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UNIVERSITI SAINS MALAYSIA

Second Semester Examination  
2010/2011 Academic Session

April/May 2011

**MSG 162 – Applied Statistical Methods**  
***[Kaedah Statistik Gunaan]***

Duration : 3 hours  
*[Masa : 3 jam]*

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

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi ENAM BELAS 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].*

1. (a) In order to study students' preference for certain universities, they were asked to give their ranking for eight universities and the results were compared to a magazine report. The ranking is given in the table below.

University	Student Ranking	Magazine Ranking
A	11	10
B	12	12
C	13	16
D	14	15
E	25	27
F	26	26
G	37	13
H	80	78

- (i) State a model and its assumptions.
- (ii) Perform an appropriate analysis at 0.05 significance level .

- (b) An automobile manufacturer wished to study the differences between cars on petrol consumption. A random sample of four cars of the same model was selected from the assembly line. Four drivers were randomly assigned to drive each car. Each driver drove the car over a 40-kilometer test course and the kilometers per litre were recorded.

Car	Driver				Total
	1	2	3	4	
A	25.3	33.6	28.5	29.3	116.7
B	28.9	36.5	30.4	32.4	128.2
C	24.8	31.7	26.3	27.7	110.5
D	27.9	35.0	29.7	30.7	123.3
Total	106.9	136.8	114.9	120.1	478.7

$$\sum_{i=1}^4 \sum_{j=1}^4 Y_{ij}^2 = 14,488.10$$

- (i) State a model and its assumptions.
- (ii) Perform an appropriate analysis at  $\alpha = 0.025$ .
- (iii) Perform a follow-up analysis.

[25 marks]

1. (a) Dalam mengkaji kegemaran pelajar bagi beberapa universiti tertentu, mereka diminta untuk memberi pangkat lapan buah universiti dan keputusan mereka dibandingkan dengan laporan suatu majalah. Pemberian pangkat adalah seperti di dalam jadual di bawah.

Universiti	Pangkat diberi pelajar	Pangkat mengikut laporan majalah
A	11	10
B	12	12
C	13	16
D	14	15
E	25	27
F	26	26
G	37	13
H	80	78

- (i) Nyatakan suatu model serta anggapannya.  
 (ii) Lakukan suatu analisis yang sepadan pada aras signifikan 0.05.

- (b) Satu syarikat pengeluar kereta ingin mengkaji perbezaan di antara kereta keatas penggunaan petrol. Suatu sampel rawak empat kereta daripada model sama dipilih daripada baris pemasangan. Empat pemandu diumpukkan secara rawak memandu setiap kereta. Setiap pemandu memandu kereta tersebut di atas trek ujian 40-kilometer dan penggunaan kilometer setiap liter dicatat.

Kereta	Pemandu				Jumlah
	1	2	3	4	
A	25.3	33.6	28.5	29.3	116.7
B	28.9	36.5	30.4	32.4	128.2
C	24.8	31.7	26.3	27.7	110.5
D	27.9	35.0	29.7	30.7	123.3
Jumlah	106.9	136.8	114.9	120.1	478.7

$$\sum_{i=1}^4 \sum_{j=1}^4 Y_{ij}^2 = 14,488.10$$

- (i) Nyatakan suatu model serta anggapannya.  
 (ii) Lakukan suatu analisis yang sepadan pada  $\alpha = 0.025$ .  
 (iii) Lakukan suatu analisis lanjutan.

[25 markah]

2. (a) A health researcher suspects that the “days of discomfort” caused by common colds can be reduced by ingesting large doses of vitamin C and visiting a sauna every day. Subjects with new colds were randomly assigned to each of the three different daily dosages of vitamin C (500, 1000, or 1500 milligrams) and to each of the two different daily exposures to a sauna (½ or 1 hour). The number of days of discomfort was then recorded.

