447	434	288	+1	+1

Suppose the number of experimental units per cell is 3.

(i) Analyze the data highlighting linear and quadratic effects of temperature and temperature × type of material interaction. Draw an interaction plot if needed.

(ii) State two further analyses that ought to be carried out when the results of (i) are known.

(iii) Why are these analyses required?

[60 marks]

(b) Given two statistics

$$t_0 = \frac{\bar{y}_1 - \bar{y}_2}{S_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}, \qquad (1)$$

and

$$t_0 = \frac{\bar{y}_1 - \bar{y}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}. \qquad (2)$$

When were they used?

[20 marks]

(c) If the assumption that random error is normal error is violated, what are the alternatives available to test H_0: $\tau_1 = \tau_2 = \ldots = \tau_a = 0$ in this case?

[20 marks]

...3/-

1. (a) *Berikut diberikan perjumlahan unit-unit ujikaji di dalam sel suhu × jenis bahan.*

	Jenis Bahan			*Pekali Kontras Ortogon* (c_{ij})	
Suhu (°F)	$1(y_{1j.})$	$2(y_{2j.})$	$3(y_{3j.})$	*Linear*	*Kuadratik*
50	404	172	192	-1	+1
65	428	377	135	0	-2
80	447	434	288	+1	+1

Andaikan bilangan unit ujikaji per sel ialah 3.

(i) Analisiskan data ini dengan mengambilkira kesan-kesan linear dan kuadratik suhu dan tindak balas jenis bahan dan suhu. Lakarkan plot tindak balas jika ia diperlukan.

(ii) Nyatakan dua jenis analisis lanjutan yang patut dijalankan ke atas data ini setelah diketahui keputusan di dalam (i).

(iii) Mengapakah analisis-analisis tersebut perlu dijalankan?

[60 markah]

(b) Diberikan dua statistik

$$t_0 = \frac{\bar{y}_1 - \bar{y}_2}{S_p\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}}, \qquad (1)$$

dan

$$t_0 = \frac{\bar{y}_1 - \bar{y}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}. \qquad (2)$$

Bilakah (i) digunakan dan bilakah (ii) digunakan?

[20 markah]

(c) Sekiranya anggapan ralat piawai tertabur secara normal tidak dapat dipertahankan, apakah alternatif-alternatif yang boleh diketengahkan supaya $H_0: \tau_1 = \tau_2 = \ldots = \tau_a = 0$ *dapat diuji?*

[20 markah]

