Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	DESIGN OF EXPERIMENT / DESIGN AND ANALYSIS OF EXPERIMENT
COURSE CODE	:	BWB 21803 / BWB 31803
PROGRAMME CODE	:	BWQ
EXAMINATION DATE	:	DECEMBER 2019 / JANUARY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **ALL** QUESTIONS

THIS EXAMINATION PAPER CONSISTS OF **SIX (6)** PAGES

Q1 (a) Explain why any experiment must be conducted at random.

(2 marks)

(b) Define the statistical terms in Design of Experiment below.

(i) Blocking
(ii) Replication
(iii) Interaction
(iv) Orthogonal
(v) Main effect

(5 marks)

(c) The tensile strength of Portland cement is being studied. Four different mixing techniques can be used economically. A completely randomized experiment was conducted and the following data in **Table Q1(c)** were collected:

Table Q1(c)

Mixing techniques	Tensile strength			
1	3129	3000	2865	2890
2	3200	3300	2975	3150
3	2800	2900	2985	3050
4	2600	2700	2600	2765

(i) State the appropriate design for the above problem. Explain your answer.

(2 marks)

(ii) Test the hypothesis that the mixing techniques will affect the strength of the cement. Use $\alpha = 0.05$.

(10 marks)

(iii) Compare the treatment means by using the Fisher Least Significant Difference (LSD) test. Interpret the result. (Use $\alpha = 0.05$).

(6 marks)

(iv) The analysis on residual are studied based on the tensile strength. What can you conclude from the normal probability plot in **Figure Q1(c)?**

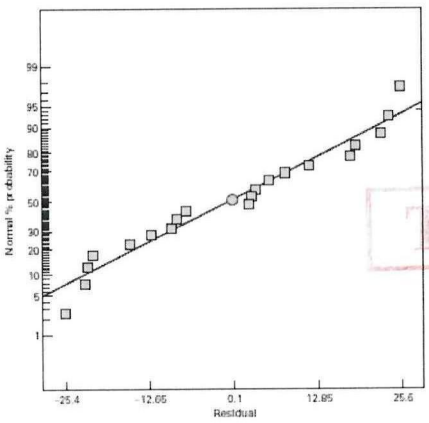

Figure Q1(c)

(2 marks)

Q2 A plant biologist conducted an experiment to compare the yields of 4 varieties of peanuts (A, B, C, D). A plot of land was divided into 16 subplots (4 rows and 4 columns). The plant biologist uses the design shown in **Table Q2**.

Table Q2

C = 26.7	A =19.7	B = 29.0	D = 29.8
A = 23.1	B = 21.7	D = 24.9	C = 29.0
B = 29.3	D = 20.1	C = 29.0	A = 27.3
D = 25.1	C =17.4	A = 28.7	B = 35.1

(a) What is the most appropriate design for this problem? State the statistical model with the necessary assumptions and identify the terms.

(4 marks)

(b) Is the design symmetric? Justify your answer.

(2 marks)

(c) Analyze these data with the appropriate conclusions. (Use $\alpha = 0.05$).

(14 marks)

Q3 (a) The following output in **Table Q3(a)** was obtained from a computer program that performed a two-factor ANOVA on a factorial experiment.

Table Q3(a)

Source	Degree of freedom	Sum of squares	Mean squares	*F*
A	1	0.322		
B		80.554	40.2771	4.59
Interaction				
Error	12	105.327	8.7773	
Total	17	231.551		

(i) Fill in the blanks in the ANOVA table.

(7 marks)

(ii) Identify the levels used for factor B.

(1 mark)

(iii) Identify the number of replications in this experiment.

(1 mark)

(iv) What can you conclude from this experiment? (Use $\alpha = 0.05$).

(1 mark)

(b) An industrial engineer employed by a beverage bottler is interested in the effects of two different types of 32-ounce bottles on the time to deliver 12-bottle cases of the product. The two bottle types are glass and plastic. Two

workers are used to perform a task consisting of moving 40 cases of the product 50 feet on a standard type of hand truck and stacking the cases in a display. Four replicates of a 2^2 factorial design are performed, and the times observed are listed in **Table Q3(b).**

Table Q3(b)

Bottle type	Worker			
	1		2	
Glass	5.12 4.98	4.89 5.00	6.65 5.49	6.24 5.55
Plastic	4.95 4.27	4.43 4.25	5.28 4.75	4.91 4.71

(i) Explain the **FOUR (4)** main effects related to both types.

(8 marks)

(ii) Calculate the magnitude of the interaction between worker and bottle type.

(6 marks)

(iii) Is there any interaction between both effects? Prove your answer by using graphical illustration for both effects.

(6 marks)

Q4 An engineer is interested in the effects of three factors. The factors are cutting speed (A), tool geometry (B), and cutting angle (C) on the life (in hours) of a mechanical tool. Two levels of each factor are chosen, and three replicates of a 23 factorial design are run. The results can be referred to **Table Q4**.

Table Q4

A	B	C	Treatment combination	Replicate		
				I	II	III
-	-	-	(1)	22	31	25
+	-	-	a	32	43	29
-	+	-	b	35	34	50
+	+	-	ab	55	47	46
-	-	+	c	44	45	38
+	-	+	ac	40	37	36
-	+	+	bc	60	50	54
+	+	+	abc	39	41	47

(a) Compute the interaction for each AB, AC, BC and ABC.

(8 marks)

(b) Illustrate the interaction above by plotting an interaction plot for A and B. Interpret the result.

(3 marks)

Q5 Hoof and Berman (1988) describes an experiment conducted to study the capability of measurements in thermal impedance (C°/w x 100) on a power module for an induction motor starter. There are 10 parts, three operators, and three replicates. The results from this experiment are shown in **Figure Q5(a)**, **Figure Q5(b)** and **Figure Q5(c)**.