Sauna Exposure	Vitamin C Dosage (milligrams)						Total
	500		1000		1500		
½ hour	4		5		4		34
	3		4		3		
	2	9	5	14	4	11	
1 hour	4		3		1		20
	2		2		2		
	3	9	2	7	1	4	
Total	18		21		15		54

$$\sum_{i=1} \sum_{j=1} \sum_{k=1} Y_{ijk}^2 = 188$$

- (i) State a model and its assumptions.
- (ii) Perform an appropriate analysis at  $\alpha = 0.10$ .
- (iii) Perform a follow-up analysis.

- (b) Cyclamate is a possible carcinogenic sweetener which is often used in soft drinks. Three procedures were used to test for the substance in a laboratory on a commercially produced orange drink. Each of the procedures was applied to eight different samples of the drink. The percentage of sodium cyclamate is recorded.

Procedure	Drink sample								Total
	1	2	3	4	5	6	7	8	
PcrCh1	42	78	46	40	42	51	42	62	403
Davies	59	82	62	67	60	60	67	62	519
AOAC	65	80	70	66	67	91	67	66	572
Total	166	240	178	173	169	202	176	190	1494

$$\sum_{i=1} \sum_{j=1} Y_{ij}^2 = 97, 104$$

- (i) State a model and its assumptions.
- (ii) Perform an appropriate analysis at  $\alpha = 0.05$ .
- (iii) Perform a follow-up analysis.

[25 marks]

2. (a) Seorang pengkaji kesihatan menjangka bahawa “hari tidak selesa” disebabkan selsema biasa boleh dikurangkan dengan mengambil dos besar vitamin C dan terima rawatan sauna setiap hari. Subjek yang baru mendapat selsema diumpukkan secara rawak kepada setiap daripada tiga dos vitamin C yg berlainan (500, 1000, atau 1500 milligram) dan kepada setiap daripada dua pendedahan harian berlainan di sauna (1/2 atau 1 jam). Bilangan hari tidak selesa dicatat.

Pendedahan Sauna	Dos Vitamin C (milligram)						Jumlah
	500		1000		1500		
1/2 jam	4		5		4		34
	3		4		3		
	2	9	5	14	4	11	
1 jam	4		3		1		20
	2		2		2		
	3	9	2	7	1	4	
Jumlah	18		21		15		54

$$\sum_{i=1} \sum_{j=1} \sum_{k=1} Y_{ijk}^2 = 188$$

- (i) Nyatakan suatu model serta anggapannya.
- (ii) Lakukan suatu analisis yang sepadan pada  $\alpha = 0.10$ .
- (iii) Lakukan suatu analisis lanjutan.

- (b) Cyclamate sejenis pemanis yang sering digunakan di dalam minuman ringan mungkin karsinogenik. Tiga kaedah digunakan untuk menguji bahan tersebut di dalam sebuah makmal bagi suatu minuman oren yang dihasilkan secara komersial. Setiap prosidur digunakan kepada lapan sampel minuman berlainan. Peratusan sodium cyclamate dicatat.

Prosidur	Sampel minuman								Jumlah
	1	2	3	4	5	6	7	8	
PcrChI	42	78	46	40	42	51	42	62	403
Davies	59	82	62	67	60	60	67	62	519
AOAC	65	80	70	66	67	91	67	66	572
Jumlah	166	240	178	173	169	202	176	190	1494

$$\sum_{i=1} \sum_{j=1} Y_{ij}^2 = 97, 104$$

- (i) Nyatakan suatu model serta anggapannya.
- (ii) Lakukan suatu analisis yang sepadan pada  $\alpha = 0.05$ .
- (iii) Lakukan suatu analisis lanjutan.

[25 markah]

3. (a) A sample of seven 30-watts light bulbs was taken from each of three manufacturers and the bulbs were lighted until failure. The number of hours that each remained lit is listed in the following table.