...4/-

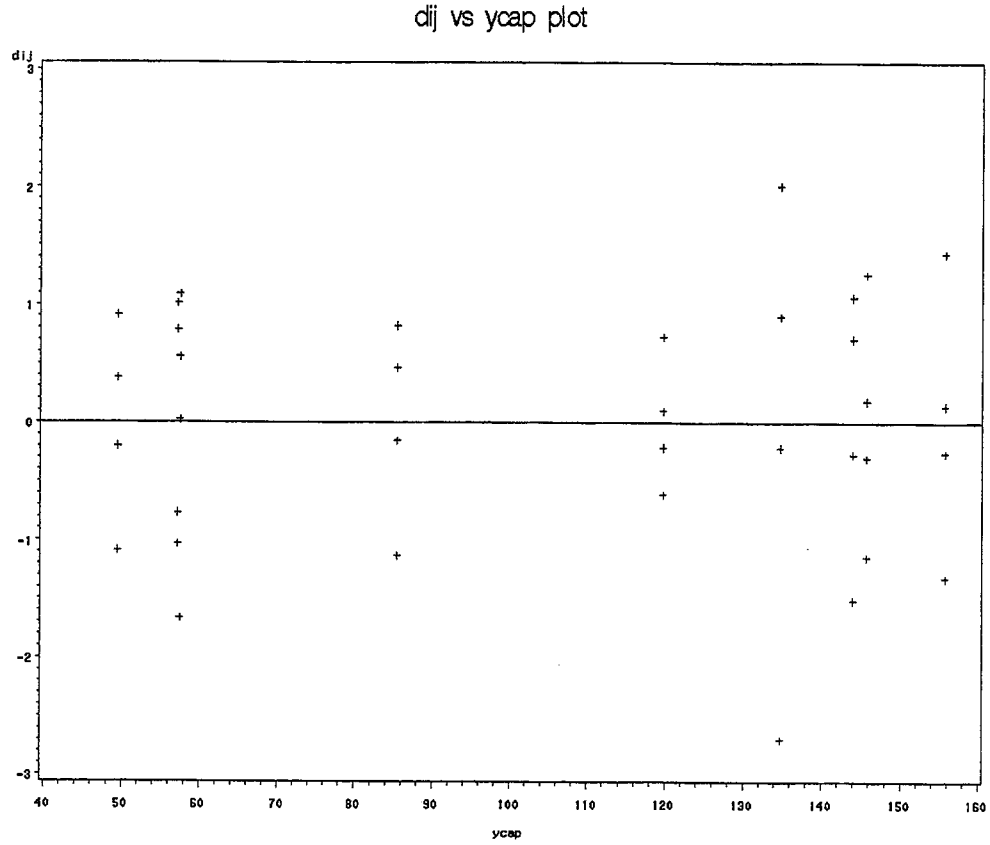
2. *(a) Berikan segiempat sama latin piawai tunggal* 3 × 3, *dan takrifkan persamaan model yang menggunakan rekabentuk ini.*

[20 markah]

(b) Pertimbangkan suatu ujikaji faktoran dua-faktor dengan faktor A mempunyai 3 *aras, faktor B mempunyai* 2 *aras, dan terdapat* 4 *replika setiap sel. Diberikan plot ralat piawai lawan* y *teranggar, plot kebarangkalian ke kebarangkalian ralat piawai dan plot histogram ralat piawai.*

(i) Apakah yang disemak oleh plot-plot tersebut?

(ii) Apakah kesimpulan yang boleh diperolehi daripada pemerhatian plot-plot tersebut?



