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UNIVERSITI SAINS MALAYSIA

Second Semester Examination  
2012/2013 Academic Session

June 2013

**EEM 332 – Design Of Experiments**  
**[Rekabentuk Ujikaji]**

Duration : 3 hours  
Masa : 3 jam

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Please check that this examination paper consists of **THIRTEEN (13)** pages of printed material before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **TIGA BELAS (13)** muka surat bercetak sebelum anda memulakan peperiksaan ini]*

**Instructions:** This question paper consists **SIX (6)** questions. Answer **FIVE (5)** questions. Question **ONE** must be answered. All questions carry the same marks.

**Arahan:** Kertas soalan ini mengandungi **ENAM (6)** soalan. Jawab **LIMA (5)** soalan. Soalan **SATU** perlu dijawab. Semua soalan membawa jumlah markah yang sama]

Answer to any question must start on a new page.

*[Mulakan jawapan anda untuk setiap soalan pada muka surat yang baru]*

“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) Terangkan apa yang dimaksudkan dengan rekabentuk ujikaji berstatistik.

*Explain what is meant by statistical design of experiments.*

(20 markah/marks)

- (b) Senaraikan kelebihan rekabentuk ujikaji berstatistik berbanding dengan pendekatan tradisional untuk ujikaji. Huraikan jawapan anda.

*List the advantages of statistical design of experiments as compared to the traditional approach of experimentation. Elaborate on your answers.*

(40 markah/marks)

- (c) Nyatakan jenis rekabentuk ujikaji berstatistik yang paling sesuai untuk merancang ujikaji untuk menentukan faktor input yang manakah yang mempunyai pengaruh yang kuat ke atas hasil sebuah proses. Andaikan bahawa bilangan faktor input melebihi 4. Beri justifikasi bagi jawapan anda. Nyatakan juga andaian untuk rekabentuk yang anda telah pilih.

*State the most appropriate type of statistical design of experiments for planning an experiment for determining which input factors significantly influence the process output. Assume that the number of input factors exceeds four. Justify your answer. Also state the assumptions for the design that you have selected.*

(40 markah/marks)

2. Rekabentuk faktor umum telah digunakan untuk merancang dan menjalankan sebuah ujikaji yang melibatkan 3 faktor. Jadual 2.1 menunjuk butiran bagi faktor. Respons adalah jumlah sisihan dari nilai sasaran sifar. Kesemua faktor adalah faktor tetap. Bilangan replika adalah dua. Jadual ANOVA ditunjukkan di dalam Jadual 2.2. Rajah 2 menunjuk plot bagi kesan utama dan interaksi.

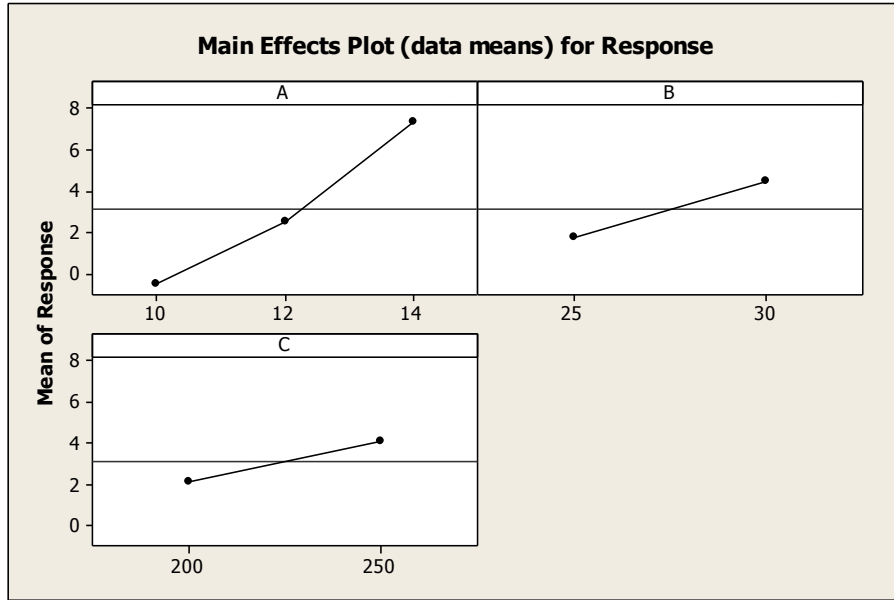
*The general factorial design has been used to plan and carry out an experiment involving 3 factors. Table 2.1 show the details of the factors. The response is the amount of deviation from the target value of zero. All of the factors are fixed factors. The number of replicates is two. The ANOVA table is shown in Table 2.2. Figure 2 shows the main effect and interaction plots.*