Light bulb	Manufacturer 1	Manufacturer 2	Manufacturer 3	Total
1	905	1350	571	2826
2	905	835	292	2032
3	958	1036	676	2670
4	904	1029	818	2751
5	856	1040	90	1986
6	1300	959	2246	4505
7	1006	996	104	2106
Total	6834	7245	4797	18876

$$\sum_{i=1}^7 \sum_{j=1}^3 Y_{ij}^2 = 21,053,798$$

- (i) State a model and its assumptions.
  - (ii) Perform an appropriate analysis at  $\alpha = 0.10$ .
  - (iii) Perform a follow-up analysis.
  - (iv) If the observation “2246” from manufacturer 3 is changed to “1700”, will there be any effect in the hypothesis test result? Explain why.
- (b) Two experimental pain killer drugs, drug A and drug B, for relief of migraine headaches were studied at a major medical center. The drugs are given in different levels of dosage, low or high dose. Five persistent migraine sufferers were randomly selected for a pilot study and received in random order each of the possible treatment of drugs with a suitable interval between drug administrations. The reduction in pain intensity was recorded (the higher the score, the greater reduction in pain).

Subject	Drug B	Drug A	Drug A	Drug B	Total
	Low dose	High dose	Low dose	High dose	
1	1.6	3.4	2.7	4.3	12.0
2	2.3	5.1	4.2	6.5	18.1
3	4.2	5.3	4.6	6.0	20.1
4	6.0	7.2	6.3	7.3	26.8
5	1.2	1.4	1.3	1.7	5.6
Total	15.3	22.4	19.1	25.8	82.6

$$\sum_{i=1}^5 \sum_{j=1}^4 Y_{ij}^2 = 422.78$$

- (i) State a model and its assumptions.
- (ii) Perform an appropriate analysis at  $\alpha = 0.01$ .
- (iii) Perform a follow-up analysis using Duncan multiple range test.
- (iv) Determine the following effects on pain intensity:
  - a. drug effect
  - b. dose effect

[25 marks]

3. (a) Suatu sampel tujuh biji lampu mentol 30-watt diambil dari setiap tiga pengusaha dan mentol-mentol tersebut dinyalakan sehingga gagal menyala. Bilangan jam setiap mentol yang masih menyala disenaraikan dalam jadual berikut.

Lampu mentol	Pengusaha 1	Pengusaha 2	Pengusaha 3	Jumlah
1	905	1350	571	2826
2	905	835	292	2032
3	958	1036	676	2670
4	904	1029	818	2751
5	856	1040	90	1986
6	1300	959	2246	4505
7	1006	996	104	2106
Jumlah	6834	7245	4797	18876

$$\sum_{i=1}^7 \sum_{j=1}^3 Y_{ij}^2 = 21,053,798$$

- (i) Nyatakan suatu model serta anggapannya.  
 (ii) Lakukan suatu analisis yang sepadan pada  $\alpha = 0.10$ .  
 (iii) Lakukan suatu analisis lanjutan.  
 (iv) Jika cerapan "2246" dari pengusaha 3 ditukar kepada "1700", adakah terdapat sebarang kesan kepada keputusan ujian hipotesis? Terangkan sebabnya.
- (b) Dua ubat penahan sakit dalam kajian, ubat A dan ubat B, untuk melegakan pening migrain dikaji di sebuah pusat perubatan utama. Ubat tersebut diberi dalam aras dos berlainan, dos rendah atau tinggi. Lima pengidap migrain berterusan dipilih secara rawak bagi suatu kajian pilot dan mereka menerima secara rawak setiap kemungkinan rawatan ubat dengan suatu selang yang sesuai antara pemberian ubat. Pengurangan dalam keamatan sakit dicatat (lebih tinggi skor, lebih besar pengurangan sakit).

