THE OPEN UNIVERSITY OF SRI LANKA

B.Sc. Degree Programme

OPEN ELECTIVE - LEVEL 05

ADU5319 - DESIGN AND ANALYSIS OF EXPERIMENTS

OPEN BOOK TEST 2023/2024

Duration: One Hour

Date: 28.12.2023	Time: 02.30 p.m- 03.30 p.m

Instructions:

- **This question paper consists of 20 multiple choice questions and 06 pages.**
- **Statistical Tables are attached in last pages.**
- **Non-programmable calculators are permitted.**
- **Consider the level of significance as 0.05 for all the tests.**
- **Handover the question paper with the underlined answers.**

Underline the most suitable answer.

1) Performing the same treatment combination more than once is called:

   a) Blocking
   c) Replication

   b) Randomization
   d) None of the above

2) CRD can be used with

   a) Equal replications
   c) equal and unequal replications

   b) unequal replications
   d) single replication

3) An ANOVA is performed under the assumption of

   a) Homogeneity of variances
   c) Heterogeneity of variances

   b) Homogeneity of means
   d) Heterogeneity of means

4) In a one-way ANOVA, which of the following statements is correct?

   a) Reject H_0 since there is evidence of a treatment effect

   b) Do not reject H_0 because a mistake has been made

   c) Reject H_0 since there is evidence that all means differ

   d) Reject H_0 since there is no evidence of a difference

5) ANOVA is a statistical technique comparing the _____ of several populations.

   a) Variances   b) standard deviations   c) means   d) All of the above

6) For lab experiments which type of design is more suitable?

   a) CRD   b) RCBD   c) Latin square design   d) All of the above

Using the following problem, answer questions 7 to 20.

A researcher wanted to determine whether the 3 energy drinks, say *A, B,* and *C,* differ in their effects on endurance. Six male persons of same age participated in the research and each person drinks each energy drink. The time to exhaustion on a treadmill is measured. The results of the measurements are given in the following table.

Person	Drink 1	Drink 2	Drink 3
1	42	48	62
2	36	34	48
3	54	56	75
4	44	46	52
5	28	32	44
6	45	50	65

Total uncorrected sum of squares $= \sum y^2 = 43595$

7) What are the treatments used in relation this study?

   a) Time to exhaustion   b) Six male persons
   c) Three energy drinks   d) None of the above

8) What are the experimental units in relation this study?

   a) Three energy drinks   b) Six male persons
   c) Time to exhaustion   d) None of the above

9) What is the response variable in relation this study?

   a) Time to exhaustion   b) Six male persons
   c) Three energy drinks   d) None of the above

10) What is the design used in this study?

a) CRD   b) RCBD

c) Latin Square   d) None of the above

11) The null hypothesis to be tested for this study is:

a) At least one energy drink has a different exhaustion time.

b) All three energy drinks have different exhaustion time.

c) Average exhaustion times of 3 energy drinks are same.

d) None of the above

Suppose that you constructed the ANOVA Table and answer questions 12 to 20 based on that table.

12) Degrees of freedom of treatment,errors and total are:

a) 2,16,18   b) 2,15,17

c) 3,15,18   d) None of the above

13) Sum of squares of treatment, errors and total are:

a) 1516.17, 894.33, 2410.5   b) 874.33, 1536.17, 2410.5

c) 894.33, 1516.17, 2410.5   d) None of the above

14) Mean squares of treatment and errors are:

a) 447.17, 101.08   b) 298.11, 101.08

c) 758.08, 55.89   d) None of the above

15) The $F_{calculated}$ and F_{table} values are:

a) 3.682, 4.42   b) 4.42, 3.682

c) 2.94, 3.287   d) None of the above

16) What is the appropriate interpretation of this test?

a) Reject H_0: All three energy drinks have different average exhaustion time.

b) Reject H_0: At least one of the energy drinks differs from the others in terms of their average exhaustion time

c) Fail to reject H_0: There is no significant difference between average exhaustion time of three energy drinks.

d) None of the above.