Jadual 2.1  
Table 2.1

Factors	Name	Levels
A	Percent carbonation	10,12,14
B	Operating pressure	25,30
C	Line Speed	200,250

Jadual 2.2  
Table 2.2

<b>ANOVA: Response versus A, B, C</b>						
Factor	Type	Levels	Values			
A	fixed	3	10, 12, 14			
B	fixed	2	25, 30			
C	fixed	2	200, 250			
Analysis of Variance for Response						
Source	DF	SS	MS	F	P	
A	2	252.750	126.375	178.41	0.000	
B	1	45.375	45.375	64.06	0.000	
C	1	22.042	22.042	31.12	0.000	
A*B	2	5.250	2.625	3.71	0.056	
A*C	2	0.583	0.292	0.41	0.671	
B*C	1	1.042	1.042	1.47	0.249	
A*B*C	2	1.083	0.542	0.76	0.487	
Error	12	8.500	0.708			
Total	23	336.625				
S = 0.841625    R-Sq = 97.47%    R-Sq(adj) = 95.16%						



Rajah 2  
Figure 2

Jawab soalan-soalan berikut:

*Answer the following questions.*

- (a) Bilakah rekabentuk faktorasi umum sesuai untuk digunakan?  
*When is it appropriate to use the general factorial design?*  
(30 markah/marks)
- (b) Maklumat apakah yang boleh didapati daripada jadual ANOVA di dalam Jadual 2.2?  
*What information can be obtained from the ANOVA table in Table 2.2?*  
(30 markah/marks)
- (c) Maklumat apakah yang boleh didapati daripada plot di dalam Rajah 2?  
*What information can be obtained from the plots in Figure 2?*  
(40 markah/marks)

3. Sebuah ujikaji yang melibatkan 3 faktor telah dijalankan menggunakan rekabentuk faktorasi dua aras. Jadual 3.1 menunjuk butiran bagi faktor. Respons adalah jumlah sisihan dari nilai sasaran sifar. Kesemua faktor adalah faktor tetap. Ujikaji telah dijalankan sebanyak dua kali. Perisian statistik Minitab digunakan untuk menganalisa data. Hasilnya diberi di bawah.

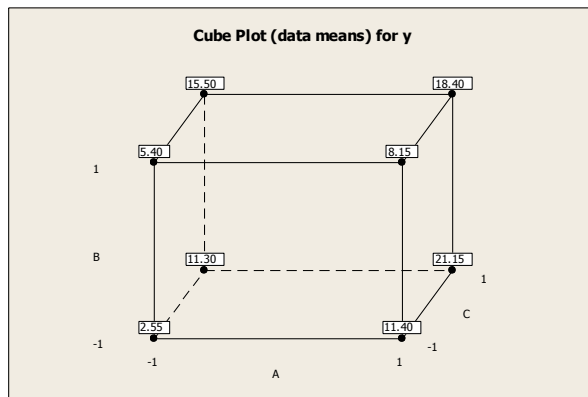
*An experiment involving 3 factors was carried out using the two-level factorial design. The details of the factors are shown in Table 3.1. The response is the amount of deviation from the target value of zero. All of the factors are fixed factors. The experiment was carried out twice. Minitab statistical software was used to analyze the data. The results are given below.*