Analysis of Variance for Thermal

Source	DF	SS	MS	F	P
Partno	9	3935.96	437.33	162.27	0.000
Insp	2	39.27	19.63	7.28	0.005
Partno*Insp	18	48.51	2.70	5.27	0.000
Error	60	30.67	0.51		
Total	89	4054.40			

S = 0.714920 R-Sq = 99.24% R-Sq(adj) = 98.88%

	Source	Variance component	Error term	Expected Mean Square for Each Term(using restricted model)
1	Partno	48.2926	3	(4) + 3 (3) + 9 (1)
2	Insp	0.5646	3	(4) + 3 (3) + 30 (2)
3	Partno*Insp	0.7280	4	(4) + 3 (3)
4	Error	0.5111		(4)

Figure Q5(a)

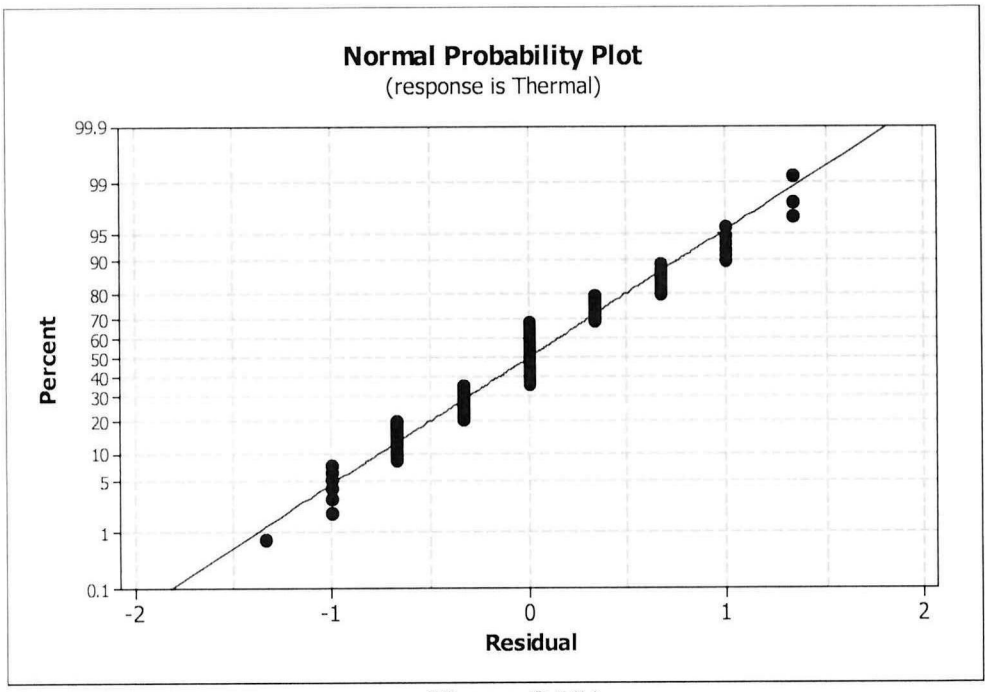

Figure Q5(b)

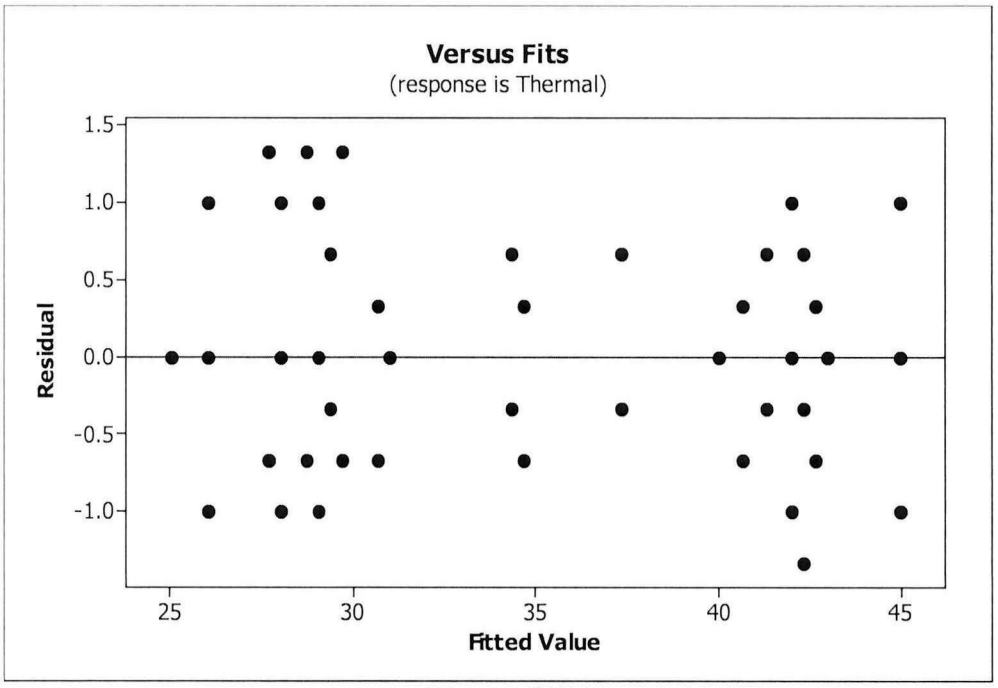

Figure Q5(c)

(a) Based on the output given in **Figure Q5(a)**, compute the variance components for all main effects.

(5 marks)

(b) List all null and alternative hypotheses for this experiment.

(3 marks)

(c) Test the model adequacy checking by referring to **Figure Q5(b)** and **Figure Q5(c).**

(4 marks)

- END OF QUESTIONS -