17) What is the Fisher's LSD value?

    a) 8.80   b) 10.45   c) 12.37   d) None of the above

18) Is there a significant difference between the means for energy drinks 1 and 3?

    a) Yes, because mean difference>LSD
    b) No, because mean difference<LSD
    c) Yes, because $57.67 \neq 41.5$
    d) No, because $57.67 \neq 41.5$

19) Ninety five percent (95%) confidence interval for the difference between the average exhaustion time for energy drink 1 and 2 is

    a) (-9.54, 15.2)   b) (3.8, 28.54)
    c) (0.97, 25.7)   d) None of the above

20) Based on the confidence interval, what can you say about the energy drink 1 and 2?

    a) Drink 1 and 2 are not equally effective
    b) Drink 1 and 2 are equally effective
    c) There is no sufficient evidence to make a decision
    d) None of the above

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Appendix 4a

5 per cent Points of the *F*-distribution

Column represents degrees of freedom (ν_1) for numerator of *F*-test
Row represents degrees of freedom (ν_2) for denominator of *F*-test

	1	2	3	4	5	6	7	8	9	10	12	24	∞
1	161.4	199.5	215.7	224.6	230.2	234.0	236.8	238.9	240.5	241.9	243.9	249.1	254.3
2	18.51	19.00	19.16	19.25	19.30	19.33	19.35	19.37	19.38	19.40	19.41	19.45	19.50
3	10.13	9.552	9.277	9.117	9.013	8.941	8.887	8.845	8.812	8.785	8.745	8.638	8.526
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	5.964	5.912	5.774	5.628
5	6.608	5.786	5.409	5.192	5.050	4.950	4.876	4.818	4.772	4.735	4.678	4.527	4.365
6	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.099	4.060	4.000	3.841	3.669
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726	3.677	3.637	3.575	3.410	3.230
8	5.318	4.459	4.066	3.838	3.688	3.581	3.500	3.438	3.388	3.347	3.284	3.115	2.928
9	5.117	4.256	3.863	3.633	3.482	3.374	3.293	3.230	3.179	3.137	3.073	2.900	2.707
10	4.965	4.103	3.708	3.478	3.326	3.217	3.135	3.072	3.020	2.978	2.913	2.737	2.538
11	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896	2.854	2.788	2.609	2.405
12	4.747	3.885	3.490	3.259	3.106	2.996	2.913	2.849	2.796	2.753	2.687	2.505	2.296
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714	2.671	2.604	2.420	2.206
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646	2.602	2.534	2.349	2.131
15	4.543	3.682	3.287	3.056	2.901	2.790	2.707	2.641	2.588	2.544	2.475	2.288	2.066
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.538	2.494	2.425	2.235	2.010
17	4.451	3.592	3.197	2.965	2.810	2.699	2.614	2.548	2.494	2.450	2.381	2.190	1.960
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510	2.456	2.412	2.342	2.150	1.917
19	4.381	3.522	3.127	2.895	2.740	2.628	2.544	2.477	2.423	2.378	2.308	2.114	1.878
20	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.393	2.348	2.278	2.082	1.843
21	4.325	3.467	3.072	2.840	2.685	2.573	2.488	2.420	2.366	2.321	2.250	2.054	1.812
22	4.301	3.443	3.049	2.817	2.661	2.549	2.464	2.397	2.342	2.297	2.226	2.028	1.783
23	4.279	3.422	3.028	2.796	2.640	2.528	2.442	2.375	2.320	2.275	2.204	2.005	1.757
24	4.260	3.403	3.009	2.776	2.621	2.508	2.423	2.355	2.300	2.255	2.183	1.984	1.733
25	4.242	3.385	2.991	2.759	2.603	2.490	2.405	2.337	2.282	2.236	2.165	1.964	1.711
26	4.225	3.369	2.975	2.743	2.587	2.474	2.388	2.321	2.265	2.220	2.148	1.946	1.691
27	4.210	3.354	2.960	2.728	2.572	2.459	2.373	2.305	2.250	2.204	2.132	1.930	1.672
28	4.196	3.340	2.947	2.714	2.558	2.445	2.359	2.291	2.236	2.190	2.118	1.915	1.654
29	4.183	3.328	2.934	2.701	2.545	2.432	2.346	2.278	2.223	2.177	2.104	1.901	1.638