Jadual 3.1

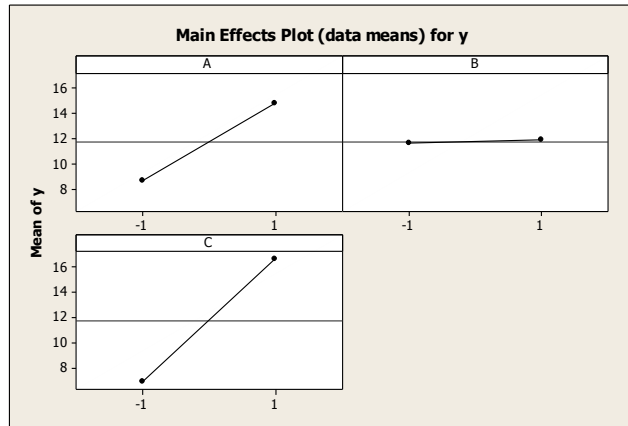
Table 3.1

Factors	Name	Levels
A	Transducer	H5M, H10M
B	Filtering	With, Without
C	Evaluation criteria	Curve 1, Curve 2

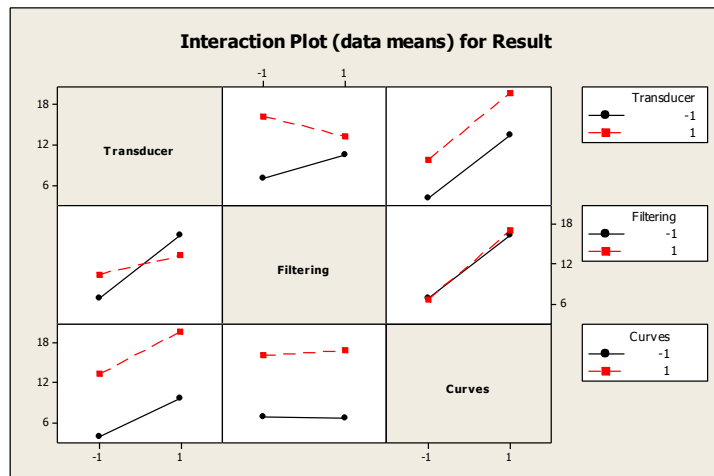
GRAPHICAL ANALYSIS



### GRAPHICAL ANALYSIS



### GRAPHICAL ANALYSIS





NUMERICAL ANALYSIS

**Factorial Fit: y versus A, B, C**

Estimated Effects and Coefficients for y (coded units)

Term	Effect	Coef	SE Coef	T	P
Constant	11.731	0.5262	22.30	0.000	
A	6.087	3.044	0.5262	5.78	0.000
B	0.262	0.131	0.5262	0.25	0.809
C	9.712	4.856	0.5262	9.23	0.000
A*B	-3.263	-1.631	0.5262	-3.10	0.015
A*C	0.288	0.144	0.5262	0.27	0.792
B*C	0.463	0.231	0.5262	0.44	0.672
A*B*C	-0.212	-0.106	0.5262	-0.20	0.845

S = 2.10461 R-Sq = 94.15% R-Sq(adj) = 89.02%

- (a) Sahkan nilai bagi kesan utama A, B, dan C di dalam analisis numerik. Tunjuk semua perjalanan kerja.

*Verify the value of the main effects of A, B, and C in the numerical analysis. Show all of your workings.*

(30 markah/marks)

- (b) Apakah tujuan nilai p dalam analisis numerik? Kesimpulan apakah yang boleh anda buat berdasarkan nilai p di dalam analisis numerik yang di atas?

*What is the purpose of the p-values in the numerical analysis? What can you conclude based on the p values in the above numerical analysis?*

(30 markah/marks)

- (c) Apakah setting yang paling bagus untuk faktor A, B, dan C berdasarkan keputusan analisis grafik dan numerik? Beri justifikasi bagi jawapan anda.

*What are the best settings for factors A, B and C based on the results of the graphical and numerical analysis? Justify your answer.*

(40 markah/marks)

...10/-

4. (a) Seorang jurutera elektrik sedang mempelajari tiga jenis pemproses di dalam kalkulator elektronik. Masa tidakbalas dalam menyelesaikan 5 masalah statistik telah diukur. Andaikan masalah sebagai blok dan uji perbezaan antara purata masa yang diperlukan dalam menyelesaikan masalah statistik. Keputusan eksperimen diberikan seperti berikut. Bina jadual ANOVA.

