Experimental design (KKR031, KBT120)

Wednesday 20/10 2010 - 8:30-13:30 V

Jan Rodmar will be available at ext 3024 and will visit the examination room at ca 10:30.

The examination results will be available for review at Wednesday 17/11 2010 at 12.45 in CRE seminar room.

Time for examination = 5 h

Examination aids written examination:

Textbook (Douglas C. Montgomery: Design and Analysis of Experiments) with notes. No calculation examples (book or on paper) is allowed as aid. All type of calculators is allowed. Standard Math. Tables, TEFYMA table, Beta Mathematics Handbook or Handbook of Chemistry and Physics are accepted as aids.

Problem 1 (6 credits)

A commuter wanted to find a quicker route home from work. There were two alternatives to bypass traffic bottlenecks. The commuter timed the trip over a month and a half, recording ten data points for each alternative. The data are shown below.

Treatment		
A Usual route	**B Alternate**	**C Alternate**
27.0	26.0	29.5
31.0	33.0	25.0
28.5	26.5	28.5
26.0	27.5	25.5
27.5	29.0	24.0
29.0	27.5	27.5
33.0	26.5	28.0
35.0	27.0	26.0
28.0	28.0	25.5
29.0	32.0	26.5

A: Has the treatment a significant effect on driving route time?
Use $\alpha = 0.05$.

B: Is there any significant difference between route A and C?
Use $\alpha = 0.05$ and 0.01.

Problem 2 (8 credits)

An experiment was performed to determine the effect of four different chemicals on the strength of a fabric. These chemicals are used as a part of the permanent press finishing process. Five fabric samples were selected, and a RCBD was run by testing each chemical type once in random order on each fabric sample. The following data were obtained:

Chemical type	Fabric sample				
	1	2	3	4	5
1	1.3	1.6	0.5	1.2	1.1
2	2.2	2.4	0.4	2.0	1.8
3	1.8	1.7	0.6	1.5	1.3
4	3.9	4.4	2.0	4.1	3.4

A: Evaluate if the chemical type and/or the fabric sample have a significant effect on the fabric strength.

B: Follow–up test: Plot the residuals vs chemical type and fabric sample. What do these plots indicate?. Which is the preferable chemical type?

α = 0.05

Problem 3 (5 credits)

The purpose is to estimate β_0 and β_1 in the model

$$E(y) = \beta_0 + \beta_1 x$$

where the response y is the yield in % and the scaled and centred variable x is the catalyst concentration. Experiments have been performed for the x-values:

x = [-3 -2 -1 0 1 2 3]

One suspects that the relationship is somewhat nonlinear and this property can be described by the terms $\beta_{11}x^2 + \beta_{111}x^3$. If this is the case how will this affect the least square estimate of β_0 and β_1 with b_0 and b_1?

What are then the expected values of b_0 and b_1?

Problem 4 (7 credits)

An engineer is interested in the effects of cutting speed (A), tool geometry (B) and cutting angle (C) on the life (y), in hours, of a machine tool . The experiments were run according to a factorial design. In addition he ran four center points. The results follow:

Treatment combination	(1)	a	b	ab	c	ac	bc	abc	center	center	center	center
Life time (y)	22	32	35	55	44	40	60	39	36	40	43	45

A: Estimate the factor effects.

B: Perform an analysis of variance, including a check for pure curvature
What are your conclusions?

C: Write down a regression model for predicting tool life based on the results of this experiments.

D: What are the appropriate operating conditions for this process?

Problem 5 (8 credits)

A series of experiments has been done according to a spherical central composite design with two variables x_1 and x_2. The design and the result are:

x_1	-1	-1	1	1	0	0	0	0	-1.414	1.414	0	0
x_2	-1	1	-1	1	0	0	0	0	0	0	-1.414	1.414
Response (y)	86	107	90	112	99	102	101	99	104	105	79	108

A: Estimate the parameters in a linear model of first order with interaction:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_{12} x_1 x_2 + \varepsilon$$

B: Calculate a 95% confidence interval for all parameters.
Comment the reliability of the parameter estimation.

C: Construct an ANOVA table and draw conclusions.

Problem 6 (6 credits)

The analysis of a product is done by taking samples from different bags, preparing the samples and then analyzing the samples. Derive the variance for the final result if one takes:

a. **one sample from one bag which is prepared and analyzed**
b. **one sample from one bag which is prepared and then analyzed n_1 times**
c. **one sample from one bag which is divided in n_2 samples which are prepared and analyzed**
d. **n_3 samples from n_3 bags, where each sample is divided in n_2 samples which are prepared and each prepared sample is analyzed n_1 times.**

The variance in the analyses is σ_I^2, between the sample preparations σ_{II}^2 and between the bags σ_{III}^2.