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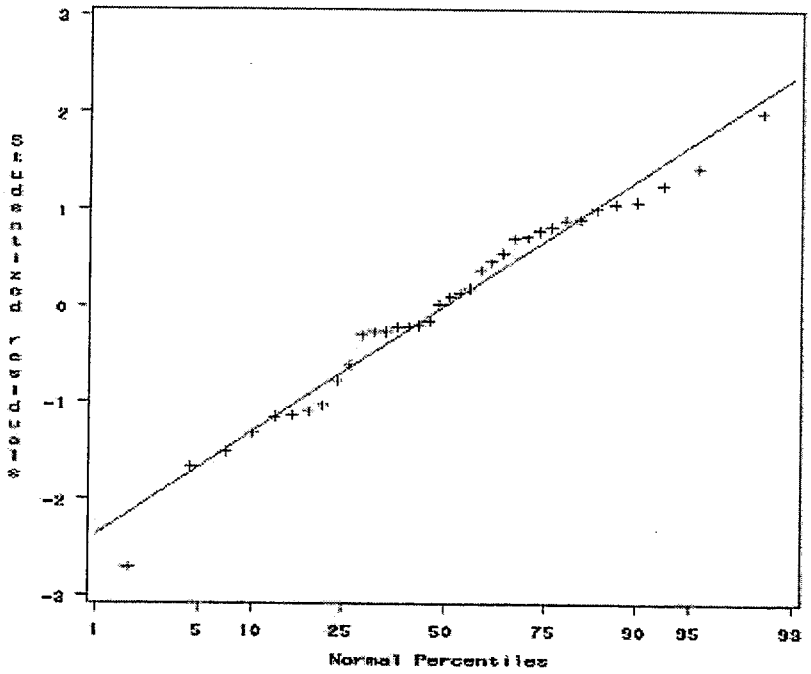
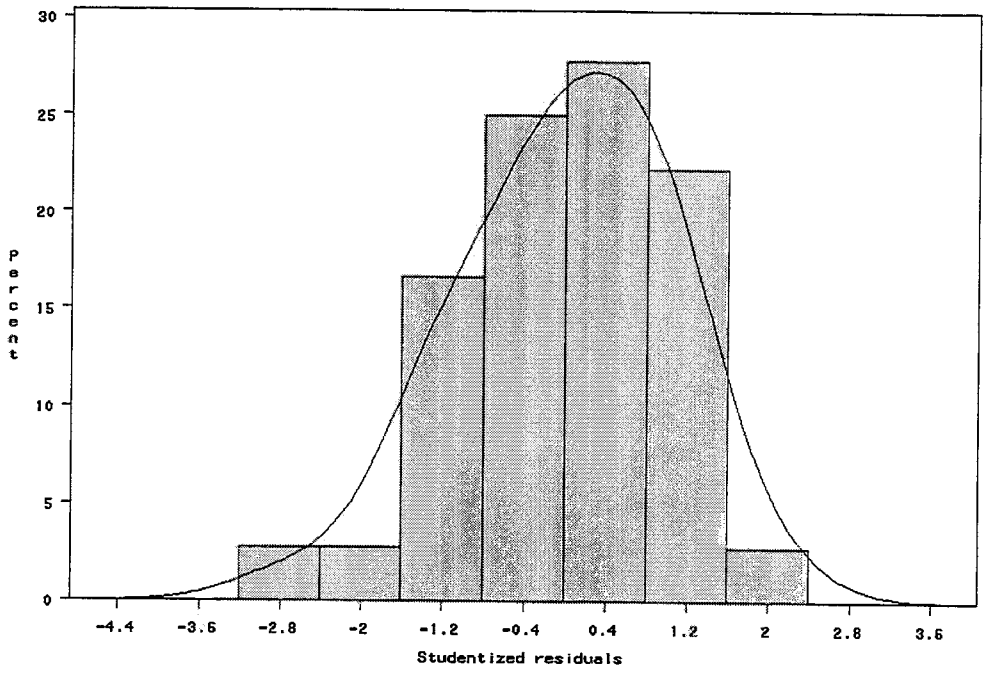
P-P Plot of the dijs



Histogram of the dijs



[30 marks]

