

**EXAMINATION:** Experimental design MSN460, 1 September, 2006

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**Aid:** Calculator

**Read this before you start to solve the problems:** The last two pages gives you expressions that you may need for calculations and a table over the t-distribution. Motivate all your answers. For the grade G you will need 12 points and for the grade VG you will need 24 points out of 30 points. Good Luck!

1 Your task is to study the influence of two design parameters on the flying time of a paper helicopter. The design parameters are body length and wing length. The body lengths 80 mm, 100 mm and 120 mm and the wing lengths 80 mm, 100 mm and 120 mm should be studied. There is enough paper to make 18 helicopters.

- (a) How would you plan the experiment? (3 points)
- (b) Is the order in which you perform the individual trials important? (Why/why not?) (1 point)
- (c) Which method would you use to analyse the data resulting from your experiment? (2 points)

2 A gardening magazine have tested two types of soil, type A and type B. Type A is a well known brand and type B is a new brand that is supposed to give faster growing plants. The magazine have used 6 plants. Three of the plants have been randomly chosen to grow in soil A and the other three in soil B. The plants have grown from seeds for six weeks and then the heights were measured.

| Plant  | 1    | 2    | 3    | 4    | 5    | 6    |
|--------|------|------|------|------|------|------|
| Soil   | A    | A    | B    | A    | B    | B    |
| Height | 16.3 | 20.1 | 17.7 | 21.1 | 22.8 | 25.1 |

The difference in means between the heights of plants in soil B and soil A is 2.70. The variance,  $s^2$  of the heights of plants growing in soil A is 3.69 and for plants growing in soil B it is 4.03. There are 20 permutations of the soil labels. The difference in mean height for the other 19 permutations are -4.97, -4.30, -3.17, -2.70, -1.77, -1.63, -1.57, -0.90, -0.63, -0.03, 0.03, 0.63, 0.90, 1.57, 1.63, 1.77, 3.17, 4.30, and 4.97.

- (a) Does soil B give faster growing plants? Use a randomisation test. (3 points)
- (b) Use a t-test to answer the same question as in a). What extra assumptions do you need compared with the randomisation test? (3 points)

- 3 A nutritional expert is interested in the effect of a diet of fat fish on the amount of a triglycerides (TG) in the blood. The expert has 10 persons that are willing to try two different diets during six weeks each. The first diet is a normal but specified diet and the other diet include a main meal with herring. The amount of triglycerides in the blood is measured after each 6 week period. The order in which each subject took the diets was randomised.

| Subject          | 1   | 2   | 3   | 4   | 5   | 6   | 7   | 8   | 9   | 10  |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| TG, normal diet  | 2.7 | 2.6 | 2.7 | 2.7 | 2.5 | 2.5 | 2.5 | 2.3 | 2.5 | 2.6 |
| TG, herring diet | 2.8 | 2.2 | 2.0 | 2.7 | 2.3 | 1.6 | 2.8 | 2.0 | 2.9 | 2.8 |

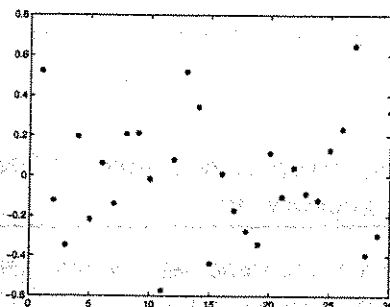
Does the herring diet give lower levels of fatty acid? Perform a test of your own choice and state the assumptions. (6 points)

- 4 A quality control engineer conducted an experiment to investigate the effect of experience on an assembly line on the time required to complete a task. The engineer selected 8 workers randomly from each of four groups of employees with work experience 1, 2, 3 and 4 years respectively. The experiment was performed as a randomised block design, with 8 different tasks as blocks. The ANOVA table from the experiment is given below.

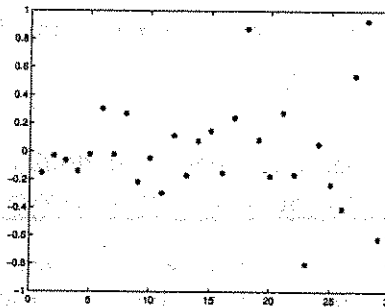
| Source     | Sum of squares | Degrees of freedom | Mean square | F   | Significance prob. |
|------------|----------------|--------------------|-------------|-----|--------------------|
| Experience | 216.6          | 3                  | 72.2        | 3.4 | 0.038              |
| Task       | 229.5          | 7                  | 32.8        | 1.5 | 0.212              |
| Residuals  | 450.6          | 21                 | 21.5        |     |                    |
| Total      | 896.7          | 31                 |             |     |                    |

- (a) Write the statistical model for the experiment. (2 points)
- (b) Is there a significant difference in assembly time for workers with different experience? (2 points)
- (c) Was the blocking with tasks effective in the sense that block effect was significant? (2 points)

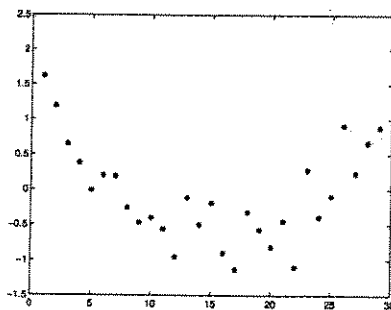
- 5 Below there are 4 different residual plots for 4 least squares problems. In all the cases the residuals are plotted against the regressor variables. What assumptions are needed when doing statistical analysis of a least squares problem? In which of the cases below are the assumptions violated? (6 points)



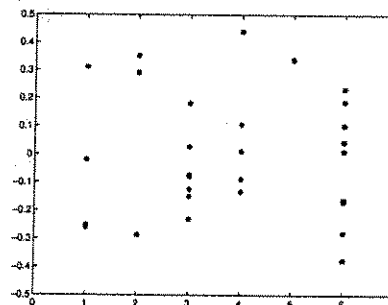
(a)



(b)



(c)



(d)