IE333 -Midterm 2

Student ID:	**Day: Monday**
Student Name:	**Date: 22nd December 2013**
	Time: 90 Mins

Sample 2013

Question	Max Marks	Marks Obtained
Q1	12	
Q2	04	
Q3	14	
Total	30	

NOTE:

OPEN SHEET EXAM

Show your work.

Writing final results only will grant you big ZERO, whether the answer is true or wrong. You have to write the formulas that you used and show the substitutions.

Question 1: (12 points)

An industrial engineer employed by a beverage bottler is interested in the effects of two different types of bottles on the standard time to deliver standard cases of the product. The two bottle types are glass and plastic. Two workers are used to perform a task consisting of moving standard cases of the product 50 feet on a standard type of hand truck and stacking the cases in a standard display. Four replicates of a 2^2 factorial design are performed, and the times observed are listed in the following table.

- Estimate main effect of factors and interaction effect
- Analyze the data and draw the appropriate conclusions.

Bottle Type	Worker 1		Worker 2	
Glass	5.12	4.89	6.65	6.24
	4.98	5.00	5.49	5.55
Plastic	4.95	4.43	5.28	4.91
	4.27	4.25	4.75	4.71

2^2 Factorial Design:-

Factor: Bottel Type A	Factor: Worker B	Replicates I	II	III	IV	Total	Code
Glass (−)	1 (−)	5.12	4.89	4.98	5.00	19.99	(1)
Plastic (+)	1 (−)	4.95	4.43	4.27	4.25	17.90	a
Glass (−)	2 (+)	6.65	6.24	5.49	5.55	23.93	b
Plastic (+)	2 (+)	5.28	4.91	4.75	4.71	19.65	ab
						81.47	

Main Effect

Of A: Bottel Type $= \frac{1}{2n}\left[ab + a - b - (1)\right]$

$$= \frac{1}{2\times4}\left[19.65 + 17.9 - 23.93 - 19.99\right]$$

$$= \frac{1}{8}\left[-6.37\right] = -0.79625$$

of B: Worker $= \frac{1}{2n}\left[ab + b - a - (1)\right]$

$$= \frac{1}{2\times4}\left[19.65 + 23.93 - 17.9 - 19.99\right]$$

$$= \frac{1}{8}\left[5.69\right] = 0.71125$$

Interaction Effect

of AB: Bottel x Worker Interaction

$$= \frac{1}{2n}\left[ab + (1) - a - b\right]$$

$$= \frac{1}{2\times4}\left[19.65 + 19.99 - 17.9 - 23.93\right]$$

$$= \frac{1}{8}\left[-2.19\right] = -0.27375$$

$$SS_A = SS_{\text{Bottel Type}} = \frac{\left[ab + a - b - (1)\right]^2}{4\cdot n} = \frac{\left[-6.37\right]^2}{4\times4}$$

$$= 2.5361$$

$$SS_B = SS_{\text{worker}} = \frac{\left[ab + b - a - (1)\right]^2}{4n} = \frac{\left[5.69\right]^2}{4\times4}$$

$$= 2.0235$$

$$SS_{AB} = \frac{[ab + (1) - a - b]^2}{4n} = \frac{[-2.19]^2}{4 \times 4}$$

$$= 0.2998$$

$$SS_{TOTAL} = \sum_{i=1}^{2} \sum_{j=1}^{2} \sum_{K=1}^{4} y_{ijk}^2 - \frac{y_{..}^2}{N}$$

$$= \begin{bmatrix} 5.12^2 + \cdots \\ \cdots + 4.71^2 \end{bmatrix} - \frac{[81.47]^2}{16}$$

$$= 421.1855 - 414.8351$$

$$= 6.3504$$

$$SS_E = SS_{TOTAL} - SS_A - SS_B - SS_{AB}$$

$$SS_E = 1.491$$

Source of Variation	Sum of Sqvare	Degree of freedom	Mean Sqvare	F
A	2.5361	1	2.5361	22.1107
B	2.0235	1	2.0235	17.6417
AB	0.2998	1	0.2998	2.6138
Error	1.491	12	0.1147	
Total	6.3504	15		

Question 2: (4 points)

Fractional designs are expressed using the notation L^{k-p},

Where L is the number of Levels

Where k is the number of Factors

And 'p' describes the size of Fraction of the full factorial used.

