Practice Exercises Lesson No. 6 to 10

Lesson No. 6

MCQs : Each MCQ carries 1 mark

1. Replication in a Latin Square design is
   a) Time Consuming
   b) Costly
   c) Time Consuming and Costly
   d) Economical

2. An experimental design where the experimental units are appear once and only once in each direction.
   a) Fractional Factorial design
   b) Randomized Complete Block design
   c) Completely Randomized design
   d) Latin Square design

Question carry 2 marks

3. If in a Latin Square design with one missing observation, the Treatment SS is 16 with the degrees of freedom 4 and the Mean Square Error is 2, then what would be the value of F-ratio corresponding to these results?

Question carry 3 marks

4. Write down any three advantages of a Latin Square design.

Question carry 5 marks

5. Complete the given ANOVA table of Latin Square Design for one missing observation.

Source of variation	**Degrees of freedom**	**Sums of Squares (SS)**	**Mean Square (MS)**	**F**
Rows (*R*)	$k-1$	*SSR*	?	?
Columns (*C*)	$k-1$	*SSC*	?	?
Treatments (*Tr*)	$k-1$	*SSTr*	?	?
Error (*E*)		*SSE*	?	
Total (*T*)		*SST*		

Lesson No. 7

MCQs : Each MCQ carries 1 mark

6. Write the formula for finding the sum of square of treatments in Completely Randomized design. Which condition must be hold for applying multiple comparison tests?
   a) Rejection of Alternative Hypothesis
   b) Rejection of Null Hypothesis
   c) Minimum Sum of Square Error
   d) Maximum Mean Square Error

7. To evaluate the efficiency of a Latin Square design relative to Completely Randomized design, the appropriate formula is

   a) $\frac{s_r^2 - s_c^2 + (k-1)s_e^2}{(k+2)s_e^2}$ b) $\frac{s_r^2 + s_c^2 + (k-1)s_e^2}{(k-2)s_e^2}$

   c) $\frac{s_r^2 + s_c^2 + (k-1)s_e^2}{(k+1)s_e^2}$ d) $\frac{s_r^2 - s_c^2 + (k-1)s_e^2}{(k+1)s_e^2}$

Question carries 2 marks

8. Write the formula to find out the efficiency of a Latin Square design relative to Completely Randomized design.

Question carries 3 marks

9. Find the values of Sum of Squares for the given ANOVA table of Completely Randomized design.

Source of Variation	**d.f**	**SS**	**MS**
Columns	3	1558.5	519.50
Rows	3	777.5	259.17
Treatments	3	4548.5	1516.17
Error	6	400.5	66.75
Total	15	7285.0	

Question carries 5 marks

10. Three varieties A, B and C of a crop are tested in Randomized Complete Block design with four replications. The treatment means are 116.7, 137.6 and 172.7. What mean or means do you suspect might represent different populations by *LSD* test. The resulted analysis is as follows:

SOV	**d.f**	**SS**	**MS**	**F**
Treatment	2	400.40	200.20	2.09
Replication	3	528.97	176.32	1.87
Error	6	575.05	95.84	

Lesson No. 8

MCQs : Each MCQ carries 1 mark

11. A main effect is sometimes regarded as an interaction of order
    a) Zero
    b) One
    c) Two
    d) Three

12. In a factorial design, the independent variables are called
    a) Levels
    b) Types
    c) Factors
    d) None of these

Question carries 2 marks

13. Where the Factorial experiments are appropriate to be conducted?

Question carries 3 marks

14. Write down any THREE disadvantages of Factorial Design.

Question carries 5 marks

15. What are the advantages of a Factorial design?

Lesson No. 9

MCQs : Each MCQ carries 1 mark

16. In a 2 x 2 factorial experiment, the possible interaction effects are
    a) 0
    b) 1
    c) 2
    d) 4

17. In a 2 x 2 factorial experiment, the degrees of freedom for the first main effect will be
    a) 0
    b) 1
    c) 2
    d) 4

Question carries 2 marks

18. How many factors and levels are involved in a 2 x 2 factorial design?

Question carries 3 marks

19. Construct the sign table for 2 x 2 factorial design.

Question carries 5 marks

20. Complete the following table of a 2^2 factorial design.

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	*F*-Ratio
Treatment A	?	SSA	MSA=?	MSA/MSE
Treatment B	?	SSB	MSB=?	MSB/MSE
Interaction AB	?	SSAB	MSAB=?	MSAB/MSE
Error	?	SSE	MSE=?	-
Total	?	SST	-	-

Lesson No. 10

MCQs : Each MCQ carries 1 mark

21. In a 2 x 2 x 2 factorial experiment, the possible treatment combinations can be
    a) 2
    b) 4
    c) 6
    d) 8

22. In the sign table for factorial design, except for the first column M, every column has
    a) Equal number of " + " and " - " signs
    b) More " + " signs than " - " signs
    c) More " - " signs than " + " signs
    d) There is no such rule.

Question carries 2 marks

23. In a 2 x 2 x 2 factorial experiment, if the factors A, B and C are of interest and Sum of Squares for factor A (SSA) is 345, what will be the Mean Square for factor A (MSA)?

