

MA 60209 Design of Experiments
Assignment No. 5

1. The *Micogrex terrae-sanctae* is a commercial sardinelike fish found in the Sea of Galilee. A study is conducted to determine the effect of light and temperature on the growth of the ovary of these fish. Two photoperiods (14 hours of light-10 hours of dark and 9 hours of light-15 hours of dark) and two temperatures (16°C and 17°C) are used. In this way the experimenter can simulate both the summer and winter conditions in the region. Based on the following data, determine the effects of factors and carry out ANOVA.

	Factor A	
Factor B (Temperature)	9 hours light (low)	14 hours light (high)
16°C (low)	1.30 1.88	1.01 1.52
17° (high)	0.90 1.06	0.83 0.67

2. A study is conducted on the effect of temperature, time in process, and rate of temperature rise on the amount of dye (in mg) left in the residue bath for a dying process. The experiment was run at two levels of temperature (120°C , 135°C), two levels of time in process (30 min, 60 min), and two levels of rate of temperature rise (R_1 , R_2). The experiment is run as a 2^3 factorial experiment with two replications, yielding the following data. Estimate the effects and carry out ANOVA.

	Temperature			
Rate	120°C		135°C	
	30 min	60 min	30 min	60 min
R_1	19.9 18.6	17.4 16.8	25.0 22.8	19.5 18.3
R_2	14.5 16.1	16.3 14.6	27.7 18.0	28.3 26.2

3. Consider the data from one replicate of a 2^4 factorial design shown below. Construct a design with two blocks of eight observations each, with ABCD confounded. Analyze the data and draw conclusions. Assume 3-factor interactions are negligible.

(1)	190	d	198
a	174	ad	172
b	181	bd	187
ab	183	abd	185
c	177	cd	199
ac	181	acd	179
bc	188	bcd	187
abc	173	abcd	180

4. A 2^4 factorial experiment is to be run. Since laboratory facilities are such that only eight treatment combinations (experimental runs) can be run in a single laboratory the scientist decided to use two laboratories with the separate laboratories treated as blocks. Using the ABCD interaction as the defining contrast the following blocks and treatment combination responses were obtained. Form the complete ANOVA table if three-factor interactions are pooled into error.

Block 1	Block 2
(1)=229.5	a=39.2
ab=38.2	b=32.1
ac=33.8	c=27.3
bc=25.3	d=31.4
ad=37.6	abc=35.7
bd=31.0	abd=38.9
cd=24.9	acd=35.9
abcd=34.1	bcd=27.1

5. An experiment to investigate the effects of temperature (A), gas throughput (B), and concentration (C) on the strength of product solution in a recirculation unit. Two blocks were used with ABC confounded and two replications. Analyze the data from this experiment as given below:

Replicate 1		Replicate 1	
Block 1	Block 2	Block 1	Block 2
(1) = 99	a = 18	(1) = 46	a = 18
ab = 52	b = 51	ab = -47	b = 62
ac = 42	c = 108	ac = 22	c = 104
bc = 95	abc = 35	bc = 67	abc = 36

6. To examine the variability of outside diameters of coils of wire, three treatment factors were considered each at two levels, A – two winding machines, B – two wire stocks, C – two positions on the coil. Only four of eight treatment combinations could be measured at any time. Consequently, the experiment was divided into blocks of size 4. Total 32 observations could be taken. A partially confounded design with four single replicated designs each confounding a different interaction was selected. Analyze the data obtained from the experiment:

Confounded	Block	Treatment Combination (Response)			
ABC	I	000 (2208)	110 (2133)	101 (2459)	011 (3096)
	II	100 (2196)	010 (2086)	001 (3356)	111 (2776)
AB	III	000 (2004)	110 (2112)	001 (3073)	111 (2631)
	IV	100 (2179)	010 (2073)	101 (3474)	011 (3360)
AC	V	001 (2839)	100 (2189)	011 (3522)	110 (2095)
	VI	000 (1916)	101 (2979)	010 (2151)	111 (2500)
BC	VII	100 (2056)	000 (2010)	011 (3209)	111 (3066)
	VIII	010 (1878)	110 (2156)	001 (3423)	101 (2524)

7. A 2^{5-1} design with $I = ABCDE$ was used to analyze an experiment with five factors. The results obtained were:

Treatment Combination	e	a	b	abe	c	ace	bce	abc
Response	-0.63	2.51	-2.68	1.66	2.06	1.22	-2.09	1.93
Treatment Combination	d	ade	bde	abd	cde	acd	bcd	abcde
Response	6.79	5.47	3.45	5.68	5.22	4.38	4.30	4.05

Investigate the effects of factors and if any factors are negligible, reduce the design to a full factorial by considering the aliases. Interpret the results.

8. Consider a 2^{5-2} design with generators $I = ACE$ and $I = BDE$. Write the complete defining relation and the aliases for this design. Estimate the main effects and carry out ANOVA. The results of the experiment are as follows:

Treatment Combination	e	ad	cd	bde	ab	bc	ace	abcde
Response	23.2	16.9	23.8	16.8	15.5	16.2	23.4	18.1

9. The effects of developer strength (A) and development time (B) on the density of photographic plate films are being studied. Three strengths and three times are used and four replicates of a 3^2 factorial experiment are run. The data from this experiment are as follows. Note that corresponding to each treatment combination there are four responses. Analyze using an ANOVA table. Give your conclusions.

Developer Strength	Development Time (minutes)					
	10		14		18	
1	0	2	1	3	2	5
	5	4	4	2	4	6
2	4	6	6	8	9	10
	7	5	7	7	8	5
3	7	10	10	10	12	10
	8	7	8	7	9	8

10. Give the layout, aliases and degrees of freedom of main effects for the following designs:
- 2^{5-2} with generators $I = ABE = CDE = ABCD$.
 - 2^{5-1} with generator $I = ABCDE$.
 - 2^{6-2} with generators $I = ABCE = ABDF = CDEF$.

11. Analyze the data of the following 2^3 factorial experiment run in two replications. Give your conclusions.

Run	Treatment combination	Replicate I	Replicate II
1	(1)	-3	-1
2	a	0	1
3	b	-1	0
4	ab	2	3
5	c	-1	0
6	ac	2	1
7	bc	1	1
8	abc	6	5

12. A preliminary investigation in a 2^4 factorial experiment shows the only factors significant to be A, C, D, AC, AD, CD and ACD. Combine all other factors in error and carry out ANOVA for the following data of a single replicate of the experiment. Give your conclusions.

Run	Treatment combination	Response	Run	Treatment combination	Response
1	(1)	45	9	d	43
2	a	71	10	ad	100
3	b	48	11	bd	45
4	ab	65	12	abd	104
5	c	68	13	cd	75
6	ac	60	14	acd	86
7	bc	80	15	bcd	70
8	abc	65	16	abcd	96