Critical values of *t* for two-tailed tests

Significance level (α)

Degrees of freedom (df)	0.2	0.15	0.1	0.05	0.025	0.01	0.005	0.001	0.0005
1	3.078	4.165	6.314	12.706	25.452	63.657	127.321	636.619	1273.239
2	1.886	2.282	2.920	4.303	6.205	9.925	14.089	31.599	44.705
3	1.638	1.924	2.353	3.182	4.177	5.841	7.453	12.924	16.326
4	1.533	1.778	2.132	2.776	3.495	4.604	5.598	8.610	10.306
5	1.476	1.699	2.015	2.571	3.163	4.032	4.773	6.869	7.976
6	1.440	1.650	1.943	2.447	2.969	3.707	4.317	5.959	6.788
7	1.415	1.617	1.895	2.365	2.841	3.499	4.029	5.408	6.082
8	1.397	1.592	1.860	2.306	2.752	3.355	3.833	5.041	5.617
9	1.383	1.574	1.833	2.262	2.685	3.250	3.690	4.781	5.291
10	1.372	1.559	1.812	2.228	2.634	3.169	3.581	4.587	5.049
11	1.363	1.548	1.796	2.201	2.593	3.106	3.497	4.437	4.863
12	1.356	1.538	1.782	2.179	2.560	3.055	3.428	4.318	4.716
13	1.350	1.530	1.771	2.160	2.533	3.012	3.372	4.221	4.597
14	1.345	1.523	1.761	2.145	2.510	2.977	3.326	4.140	4.499
15	1.341	1.517	1.753	2.131	2.490	2.947	3.286	4.073	4.417
16	1.337	1.512	1.746	2.120	2.473	2.921	3.252	4.015	4.346
17	1.333	1.508	1.740	2.110	2.458	2.898	3.222	3.965	4.286
18	1.330	1.504	1.734	2.101	2.445	2.878	3.197	3.922	4.233
19	1.328	1.500	1.729	2.093	2.433	2.861	3.174	3.883	4.187
20	1.325	1.497	1.725	2.086	2.423	2.845	3.153	3.850	4.146
21	1.323	1.494	1.721	2.080	2.414	2.831	3.135	3.819	4.110
22	1.321	1.492	1.717	2.074	2.405	2.819	3.119	3.792	4.077
23	1.319	1.489	1.714	2.069	2.398	2.807	3.104	3.768	4.047
24	1.318	1.487	1.711	2.064	2.391	2.797	3.091	3.745	4.021
25	1.316	1.485	1.708	2.060	2.385	2.787	3.078	3.725	3.996
26	1.315	1.483	1.706	2.056	2.379	2.779	3.067	3.707	3.974
27	1.314	1.482	1.703	2.052	2.373	2.771	3.057	3.690	3.954
28	1.313	1.480	1.701	2.048	2.368	2.763	3.047	3.674	3.935
29	1.311	1.479	1.699	2.045	2.364	2.756	3.038	3.659	3.918
30	1.310	1.477	1.697	2.042	2.360	2.750	3.030	3.646	3.902
40	1.303	1.468	1.684	2.021	2.329	2.704	2.971	3.551	3.788
50	1.299	1.462	1.676	2.009	2.311	2.678	2.937	3.496	3.723
60	1.296	1.458	1.671	2.000	2.299	2.660	2.915	3.460	3.681
70	1.294	1.456	1.667	1.994	2.291	2.648	2.899	3.435	3.651
80	1.292	1.453	1.664	1.990	2.284	2.639	2.887	3.416	3.629
100	1.290	1.451	1.660	1.984	2.276	2.626	2.871	3.390	3.598
1000	1.282	1.441	1.646	1.962	2.245	2.581	2.813	3.300	3.492
Infinite	1.282	1.440	1.645	1.960	2.241	2.576	2.807	3.291	3.481