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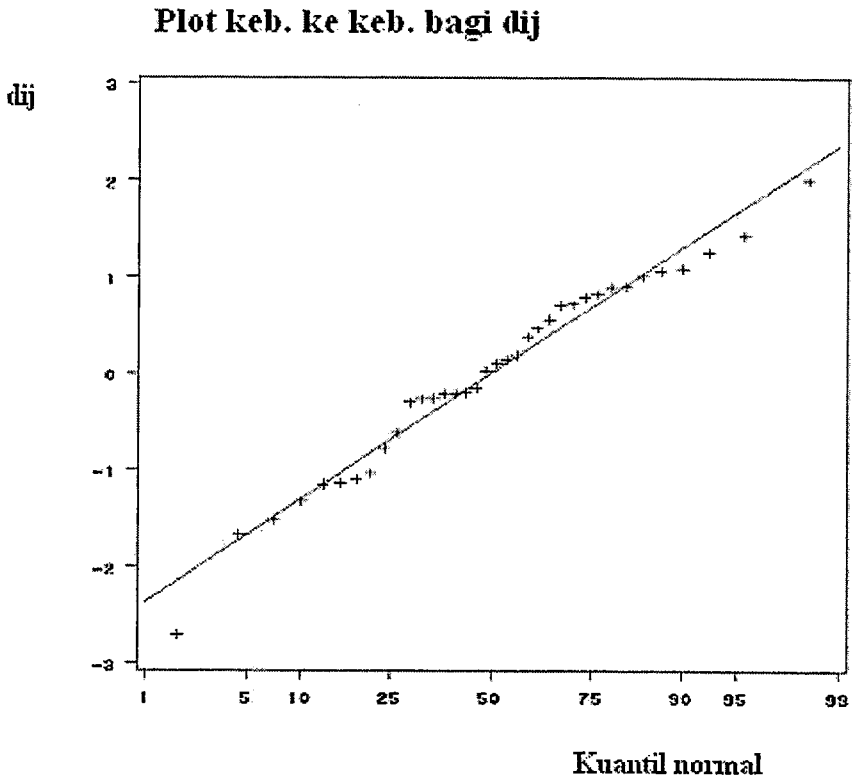
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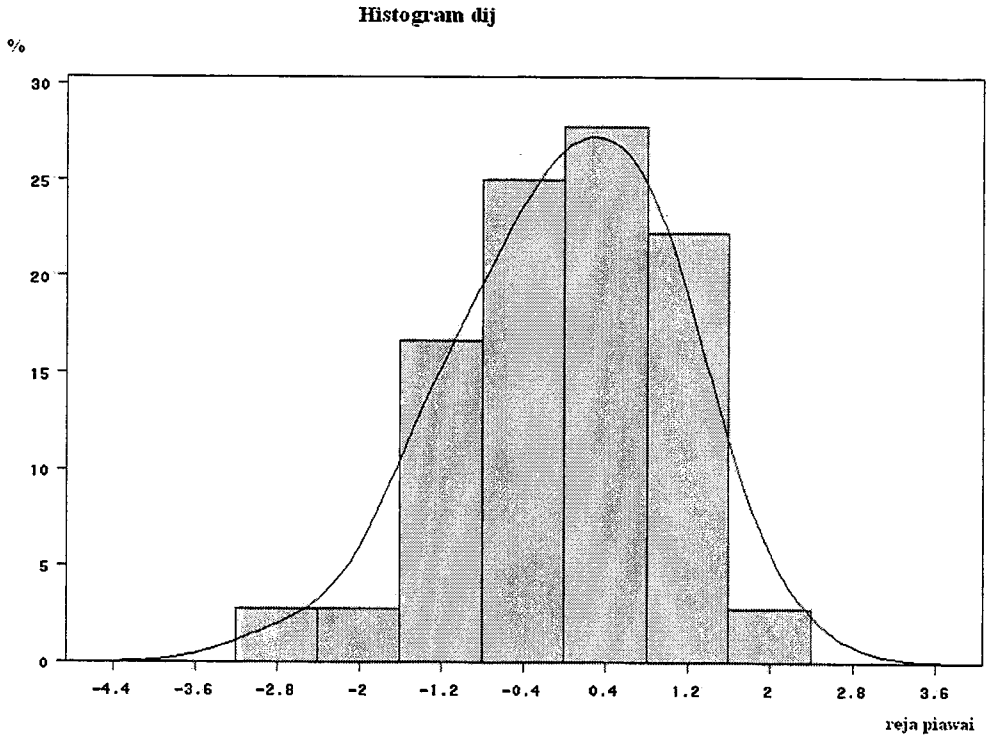
Histogram dij
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2
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reja piawai

[30 markah]

...8/-

(c) A 2^2 design in two blocks is defined as follows.

Block 1	Block 2
(1)	a
ab	b

(i) What is the effect that is confounded with blocks?

(ii) Suppose there are 4 replicates of each block, construct a simplified ANOVA table consisting of the source of variation and degrees of freedom only.

[20 marks]

(d) Given a fractional design 2^{4-1}_{IV} with design generator D = ABC.

(i) Construct an alias structure of this design. Give an example of a confounded effect from the structure.

(ii) What is meant by 2, 4 – 1 and IV in the notation 2^{4-1}_{IV}?