Subjek	Ubat B	Ubat A	Ubat A	Ubat B	Jumlah
	Dos rendah	Dos tinggi	Dos rendah	Dos tinggi	
1	1.6	3.4	2.7	4.3	12.0
2	2.3	5.1	4.2	6.5	18.1
3	4.2	5.3	4.6	6.0	20.1
4	6.0	7.2	6.3	7.3	26.8
5	1.2	1.4	1.3	1.7	5.6
Jumlah	15.3	22.4	19.1	25.8	82.6

$$\sum_{i=1}^5 \sum_{j=1}^4 Y_{ij}^2 = 422.78$$

- (i) Nyatakan suatu model serta anggapannya.  
 (ii) Lakukan suatu analisis yang sepadan pada  $\alpha = 0.01$ .  
 (iii) Lakukan suatu analisis lanjutan menggunakan ujian julat berganda Duncan  
 (iv) Tentukan kesan berikut atas keamatan sakit:  
 a. kesan ubat  
 b. kesan dos

[25 markah]

4. The price of houses has risen quite abruptly for the past few months and has raised concerns as to whether there have been speculations. Eight houses were surveyed by a house broker. The prices in RM given by the sellers, the number of bedrooms and the number of bathrooms are given in the data.

No. of Bedrooms	No. of Bathrooms	Price (RM)
3	2	78800
2	1	74300
4	3	83800
2	1	74200
3	2	79700
2	2	74900
5	3	88400
4	2	82900

Refer to the appendix output for question 4

- (i) State the model and its assumptions.
- (ii) Perform an appropriate analysis to obtain the estimated model. Use  $\alpha = 0.05$
- (iii) Obtain an estimation interval and prediction interval of house prices with 3 bedrooms and 3 bathrooms.

[25 marks]

4. Harga rumah telah meningkat secara mendadak dalam beberapa bulan yang lalu dan ia telah meningkatkan kebimbangan sama ada hal ini disebabkan oleh spekulasi. Lapan buah rumah diselidiki oleh seorang agen rumah. Harganya dalam RM diberi oleh penjual-penjual serta bilangan bilik tidur dan bilangan bilik mandi diberi dalam data.

<i>Bilangan bilik tidur</i>	<i>Bilangan bilik mandi</i>	<i>Harga (RM)</i>
3	2	78800
2	1	74300
4	3	83800
2	1	74200
3	2	79700
2	2	74900
5	3	88400
4	2	82900

Rujuk kepada apendiks output bagi soalan 4

- (i) Nyatakan model serta anggapannya.
- (ii) Lakukan suatu analisis yang sesuai untuk mendapatkan suatu model yang dianggarkan. Guna  $\alpha = 0.05$
- (iii) Dapatkan suatu selang anggaran dan selang ramalan untuk harga rumah bagi rumah yang mempunyai 3 bilik tidur dan 3 bilik mandi.

[25 markah]

APPENDIX: OUTPUT

**Question 4**

<b>Predictor</b>	<b>Coefficient</b>	<b>Standard error</b>
Constant	65,587.273	377.172
No. of Bedrooms	4,000.000	235.565
No. of Bathrooms	723.636	267.645

**Analysis of Variance**

<b>Source of Variation</b>	<b>df</b>	<b>SS</b>
Regression	2	185,400,000
Error	5	555,000
Total	7	185,955,000

$$\mathbf{X}'\mathbf{X}^{-1} = \begin{bmatrix} 1.2818 & -0.5000 & 0.1909 \\ -0.5000 & 0.5000 & -0.5000 \\ 0.1909 & -0.5000 & 0.6455 \end{bmatrix}$$

**1. Completely Randomized Design**

$$SST = \sum_i \sum_j Y_{ij}^2 - \frac{Y^2}{N}$$

$$SSA = \sum_i \frac{Y_{i.}^2}{n_i} - \frac{Y^2}{N}$$

For any contrast :  $L = \sum_i c_i \bar{Y}_{i.}$

$$SSL = \frac{\left( \sum_i c_i \bar{Y}_{i.} \right)^2}{\sum_i \frac{c_i^2}{n_i}}$$