Question carries 3 marks

24. Calculate the Effect of *B* using the data given below which is obtained from a 2^3 factorial experiment repeated 3 times:

(1)	*a*	*b*	*ab*	*c*	*ac*	*bc*	*abc*
41	51	57	67	63	54	76	73

Question carries 5 marks

25. Complete the Sign Table for 2^3 factorial design.

	M	A	B	C	AB	BC	AC	ABC
(1)	+		-	-	+		+	
a	+		-	-	-		-	
b	+		+	-	-		+	
c	+		-	+	+		-	
ab	+		+	-	+		-	
ac	+		-	+	-		+	
bc	+		+	+	-		-	
abc	+		+	+	+		+	

Answer Key

1. Costly
2. Latin Square design
3. MSTr=SSTr/d.f=16/4=4 and F=MSTr/MSE=4/2=2
4. Disadvantages
    - A Latin square design is less flexible than RCBD. It is practical only for 5 to 10 treatments. When the number of treatments exceeds 10, the design is seldom used.
    - For a small number of treatments, a Latin Square design does not provide a sufficient number of replicates to give a valid estimate of error.
    - Replication in a Latin square design is costly.
    - In agriculture experimentation, the land requirement is rigid, the actual layout in the field may be laborious and approach to the central most plot becomes difficult.
5.

Source of variation	**Degrees of freedom**	**Sums of Squares(SS)**	**Mean Square (MS)**	***F***
Rows (*R*)	$k-1$	*SSR*	*MSR=SSR* / $(k-1)$	*F1=MSR/MSE*
Columns (*C*)	$k-1$	*SSC*	*MSC=SSC* / $(k-1)$	*F2=MSC/MSE*
Treatments (*Tr*)	$k-1$	*SSTr*	*MSTr=SSTr* / $(k-1)$	*F3=MSTr/MSE*
Error (*E*)	$(k-1)(k-2)-1$	*SSE*	*MSE=* *SSE* / $(k-1)(k-2)-1$	
Total (*T*)	k^2-1	*SST*		

6. Rejection of Null Hypothesis
7. $\frac{s_r^2 - s_c^2 + (k-1)s_e^2}{(k+1)s_e^2}$
8. $\frac{s_r^2 - s_c^2 + (k-1)s_e^2}{(k+1)s_e^2}$
9. 11

10.

$$LSD = t_{\frac{a}{2}(errord.f)}\sqrt{\frac{2S_e^2}{r}}$$

$$= t_{0.025(6)}\sqrt{\frac{2(95.84)}{4}}$$

$$= 2.45 \times 6.922 = 16.96$$

A	B	C
116.7	137.6	3.75

$|116.7 - 137.6| = 20.9 > 16.9$ Significant

$|116.7 - 172.7| = 56 > 16.96$ Significant

$|137.6 - 172.7| = 35.1 > 16.96$ Significant

11. Zero
12. Factors
13. When it is required to study more than one factor each at different levels. These are highly used in agriculture experiments where effects of different fertilizer etc. are tested.
14. Disadvantages:
    - A factorial experiment requires an excessive amount of experimentation when there are several factors at several levels.
    - A large number of combinations when used, cause decrease in the efficiency of the experiment. The experiment may be reduced to a manageable size by confounding some effects considered of little practical consequence.
    - The experiment set up and the resulting statistical analysis is more complex.
15. Advantages:
    - A factorial experiment is usually economical.
    - All the experimental units are used in computing the main effects and interactions.
    - The use of all treatment combinations makes the experiment more efficient and comprehensive.
    - The interaction effects are easily estimated and tested through the usual analysis of variance.
    - The experiment yields unbiased estimates of effects, which are of wider applicability.

16. 1
17. 1
18. A 2 x 2 Factorial design shows that there are two factors each at two levels.
19. The sign table is as follows:

Sign Table			
M	A	B	AB
+	-	-	+
+	+	-	-
+	-	+	-
+	+	+	+

20. A complete ANOVA table of 2^2 factorial design:

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	*F*-Ratio
Treatment A	*a-1*	SSA	MSA=SSA / *(a-1)*	MSA/MSE
Treatment B	*b-1*	SSB	MSB=SSB /*(b-1)*	MSB/MSE
Interaction AB	*(a-1)(b-1)*	SSAB	MSAB=SSAB / *(a-1)(b-1)*	MSAB/MSE
Error	*ab (n-1)*	SSE	MSE=SSE / *ab(n-1)*	-
Total	*abn-1*	SST	-	-

21. 8

22. Equal number of " + " and " - " signs

23. MSA= SSA/d.f = SSA / (*a*-1) = 345 / (2-1) = 345.

24.

$$\text{Effect of } B = \frac{1}{2^{k-1}n}\left[-(1) \quad -a \quad +b \quad +ab \quad -c \quad -ac \quad +bc \quad +abc\right]$$

$$\text{Effect of } B = \frac{1}{2^{3-1}\times 3}\left[-41 \quad -51 \quad +57 \quad +67 \quad -63 \quad -54 \quad +76 \quad +73\right]$$

$$\text{Effect of } B = \frac{1}{12}\left[64\right] = 5.3333$$

25. The complete Sign table for a 2^3 factorial design is as follows:

	M	**A**	B	C	AB	**BC**	AC	**ABC**
(1)	+	-	-	-	+	+	+	-
a	+	+	-	-	-	+	-	+
b	+	-	+	-	-	-	+	+
c	+	-	-	+	+	-	-	+
ab	+	+	+	-	+	-	-	-
ac	+	+	-	+	-	-	+	-
bc	+	-	+	+	-	+	-	-
abc	+	+	+	+	+	+	+	+