DEPARTMENT OF STATISTICS AND DEMOGRAPHY

SUPPLEMENTARY EXAMINATION, 2017/18

COURSE TITLE:	DESIGN AND ANALYSIS OF EXPERIMENTS
COURSE CODE:	ST 404
TIME ALLOWED:	THREE (3) HOURS
INSTRUCTION:	1. ANSWER QUESTION ONE AND ANY THREE QUESTIONS; 2. EACH QUESTION CARRIES 25 MARKS.
SPECIAL REQUIREMENTS:	SCIENTIFIC CALCULATORS AND STATISTICAL TABLES

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Question 1

Suppose that the two supervisors are each observed on three randomly selected days for each of the different shifts. The average outputs for the three shifts are shown in in the following Table for each of the supervisors.

	Shift		
Supervisor	Day	Swing	Night
1	571	480	470
	610	474	430
	625	540	450
2	480	625	630
	516	600	680
	465	581	661

a) Analyse these data using the appropriate analysis of variance procedure.
b) Is the interaction effect significant? Conclude using the ANOVA Table.
c) Conclude using the Interaction Plot for Mean. **(20+5 marks)**

Question 2

a) Twenty-seven people participated in an experiment to compare the effects of five different stimuli on reaction time. The experiment was run using a completely randomized design, and, regardless of the results of the analysis of variance, the experimenters wanted to compare stimuli A and D. the results of the experiment are given here. Use the MINITAB printout to complete the exercise.

Stimulus	Reaction Time (sec)							Total	Mean
A	.8	.6	.6	.5				2.5	.625
B	.7	.8	.5	.5	.6	.9	.7	4.7	.671
C	1.2	1.0	.9	1.2	1.3	.8		6.4	1.067
D	1.0	.9	.9	1.1	.7			4.6	.920
E	.6	.4	.4	.7	.3			2.4	.480

MINITAB output
One-way ANOVA: Time versus Stimulus

Analysis of Variance for Time

Source	*DF*	*SS*	*MS*	*F*	*P*
Stimulus	*2*	*1.2118*	*0.3030*	*11.67*	*0.000*
Error	*22*	*0.5711*	*0.0260*		
Total	*26*	*1.7830*			

				Individual 95% CIs for Mean Based on Pooled StDev
Level	*N*	*mean*	*StDev*	---------+---------+---------+---------
A	*4*	*0.6250*	*0.1258*	(--------*--------)
B	*7*	*0.6714*	*0.1496*	(------*-----)
C	*6*	*1.0667*	*0.1966*	(-----*----)
D	*5*	*0.9200*	*0.1483*	(-----*-----)
E	*5*	*0.4800*	*0.1643*	(-----*-----)
				---------+---------+---------+---------
Pooled StDev =		*0.1611*		*0.50* *0.751.0*

(i) Conduct an analysis of variance and test for a difference in the mean reaction times due to the five stimuli. **(10 marks)**

(ii) Compare stimuli A and D to see if there is a difference in mean reaction times.**(5 marks)**

b) The experiment in a) might have been conducted more effectively using a randomised block design with people as blocks, since you would expect mean reaction time to vary from one to another. Hence, four people were used in a new experiment, and each person was subjected to each of the five stimuli in a random order. The reaction times (in seconds) are listed here:

	Stimulus				
Subject	A	B	C	D	E
1	.7	.8	1.0	1.0	.5
2	.6	.6	1.1	1.0	.6
3	.9	1.0	1.2	1.1	.6
4	.6	.8	.9	1.0	.4

MINITAB output

Two-way ANOVA: Time versus Subject, Stimulus

Analysis of Variance for Time

Source	*DF*	*SS*	*MS*	*F*	*P*
Subject	*3*	*0.14000*	*0.04667*	*6.59*	*0.007*
Stimulus	*4*	*0.78700*	*0.19675*	*27.78*	*0.000*
Error	*12*	*0.08500*	*0.00708*		
Total	*19*	*1.01200*			

Individual 95% CI

Stimulus	*Mean*	---------+---------+---------+---------+--
A	*0.700*	*(-----*-----)*
B	*0.800*	*(-----*-----)*
C	*1.050*	*(---*----)*
D	*1.025*	*(---*----)*
E	*0.525*	*(---*-----)*

--------+---------+---------+---------+--

0.600 0.800 1.000 1.200

(i) Use the MINITAB printout to analyse the data and test for differences in treatment means.

(ii) Does it appear that blocking was effective in this experiment? **(5+5 marks)**

Question 3

An industrial engineer is investigating the effect of four assembly methods (A, B, C, D) on the assembly time for a colour television component. Four operators are selected for the study. Furthermore, the engineer knows that each assembly method produces such fatigue that the time requires for the last assembly may be greater than the time required for the first, regardless to the method. That is, a trend develops in the required assembly time. to account for this source of variability, the engineer uses the Latin square design shown below. Analyse the data from this experiment ($\alpha = 0.05$) and draw appropriate conclusions.

(25 marks)

Order of Assembly	Operator			
	1	2	3	4
1	C = 10	D = 14	A = 7	B = 8
2	B = 7	C = 18	D = 11	A = 8
3	A = 5	B = 10	C = 11	D = 9
4	D = 10	A = 10	B = 12	C = 14

Question 4

Suppose that in Question 3, the engineer suspects that the workplaces used by the four operators may represent an additional source vitamin. A fourth factor, workplace ($\alpha, \beta, \gamma, \delta$) may be introduced and another experiment conducted, yielding the Graeco-Latin square that follows. Analyse the data from this experiment ($\alpha = 0.05$) and draw conclusions.

Order of Assembly	Operator			
	1	2	3	4
1	$C\beta = 11$	$B\gamma = 10$	$D\delta = 14$	$A\alpha = 8$
2	$B\alpha = 8$	$C\delta = 12$	$A\gamma = 10$	$D\beta = 12$
3	$A\delta = 9$	$D\alpha = 11$	$B\beta = 7$	$C\gamma = 15$
4	$D\gamma = 9$	$A\beta = 8$	$C\alpha = 18$	$B\delta = 6$

(25 marks)

Question 5

(a) List the effects that can be estimated with a 2^4 factorial experiment. **(3 marks)**

(b) An engineer wants to run a 2^5 factorial experiment in four blocks. Suppose that both ABCD and ACE are confounded with blocks.

(i) Determine the generalized interaction **(2 marks)**

(ii) Write down the treatment combinations for each of the four blocks. **(8 marks)**

(c) In a 2^5 design with four blocks, the treatment combinations in the principal block are:

(1) bc ae abd bde cde acd abce

Write out the treatment combinations in the other three blocks. **(12 marks)**

Question 6

An engineer is interested in the effect of cutting speed and tool geometry on the life in hours of a machine tool. Two cutting speeds and two different geometries are used. Three experimental tests are accomplished at each of the four combinations. The data are as follows:

Tool Geometry	Cutting Speed	
	Low	High
1	22	34
	28	37
	20	29
2	18	11
	15	10
	16	10

(a) Test at 5 per cent level of significance for main and interaction effects. **(20 marks)**

(b) Graphically display the interaction effect. **(5 marks)**

END OF EXAM!!!