[30 marks]

3. A photographer wanted to improve the quality of his pictures during the development process by the addition of two types of chemicals to the usual negative developer solution. The amounts used were 1.5 g and 2.5 g of metol and 4 g dan 6 g of hydroquinone with 1 g of negative developer solution. The clarity readings of his pictures along with the treatments are listed below:

Run	Treatment (in g)		Picture Quality	
	metol	hydroquinone	Replicate 1	Replicate 2
1	1.5	4	28	30
2	2.5	4	42	38
3	1.5	6	33	33
4	2.5	6	40	42

(a) Construct the table of algebraic signs for calculating the effects of this design.

[20 marks]

(b) Using (a) calculate SS(metol), SS(hydroquinone) dan SS(metol × hydroquinone) and run an ANOVA on this design.

[80 marks]

...9/-

(c) *Rekabentuk* 2^2 *dalam dua blok adalah seperti berikut.*

Blok 1	*Blok* 2
(1)	*a*
ab	*b*

(i) *Kesan apakah yang terbaur dengan blok?*

(ii) *Sekiranya terdapat empat replika kedua-dua blok di atas, binakan jadual ANOVA berlajurkan punca perubahan dan darjah kebebasan sahaja.*

[20 markah]

(d) *Diberikan rekabentuk pecahan* 2^{4-1}_{IV} *dengan penjana rekabentuk* $D = ABC$.

(i) *Binakan struktur alias rekabentuk ini. Berikan satu contoh kesan yang terbaur daripada struktur tersebut.*

(ii) *Apakah yang dimaksudkan oleh* $2, 4-1$ *dan IV di dalam tatatanda* 2^{4-1}_{IV} *?*

[30 markah]

3. *Seorang jurugambar ingin mempertingkatkan mutu gambar yang dicucinya dengan menambahkan dua bahan kimia – metol dan hydroquinone semasa mencuci negatif. Amaun yang digunakan bersama dengan* 1 *liter pencuci negatif ialah* 1.5 *g dan* 2.5 *g untuk metol dan* 4 *g dan* 6 *g untuk hydroquinone. Sukatan mutu gambar yang dihasilkan dengan gabungan bahan-bahan kimia tersebut adalah seperti berikut:*

	Rawatan (dalam g)		*Mutu Gambar*	
Larian	*metol*	*hydroquinone*	*Replika* 1	*Replika* 2
1	1.5	4	28	30
2	2.5	4	42	38
3	1.5	6	33	33
4	2.5	6	40	42

(a) *Binakan jadual tanda-tanda algebra bagi menghitung kesan-kesan faktor di dalam rekabentuk di atas.*

[20 markah]

(b) *Dengan menggunakan (a) hitungkan SS(metol), SS(hydroquinone) dan SS(metol* × *hydroquinone) dan seterusnya jalankan ANOVA terhadap rekabentuk ini.*

[80 markah]

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4. Consider the experiment in Question 3.
   (a) Run the Fisher LSD post hoc analysis on significant effects.

   [50 marks]

   (b) Construct the response surface equation of this experiment and find the optimal clarity analytically.

   [50 marks]

5. (a) Reanalyze Question 3 by assuming the replicates as blocks.

   [50 marks]

   (b) Give a brief outline of running an ANOVA on a 2^2 factorial design with Latin square. Can it be done on the experiment carried out in Question 3? State a reason for your answer.

   [25 marks]

   (c) Given any 2^3 factorial design, we know that it can be modified with confounding and fractionization. Explain the conditions whereby confounding and fractionization are feasible in this design.

   [25 marks]

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4. *Pertimbangkan ujikaji di dalam Soalan 3.*
   (a) Jalankan analisis post hoc Fisher LSD ke atas kesan-kesan bererti.

   [50 markah]

   (b) Dapatkan persamaan permukaan sambutan ujikaji ini dan dapatkan mutu gambar yang optimum secara analitis.

