The Open University of Sri Lanka
Faculty of Natural Sciences
B.Sc/ B. Ed Degree Programme

Department	: Mathematics
Level	: 5
Name of the Examination	: Final Examination
Course Title and - Code	: Design & Analysis of Experiments – ADU 5319/pcu 3142/ PCU 2142
Academic Year	: 2019/20
Date	: 27/10/2020
Time	: 1.30 p.m – 3.30 p.m
Duration	: 2 hours

General Instructions

1. Read all instructions carefully before answering the questions.

2. This question paper consists of **6** questions in **6** pages.

3. Answer **4** questions only. All questions carry equal marks.

4. Answer for each question should commence from a new page.

5. The table of critical values for the F distribution is attached at the end.

6. Involvement in any activity that is considered as an exam offense will lead to punishment

7. Use blue or black ink to answer the questions.

8. Clearly state your index number in your answer script

Question 01

A company is considering three different covers for boxes of a brand of cereal. Box type A has a picture of a sports hero eating the cereal, type B has a picture of a child eating the cereal and type C has a picture of a bowl of the cereal. The company wants to determine which cereal box type provides the highest sales. Eighteen homogeneous test markets were selected by the company and each box type was randomly assigned to six markets. The number of boxes of this cereal sold per 10,000 population in a specified period is recorded for each test market. The data are as follows:

Type A	52.4	47.8	52.4	51.3	50.0	52.1
Type B	50.1	45.2	46.0	46.5	47.4	46.2
Type C	49.2	48.3	49.0	47.2	48.6	48.2

Total uncorrected sum of squares = 42902.53

(a) In relation to this study, identify

    (i) Response variable

    (ii) Experimental unit

    (iii)Treatments

(b) Identify the design used in this study. Justify your answer.

(c) Specify the hypotheses that are to be tested.

(d) Construct the complete analysis of variance (ANOVA) table and test your hypotheses in part (c).

(e) Write down your conclusions.

Question 02

An agricultural scientist wants to conduct an experiment to compare the yield of four varieties of paddy. Five paddy fields were used for the study and each was sub divided into four homogeneous plots of equal size. In each field, each variety was randomly assigned to a plot. At the end of the season, yield in bushels was recorded for each plot.

According to the analysis of variance table, the scientist revealed that mean square error was 5 and total variation was decomposed into varieties of paddy, field and random error according to the ratio 53:42:5.

(a) Construct the complete analysis of variance table.

(b) Test whether the mean yields of four varieties are same.

(c) Is blocking worthwhile in this experiment? Justify your answer.

(d) Calculate the relative efficiency of blocking. Interpret the result.

Question 03

An investigator wanted to study the effect of four upcoming movies on the audience attraction. These movies are mystery (A), science fiction (B), comedy (C), and romantic (D). Movies are shown to audiences of 50 viewers at each showing, four times a day, and over a period of four days. It was thought that time of day and day of the week may influence the results of the study. The response is the number of people out of 50, who recommend the movie to a friend.

Time of Day	Day			
	Monday	Tuesday	Wednesday	Thursday
Morning	31(C)	23(D)	36(B)	40(A)
Afternoon	33(B)	36(A)	31(C)	22(D)
Evening	17(D)	37(C)	34(A)	41(B)
Night	35(A)	37(B)	18(D)	31(C)

Total uncorrected sum of squares = 16590

(a) Identify the design used in this experiment. Justify your answer.

(b) Construct the ANOVA table and test appropriate hypotheses. Interpret your results.

(c) Find the Least Significant Difference (LSD) for comparing any two treatment means (use 5% significance level).

(d) Using LSD computed in part(c), test whether movies A and D are equally effective. Interpret your results.

Question 04

The Following ANOVA table is from a study about the effects of different types of background music on the productivity of employees of a factory.

Source of Variation	Degrees of freedom	Sum of squares	Mean square	F values
Weeks	4	82.0	20.5	*
Days within week	4	477.2	119.3	*
Type of music	4	*	*	*
Error	*	188.4	15.7	
Total	24	1412.0		

(a) Some values were missing in the ANOVA table and marked with "*". Complete the ANOVA table by computing missing values.

(b) Based on the information given, write down the conclusions of this study.

(c) Suppose that you are interested in repeating this experiment with the same employees of the same factory, using a different design. Considering the decision taken from the above results,

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(i) write down the name of the design that you are going to implement. Justify your answer.

(ii) explain briefly how you would design your experiment.

(iii) write down the model that you would fit to the data obtained.

Question 05

A virologist is interested in studying the impact of 2 different culture media (medium 1 and medium 2) and 2 different times (12 hours and 18 hours) on the growth of a particular virus. The virologist performed the experiment having six replicates with each combination of culture media and time. The results are presented in the following table.

Time	Culture media	
	Media 1	Media 2
12 hours	21,23,20,22,28,26	25,24,29,26,25,27
18 hours	37,38,35,39,38,36	31,29,30,34,33,35

Total uncorrected sum of squares = 21857

(a) How many treatments are tested in this experiment? What are they?

(b) The interaction plot of the above data is given below. Comment on it.
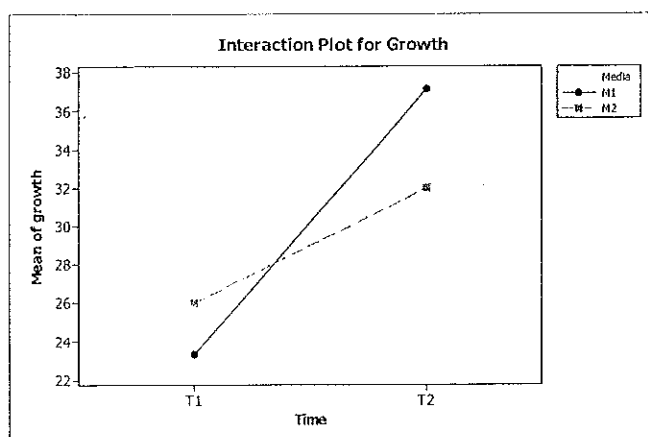
(c) A part of the ANOVA table is given below. Complete the table.

Source	Sum of squares
Media	
Time	590.04
Media*Time	
Error	
Total	793.63

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(d) Test whether the effects of media and times on the growth of virus are significant or not. Clearly explain your answer.

Question 06

A paint company wanted to test the quality of a new paint according to weather and wood combinations. They used 2 levels of weather (dry and wet) and 2 levels of wood (softwood and hardwood) for the experiment. The data obtained are given below.

Weather	Wood	Duration (in years)
Dry	Softwood	20,21,19
Dry	Hardwood	12,14,13
Wet	Softwood	21,20,22
Wet	Hardwood	15,14, 13

Total uncorrected sum of squares = 3626

(a) Identify the treatment structure of the experiment. Justify your answer.

(b) Write down two meaningful contrasts and test whether they are orthogonal.

(c) Test whether one of the contrasts that you mentioned in part(b) is significant. Interpret the result.

5 per cent Points of the *F*-distribution

Column represents degrees of freedom (v_1) for numerator of *F*-test
Row represents degrees of freedom (v_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

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