So in the design of 2^{5-2}

Estimate

- Number of factor Five
- Number of levels in each factor TWO
- Number of experiments to be conducted $2^5 = 32$
- Number of actual experiments conduction after fraction factorial design
  8
- What type of fraction factorial design it is
  ONE FOURTH

Question 3:

A pharmaceutical manufacturer wants to investigate the bioactivity of a new drug. The plan is to test the effect of two factors and their interaction on the bioactivity. Factor 1 is the dosage (20, 30, and 40 mg). Factor 2 is the patient age (KID, YOUTH, and ADULT). The random experiments were conducted with two replicates using factorial design, and the results are shown in the following table.

Experiment #	Dosage (mg)	Age	Observations	
			Replicate 1	**Replicate 2**
1	40	ADULT	52	53
2	20	YOUTH	49	53
3	20	ADULT	42	43
4	30	KID	47	45
5	40	YOUTH	59	63
6	30	ADULT	48	50
7	30	YOUTH	53	56
8	40	KID	55	60
9	20	KID	45	50

a. How many number of runs are conducted to perfrom this experimetn? (2 points)

b. Check the significance of the effect of each factor and the interaction between them on the bioactivity. Use α=0.05. (9 points)

c. Use Tukey test to illustarte the difference in means of three dosages for Kids only. (3 points)

Dosage	Age: Adult	Youth	Kid	
20	42 43 (85)	49 53 (102)	45 50 (95)	282
30	48 50 (98)	53 56 (109)	47 45 (92)	299
40	52 53 (105)	59 63 (122)	55 60 (115)	342
	288	333	302	$\boxed{923}$

a. Number of Runs conducted $3^2 = 9$ Experiments

18 Runs

$a = 3 \quad b = 3 \quad n = 2$

$$SS_{TOTAL} = \sum_{i=1}^{a} \sum_{j=1}^{b} \sum_{k=1}^{n} y_{ijk}^2 - \frac{y_{\cdots}^2}{abn}$$

$$= \left[42^2 + 43^2 + \cdots \cdots 55^2 + 60^2 \right] - \frac{903^2}{3 \times 3 \times 2}$$

$$=$$

$$= 589.611$$

$$SS_{Dosage} = \frac{1}{bn} \sum_{i=1}^{a} y_{i\cdot\cdot}^2 - \frac{y_{\cdots}^2}{abn}$$

$$= \frac{1}{3 \times 2} \begin{bmatrix} 282^2 \\ + 299^2 \\ + 342^2 \end{bmatrix} - \frac{923^2}{18}$$

$$= 318.777 \qquad 318.777$$

$$=$$

$$SS_{Age} = \frac{1}{an} \left[\sum_{j=1}^{b} y_{\cdot j \cdot}^2 - \frac{y_{\cdots}^2}{abn} \right.$$

$$= \frac{1}{3 \times 2} \left[288^2 + 333^2 + 302^2 \right] - \frac{923^2}{18}$$

$$= 176.777 \qquad 176.777$$

$$SS_{Dosege,\,Age} = \frac{1}{n}\sum_{i=1}^{a}\sum_{j=1}^{b} y_{ij.}^2 - \frac{y_{...}^2}{abn} - SS_A - SS_B$$

$$= \frac{1}{2}\begin{bmatrix} 85^2 + 102^2 \\ \cdots \\ \cdots + 95^2 \end{bmatrix} - \frac{903^2}{18}$$

$$=$$

$$= 43.557$$

$$=$$

43.557

Source of Variation	Sum of Squares	Degree of Freedom	Mean Square	F_0
Dosage	318.777	2	159.39	28.4
Age	176.777	2	88.385	15.75
Interaction	43.557	4	10.89	1.94
Error	50.5	09	5.611	
Total	589.611	17		

For Tukey's Test

$$q = \frac{\bar{y}_{max} - \bar{y}_{min}}{\sqrt{\frac{MS_E}{n}}}$$

Dosage	Kids	Avg
20	95	47.5
30	92	46
40	115	57.5

$\bar{y}_{max} = 57.5$

$\bar{y}_{min} = 46$

$$T_{0.05} = q_{0.05(3,9)} \sqrt{\frac{MS_E}{2}}$$

$$q_{\alpha(a,f)} = q_{\alpha(a,f)} \sqrt{\frac{5.611}{2}}$$

$$= \quad 6.61$$

$$=$$

$$|\bar{y}_{1.} - \bar{y}_{2.}| = |47.5 - 46| = 1.5 < 6.61$$

$$|\bar{y}_{1.} - \bar{y}_{3.}| = |47.5 - 57.5| = 10 > 6.61$$

$$|\bar{y}_{2.} - \bar{y}_{3.}| = |46 - 57.5| = 11.5 > 6.61$$

There is difference betn dosage of 20 & 40 mg and 30 & 40 mg.
But there is no difference in dosage of 20 & 30 mg.