   [50 markah]

5. *(a) Analisiskan semula Soalan 3 dengan mengandaikan replika sebagai blok.*

   [50 markah]

   (b) Berikan garis kasar analisis varians bagi suatu ujikaji faktoran 2^2 yang dijalankan dalam suatu segiempat sama Latin. Bolehkah ini dilakukan kepada ujikaji yang terdapat di dalam Soalan 3? Berikan sebab mengapa anda menjawab sedemikian.

   [25 markah]

   (c) Diberikan rekabentuk faktoran 2^3, rekabentuk ini boleh diubahsuai dengan pembauran dan dengan pecahan. Huraikan keadaan sesuai bagi pembauran dan pemecahan rekabentuk faktoran 2^3.

   [25 markah]

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Appendix/*Lampiran*

1. SS(Contrast) = $\dfrac{\left(\sum_{i=1}^{a} c_i \bar{y}_{i.}\right)^2}{\sum_{i=1}^{a} c_i^2}$	*1. SS(kontras)* = $\dfrac{\left(\sum_{i=1}^{a} c_i \bar{y}_{i.}\right)^2}{\sum_{i=1}^{a} c_i^2}$
2. Qualitative Factor (M_j) × Quantitative Contrast (T_i) Effect $(M_j \times T_i) = \sum_{i=1}^{a} c_i y_{ij.}$ $SS(M \times T_j) = \dfrac{\sum_{j=1}^{b} (\text{Effect } M_j \times T_i)^2}{n\sum_{i=1}^{a} c_i^2}$	*2. Factor Kualitatif* (M_j) × *Kontras Kuantitatif* (T_i) *Kesan* $(M_j \times T_i) = \sum_{i=1}^{a} c_i y_{ij.}$ *SS*$(M \times T_j) = \dfrac{\sum_{j=1}^{b} (\textit{Kesan } M_j \times T_i)^2}{n\sum_{i=1}^{a} c_i^2}$
3. General 2^k designs Effect = $\dfrac{2}{n2^k}$ $(\text{Contrast}_{AB...K})$ SS = $\dfrac{1}{n2^k}$ $(\text{Contrast}_{AB...K})^2$	*3. Rekabentuk* 2^k *am* *Kesan* = $\dfrac{2}{n2^k}$ $(\textit{Kontras}_{AB...K})$ *SS* = $\dfrac{1}{n2^k}$ $(\textit{Kontras}_{AB...K})^2$
4. Multiple comparisons (a) $T_{C_u} = \sqrt{MS_E \sum_{i=1}^{a} (c_{iu}^2 / n_i)}$ $T_{\alpha,u} = T_{C_u}\sqrt{(a-1)F_{\alpha,a-1,N-a}}$ (b) $T_\alpha = \dfrac{q_\alpha(a,f)}{\sqrt{2}}\sqrt{MS_E\left(\dfrac{1}{n_i}+\dfrac{1}{n_j}\right)}$ (c) $T = t_{a/2,N-a}\sqrt{MS_E\left(\dfrac{1}{n_i}+\dfrac{1}{n_j}\right)}$ (d) $T = d_\alpha(a-1, f)\sqrt{MS_E\left(\dfrac{1}{n_i}+\dfrac{1}{n_a}\right)}$	*4. Perbandingan berpasangan* *(a)* $T_{C_u} = \sqrt{MS_E \sum_{i=1}^{a} (c_{iu}^2 / n_i)}$ $T_{\alpha,u} = T_{C_u}\sqrt{(a-1)F_{\alpha,a-1,N-a}}$ *(b)* $T_\alpha = \dfrac{q_\alpha(a,f)}{\sqrt{2}}\sqrt{MS_E\left(\dfrac{1}{n_i}+\dfrac{1}{n_j}\right)}$ *(c)* $T = t_{a/2,N-a}\sqrt{MS_E\left(\dfrac{1}{n_i}+\dfrac{1}{n_j}\right)}$ *(d)* $T = d_\alpha(a-1, f)\sqrt{MS_E\left(\dfrac{1}{n_i}+\dfrac{1}{n_a}\right)}$

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