Instructions: Do 5 problems out of the 7 problems given below.

Circle 5 problems chosen: 1 2 3 4 5 6 7

February 18, 2012

1. In a study carried by agronomists to determine if major differences in yield response to Nitrogen fertilization exist among different varieties of jowar. This study involves two experimental factors, A and B. Levels (Nitrogen rates of 0, 30 and 60 Kg/ha) of factor B are randomized within each level (V_1: CO-18, V_2: CO-19, and V_3: CO-22) of factor A. The design provides more precise information about *B* than about *A*, and it often arises when *A* can be applied only to large experimental units. The study was replicated four times, and the data gathered for the experiment are shown below.

Replication	**Variety**	**Nitrogen rate, Kg/ha** 0	30	60	Row Total
		Yield, kg per plot			
I	V1	15.5	17.5	20.8	53.8
	V2	20.5	24.5	30.2	75.2
	V3	15.6	18.2	18.5	52.3
II	V1	18.9	20.2	24.5	63.6
	V2	15.0	20.5	18.9	54.4
	V3	16.0	15.8	18.3	50.1
III	V1	12.9	14.5	13.5	40.9
	V2	20.2	18.5	25.4	64.1
	V3	15.9	20.5	22.5	58.9
IV	V1	12.9	13.5	18.5	44.9
	V2	13.5	17.5	14.9	45.9
	V3	12.5	11.9	10.5	34.9
Column Total	V1	60.2	65.7	77.3	
	V2	69.2	81.0	89.4	
	V3	60.0	66.4	69.8	

a) Draw a possible layout of randomization of this experiment.

b) Write the model of this design of experiment. Conduct ANOVA and draw conclusions. (*Hint*: The sum of squares of observations is 11980.22. The sum of observations is 639.0)

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2. An experiment involved the presence or absence of biofeedback and the presence or absence of a new drug. An investigator measures blood pressure. The data are given below:

Bio & Drug	Bio only	Drug Only	Neither
158	188	186	185
163	183	191	190
173	198	196	195
178	178	181	200
168	193	176	180

   a) State whether there exists a synergistic effect on the combination of two treatments by drawing factor plots. From the estimates of effects, write an appropriate linear regression model.
   b) Conduct ANOVA to test for synergistic effect on the combination of two treatments. Clearly state the model and your hypotheses to test a synergistic effect. (Hint: The sum of squares of observations is 672320 and the sum of observations is 3660.)
   c) Now, assume that, however, only four runs can be made in one day. An investigator runs a complete replicate of the design on each day for 5 days. How does this design differ from the design in b)? Show the difference by constructing ANOVA table.

3. A study is made on amino acids in the hemolymph of millipedes. For a sample of three randomly selected males and three randomly selected females of each of three randomly selected species (S1, S2, S3), the concentrations of the amino acid (in mg/100ml) are determined. The measurements were taken over three replications of the design.

Species	Male	Female
S1	22 20 23	18 17 16
S2	14 15 15	12 11 13
S3	16 20 18	14 15 14

   a) Write the restricted mixed model with all specification. Estimate all the parameters in the model.
   b) Give the ANOVA table and draw conclusions.
   c) Construct the confidence interval comparing gender using Tukey's method.
   d) Repeat (b) under unrestricted mixed model. Compare.

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4. The death rates are measured per 1000 population per year in Virginia in 1940. They are cross-classified by age group (rows) and population group (columns). The age groups are: 50–54, 55–59, 60–64, 65–69, 70–74 and the population groups are Rural/Male, Rural/Female, Urban/Male and Urban/Female. The data are shown in the below:

	Rural Male	Rural Female	Urban Male	Urban Female
50-54	11.7	8.7	15.4	8.4
55-59	18.1	11.7	24.3	13.6
60-64	26.9	20.3	37.0	19.3
65-69	41.0	30.9	54.6	35.1
70-74	66.0	54.3	71.1	50.0

a) By performing the test for Tukey's non-additivity, conduct ANOVA. (Hint: The sum of squares of observations is 26346.12 and the sum of observations is 618.4. $SS_N = \frac{\left[\sum_{i=1}^{a}\sum_{j=1}^{b} y_{ij}y_{i.}y_{.j} - y_{..}\left(SS_A + SS_B + \frac{y_{..}^2}{ab}\right)\right]^2}{abSS_ASS_B}$)

b) An investigator wants to investigate sex differences in mortality rate in age groups and also sex differences in mortality rate in different site (Rural and Urban). Answer those by conducting ANOVA.

5. Four different feed rates were investigated in an experiment on a machine producing a component part used in an aircraft auxiliary power unit. The engineer wished to make four production runs at each feed rate, however, because of time constraint he must use an incomplete design. The accuracies of the critical dimension (in 10^{-3} mm) are obtained. Assume that all runs were made in random order.

