Examination by course unit

MAS314 Design of Experiments

15 May 2006, 14:30–16:30

Rubric:
This paper has two Sections and you should attempt both Sections. Please read carefully the instructions given at the beginning of each Section.

Calculators may be used.

Cambridge Elementary Statistical Tables are provided.

Section A: Each question carries 25 marks. You should attempt BOTH questions.

Section B: Each question carries 25 marks. You may attempt all questions. Except for the award of a bare pass, only marks for the best TWO questions will be counted.

Section A: Each question carries 25 marks. You should attempt BOTH questions.

Question 1

A market researcher intends to compare three recipes for a soft drink and two types of sweetener. He has twelve consumers available, each of whom can make six tastings and will give a score for each tasting.

(a) Identify the experimental units, the observational units and the treatments in this experiment, and state how many there are of each. [6]

(b) Draw the Hasse diagram for the factors on the observational units (ignoring the treatment factors) and the Hasse diagram for the factors on the treatments. [8]

(c) Describe how to construct and randomize the design for the trial. [6]

(d) Write down the skeleton analysis of variance, showing strata, sources and degrees of freedom. [5]

Question 2

A chemist plans to investigate the effects of three types of catalyst and four types of reagent on the rate of a chemical reaction. Before planning the experiment she seeks your advice on how to run the experiment.

She has written to you as follows.

> I intend to study the catalysts first and then the reagents. However, I am restricted to fewer than 50 observations in total. In the first experiment I could use 8 replicates of each catalyst and in the second experiment I could use 6 replicates of each reagent, so that I have 24 observations from each experiment. Alternatively I could use 7 replicates of each catalyst in the first experiment and 7 replicates of each reagent in the second experiment. Which of these would be best?

You have made an appointment to see her in order to discuss this.

Make clear notes on the most important points to discuss with her at your meeting. Explain the statistical motives for discussing these points. You do not need to restrict the discussion to her specific question and you should include a preliminary recommendation of a plan for the experiment. (A good answer is unlikely to contain more than 500 words.) [25]

Section B: Each question carries 25 marks. You may attempt all questions. Except for the award of a bare pass, only marks for the best TWO questions will be counted.

Question 3

(a) Explain what it means for an incomplete block design to be *balanced*. Explain why balance is desirable. [4]

(b) A plant scientist intends to compare the effects of six types of plant feed on the growth of begonias. She has ten benches in the laboratory, on each of which three plants can be grown.

  (i) Construct a suitable design for the plant scientist. [14]

  (ii) The plant scientist suggests that the plants could be grown not in the laboratory, but in staff offices, so that all six types of feed can be tested in each office. However, only four offices with enough space are available. Calculate the relative efficiency of the two proposed designs, assuming that both designs have the same plot variance. [7]

Question 4

A car tyre company intends to test four different types of rubber improver for their effects on the wear of tyres. Four test cars are available and each improver can be tested by the company's mechanics on one tyre of each car. The cars will be driven under normal conditions for six months, after which the wear of each tyre on each car will be measured.

(a) Identify the experimental units, observational units and any suitable block structure for this experiment. Briefly explain your decisions. [6]

(b) Construct the design and randomize it. [12]

(c) Present the plan in a suitable form for the mechanics. [3]

(d) After the experiment the data will be analysed by `GenStat`. What factors must be declared? After the data and factor values have been entered, what structures should be given in the `GenStat anova` dialogue boxes? [4]

Question 5

A psychologist wishes to test the effects of noise level, light level and temperature on the behaviour of monkeys. He plans to use each factor at five levels and assumes that there will be no interactions among these factors. He has 25 monkeys available and intends to use each animal just once.

(a) Construct a design for this experiment in such a way that all main effects can be estimated. [8]

(b) (i) Write down the skeleton analysis of variance table, showing strata, sources and degrees of freedom. [11]

(ii) What problems will there be in interpreting the results of this experiment? [2]

(c) What would be the advantages and disadvantages of using each monkey more than once. [4]

Question 6

(a) Explain what is meant by a *split-plot* design. [3]

(b) An agronomist intends to compare the effects of three harvesting mechanisms on four varieties of cranberries. The harvesting methods can only be applied to complete fields, but all four varieties can be grown on the same field. Twelve fields are available for the experiment and the response of interest is the yield of high quality fruit.

(i) Describe how to construct and randomize a split-plot design for this experiment. [8]

(ii) Write down the skeleton analysis of variance, showing strata, sources of variation and degrees of freedom. [11]

(iii) Explain the advantage of the split-plot design over a completely randomized design for this experiment. [3]

END OF EXAMINATION PAPER