**2. Completely Randomized Block Design**

$$SST = \sum_i \sum_j Y_{ij}^2 - \frac{Y^2}{N}$$

$$SSA = \sum_i \frac{Y_{i.}^2}{b} - \frac{Y^2}{N}$$

$$SSB = \sum_j \frac{Y_{.j}^2}{a} - \frac{Y^2}{N}$$

### 3. Latin Square Design

$$SST = \sum_i \sum_j \sum_k Y_{ijk}^2 - \frac{Y^2}{N}$$

$$SSR = \sum_i \frac{Y_{i..}^2}{a} - \frac{Y^2}{N}$$

$$SSC = \sum_j \frac{Y_{.j.}^2}{a} - \frac{Y^2}{N}$$

$$SSA = \sum_k \frac{Y_{..k}^2}{a} - \frac{Y^2}{N}$$

### 4. Two-way Factorial Design

$$SST = \sum_i \sum_j \sum_k Y_{ijk}^2 - \frac{Y^2}{N}$$

$$SSA = \sum_i \frac{Y_{i..}^2}{bn} - \frac{Y^2}{N}$$

$$SSB = \sum_j \frac{Y_{.j.}^2}{an} - \frac{Y^2}{N}$$

$$SSE = \sum_i \sum_j \sum_k Y_{ijk}^2 - \frac{Y_{ij.}^2}{n}$$

**5. Distributions:**

Duncan:  $r_{\alpha, p, df}$  ,  $p = \text{range}$   $df = \text{degrees of freedom}$

Tukey:  $\frac{1}{\sqrt{2}} q_{\alpha, a, df}$  ,  $a = \text{number of treatments}$   $df = \text{degrees of freedom}$

Scheffe':  $\sqrt{a-1 F_{\alpha, a-1, df}}$  ,  $a = \text{number of treatments}$   $df = \text{degrees of freedom}$

**6. Regression**

$$b_1 = \frac{SS_{XY}}{SS_X} , \quad b_0 = \bar{Y} - b_1 \bar{X}$$

$$SSE = SS_Y - \frac{[SS_{XY}]^2}{SS_X}$$

$$SS_{XY} = \frac{\sum X_i Y_i - \frac{\sum X_i \sum Y_i}{n}}{\sum X_i^2 - \frac{(\sum X_i)^2}{n}}$$

$$SS_X = \sum X_i^2 - \frac{(\sum X_i)^2}{n}$$

$$SS_Y = \sum Y_i^2 - \frac{(\sum Y_i)^2}{n}$$

$$\text{Var}(b_1) = \frac{\sigma^2}{SS_X}$$

$$\text{Var}(\hat{Y}_h) = \sigma^2 \left[ \frac{1}{n} + \frac{X_h - \bar{X}}{SS_X} \right]^2 , \quad \text{Var}(\hat{Y}_h) = \text{MSE } \mathbf{X}'_h (\mathbf{X}'\mathbf{X})^{-1} \mathbf{X}_h$$

**7. Correlation**

$$r = \frac{SS_{XY}}{\sqrt{SS_{XX} SS_{YY}}}$$

$$t = r \sqrt{\frac{n-2}{1-r^2}}$$

**8. Kruskal-Wallis Test**

$$T = \frac{12}{N(N+1)} \sum_i \frac{R_i^2}{n_i} - 3 \frac{N+1}{N}$$

**9. Friedman Test**

$$T = \frac{12}{ba(a+1)} \sum_i R_i^2 - 3b \frac{a+1}{a}$$

**10. Cochran Test**

$$T = \frac{a(a-1) \sum_i A_i^2 - (a-1) N^2}{a N - \sum_j B_j^2}$$

**11. Spearman Test**

$$r_s = 1 - \frac{6 \sum_{i=1}^n [R_{X_i} - R_{Y_i}]^2}{n(n^2-1)} = 1 - \frac{6 \sum_i d_i^2}{n(n^2-1)}$$

**APPENDIX: TABLES**

**Duncan Multiple Range Table**

**Spearman Table**