*An electrical engineer is studying three types of processors used in an electronic calculator. The response time in milliseconds for solving five problems in statistics was measured. Consider problems as blocks and test for the difference among the mean times required to solve the statistic problem. The results of the experiments are as follows. Construst an ANOVA table.*

Jadual 4(a)  
Table 4(a)

Processor types	Problems				
	1	2	3	4	5
1	19	22	20	18	25
2	20	21	33	27	40
3	16	15	18	26	17

(80 markah/marks)

- (b) Seorang jurutera elektrik ingin membuat perbandingan min jangka hayat bagi 2 jenis transistor dalam aplikasi prestasi suhu tinggi. Sebanyak 60 sampel transistor dari jenis A telah diuji dan didapati mempunyai min jangka hayat 1827 jam dengan sisihan piawai 168 jam. Sebanyak 180 transistor jenis B telah diuji dan didapati mempunyai min jangka hayat 1658 jam dengan sisihan piawai 225 jam. Dapatkan 95% selang keyakinan bagi perbezaan antara min jangka hayat bagi kedua-dua jenis transistor.

*An electrical engineer wishes to compare the mean lifetimes of two types of transistors in an application involving high-temperature performance. A sample of 60 transistors of type A were tested and were found to have a mean lifetime to 1827 hours and a standard deviation of 168 hours. A sample of 180 transistors of types B were tested and were found to have a mean lifetime of 1658 hours and a standard deviation of 225 hours. Find a 95% confidence interval for the difference between the mean lifetimes of the two types of transistors*

(20 markah/marks)

5. (a) Dua mikropemproses dibandingkan berdasarkan enam sampel kod untuk mengenalpasti sama ada terdapat perbezaan dalam kelajuannya. Masa dalam saat bagi kedua-dua mikropemproses diberi dalam Jadual 5(a). Bolehkah anda membuat kesimpulan bahawa nilai min bagi kelajuan adalah berbeza bagi kedua-dua mikropemproses ?

*Two microprocessors are compared on a sample of six benchmark codes to determine whether there is a difference in speed. The times (in seconds) used by each processor on each code are given in the following Table 5(a). Can you conclude that the mean speeds of the two processors differ?*

(50 markah/marks)

Jadual 5(a)  
Table 5(a)  
Code

	1	2	3	4	5	6
Processor A	27.2	18.1	27.2	19.7	24.5	22.1
Processor B	24.1	19.3	26.8	20.1	27.6	29.8

- (b) Satu kajian telah dijalankan untuk menguji samada terdapat perbezaan antara dua jenis petrol iaitu petrol A dan petrol B. Lima kereta telah dipilih secara rawak dan data mengenai penggunaan petrol dalam batu per gelen bagi setiap jenis petrol diperolehi seperti berikut. Guna  $\alpha = 0.05$ .

*A study was conducted to test whether there are differences between two types of petrol that is petrol A and petrol B. Five cars were selected at random and the data about petrol consumption in miles per gallon for each petrol types are obtained. Use  $\alpha = 0.05$ .*

Jadual 5(b)  
Table 5(b)

CARS	MILES PER GALLON	
	PETROL A	PETROL B
1	26.9	27.7
2	22.5	22.2
3	24.5	25.3
4	26.0	26.8
5	28.5	29.7

(50 markah/marks)

6. Satu ujikaji telah dijalankan untuk mengukur kesan dua faktor (konsentrasi sabun diukur dalam peratusan berat dan jenis asid diukur dalam milliliter) terhadap keupayaan untuk menghilangkan kesan minyak dari sehelai kain (diukur dalam peratusan minyak yang hilang). Ujikaji tersebut telah direplikasikan sebanyak dua kali. Berikut merupakan keputusan yang diperolehi. Bina jadual ANOVA dan uji sama ada terdapat interaksi antara konsentrasi sabun dan jenis asid.

*An experiment was conducted to measure the effects two factors (concentration of soap measured in percentage by weight and a type of acid measured in milliliters) on the ability of removing oil from a piece of cloth (measured in percentage of oil removed). The experiment was replicated twice. The following results are obtained :*

*Construct ANOVA table and test whether there is interaction effects between concentration of soap and acid used.*

Jadual 6  
Table 6

Concentration of soap (% weight)	Acid used (ml)	
	15	30
15	52.5 54.2	57.0 53.0
30	56.4 58.0	43.0 45.2

(100 markah/marks)