Feed	Production runs			
Rate	1	2	3	4
10	0.09	0.10	0.13	-
12	0.06	-	0.12	0.07
14	-	0.08	0.08	0.05
16	0.19	0.13	-	0.20

a) Write the statistical model. Is this a valid design? Why or why not?
b) Give the LSE's for the Feed Rate effects in the model.
c) Provide the ANOVA table and perform the hypothesis test for both Feed Rate and Runs effects.
d) Carefully explain why the sum of squares must be adjusted.

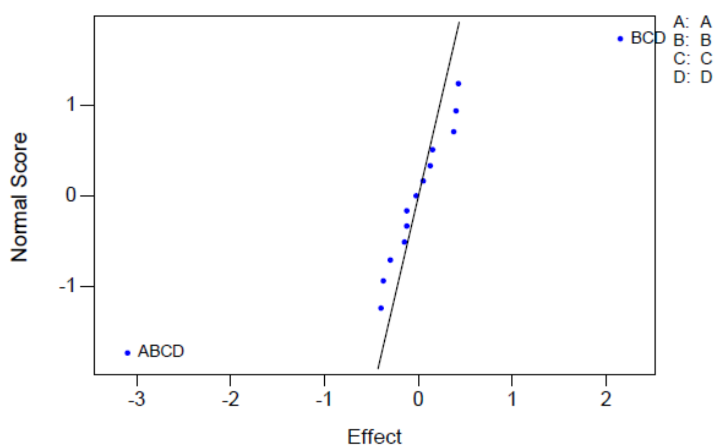
6. Consider fractional factorials with factors at two levels each.

   a) Construct a quarter fraction of a 2^5 design such that the design is confounding into four blocks using the generators ABC and CDE, but only using the block where ABC is plus and CDE is minus. Then, show how to estimate the total effect of factor A. Since neither response nor response variable is given in this problem, use a clear mathematical notation for the response variable in your answer.

   b) Now, consider nine factors at two levels of each to be explored. The full experiment is much too large, so a fractional factorial design with sixteen units is used. The factors are coded A through J by skipping I. The generators are –ACE, –ADF, –ACDG, BCDH, ABCDJ. The design and responses as well as a normal probability plot of the effects are shown here. Find the most parsimonious design using the aliased structure and conduct ANOVA. (Hint: The sum of squares of observations is 29593.22 and the sum of observations is 687.4).

	A	B	C	D	E	F	G	H	J	y
gj	–	–	–	–	–	–	+	–	+	40.2
aef	+	–	–	–	+	+	–	–	–	43.7
bgh	–	+	–	–	–	–	+	+	–	44.7
$abefhj$	+	+	–	–	+	+	–	+	+	42.4
ceh	–	–	+	–	+	–	–	+	–	45.9
$acfghj$	+	–	+	–	–	+	+	+	+	42.4
$bcej$	–	+	+	–	+	–	–	–	+	40.6
$abcfg$	+	+	+	–	–	+	+	–	–	42.2
dfh	–	–	–	+	–	+	–	+	–	45.5
$adeghj$	+	–	–	+	+	–	+	+	+	42.4
$bdfj$	–	+	–	+	–	+	–	–	+	40.6
$abdeg$	+	+	–	+	+	–	+	–	–	43.6
$cdefgj$	–	–	+	+	+	+	+	–	+	40.2
acd	+	–	+	+	–	–	–	–	–	44.0
$bcdefgh$	–	+	+	+	+	+	+	+	–	46.5
$abcdhj$	+	+	+	+	–	–	–	+	+	42.5

Normal Probability Plot of the Effects
(response is y, Alpha = .10)



   c) As an alternative way, conduct ANOVA using just main effects. (Hint: Effect estimates for $A = -.125, B = -.150$, C = calculate, D = calculate, $E = .400, F = -.050, G = -.375$, H = calculate, J = calculate)

Continue to #7 on the next page

7. A telephone company based in Southern California covering three counties (Orange, LA, San Bernardino) wants to know whether a newly proposed saving program for business is satisfactory. Three cities are randomly selected within each county and two randomly selected companies in each city were interviewed. The level of satisfaction with the proposed program is recorded.

County	OC			LA			SB		
City	1	2	3	1	2	3	1	2	3
	74	56	83	65	57	78	97	42	78
	94	59	60	83	67	82	87	32	79

a) Specify the design and write the statistical model with all specifications. Estimate all the parameters in the model.
b) Provide the ANOVA table for this design. Carefully write the hypotheses and draw conclusions.
c) Use Fisher's LSD for pairwise comparisons between counties.
d) Now, assume that the experimenter ignored the variability due to the city factor and perform on factor ANOVA. Provide the one-way ANOVA table and draw conclusion. Carefully compare the results with that in (b).

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