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B. Sc. Examination 2007

MAS 314 Design of Experiments

Duration: 2 hours

Date and time: 16 May 2007, 1430h

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

Calculators ARE permitted in this examination. The unauthorized use of material stored in pre-programmable memory constitutes an examination offence. Please state on your answer book the name and type of machine used.

Statistical functions provided by the calculator may be used provided that you state clearly where you have used them.

The New Cambridge Statistical Tables are provided.

Do not start reading the question paper until instructed to do so.

The question paper must not be removed from the examination room.

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

Question 1 Mountain bags are often carried by walkers in the Scottish Highlands. If a walker is trapped by injury or bad weather, he or she gets into the mountain bag, which is supposed to stop them getting too cold.

Three new makes of mountain bag are going to be assessed at a Scottish university. Thirty-six students will take part in the experiment. Twelve mountain bags of each make will be bought and allocated to students. The thirty-six students will go into a special temperature-controlled room and get into their mountain bags. The temperature in the room will be reduced. After one hour, the skin temperature of each student will be measured on the chest, arm, thigh and calf.

- (a) Identify the experimental units, the observational units and the treatments in this experiment, and state how many there are of each. [5]
- (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. [6]
- (c) Describe how to construct and randomize the design for the trial. [4]
- (d) Write down the skeleton analysis of variance, showing stratum, source and degrees of freedom. [6]
- (e) Someone suggests that it would be better to let each student try all three makes of mountain bag. In this case only twelve students would be needed, but the temperature-controlled room would need to be used on three different days. Explain two important ways in which this new design is different from the old. [4]

- Question 2**
- (a) Name the three most important experimental designs for comparing two drugs (A and B) on animals. For each design, briefly state how to construct and randomize it, and state one advantage and one disadvantage of the design. [15]
 - (b) A vet has made an appointment to see you to discuss a proposed trial of two new drugs A and B on horses, for a disease which you have never heard of. Make clear notes on TWO of the important points to discuss with her at your meeting. Include reasons for discussing these points. [10]

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 Two treatment factors F and G are to be investigated. Each has seven levels.

The experimental units are 49 plastic buckets, arranged in a 7×7 square. There may be differences between columns. Also, there may be differences between rows.

A combination of one level of F and one level of G should be allocated to each bucket.

- (a) Construct a suitable design for this experiment, on the assumption that there is no interaction between F and G . [14]

- (b) Write down the skeleton analysis-of-variance table, showing stratum, source and degrees of freedom. [6]
- (c) Explain how the design should be randomized. [5]

Question 4 (a) Explain what it means for an incomplete-block design to be *balanced*. State one advantage and one disadvantage of balance. [6]

- (b) A horticulture research institute wants to compare nine methods of treating a certain variety of houseplant while it is being grown in a greenhouse in preparation for the Christmas market. One possibility is to ask twelve small growers to test three treatments each in separate chambers in their greenhouses. A second possibility is to ask three large commercial growers to test nine methods each, also in separate greenhouse chambers.
- (i) Construct a suitable design for the first possibility. [8]
- (ii) Explain how the design should be randomized. [4]
- (iii) If the plots stratum variance is the same in both cases, which design is more efficient? [7]

Question 5 The director of a chain of small supermarkets wants to find out what type of music should be played in her shops to encourage customers to spend money. She wants to compare three types of music:

r: rock music
c: classical music
e: “easy listening” music

She decides to use nine of her supermarkets for her experiment, from different parts of London:

Acton	Barking	Chelsea
Deptford	East Ham	Finsbury Park
Greenwich	Hampstead	Isleworth

Each of these supermarkets is open from 0800 to midnight Monday to Saturday inclusive. The experiment will last for one week. At the end of each day the manager of each supermarket will add up how much money has been spent in that shop that day, and will report this to the director.

- (a) Identify the plots and any suitable blocks in this experiment. [7]
- (b) Construct the design and randomize it. [10]
- (c) Present the plan in a form suitable for the director. [4]
- (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 further information should be given to **GenStat** to analyse the data? [4]

Question 6 An experiment was carried out on a small orchard of 30 cider-apple trees, to investigate the combined effects of five methods of pruning and three types of spray.

It is not practical to spray trees individually, so the orchard was divided into six parts, each containing five trees. The sprays were randomly allocated to the parts in such a way that each spray was used to spray all the trees in two parts. Within each part, the five pruning methods were randomly allocated to trees.

The response on each tree was the percentage of apples that fell to the ground before picking time.

- (a) Fill in the blank spaces in the following incomplete anova table. [7]

stratum	source	SS	df	MS	VR
mean	mean	51915.97	1	51915.97	—
parts	sprays	1116.75			
	residual				—
	total	1835.04			
trees	pruning	1835.15			
	sprays $\wedge$ pruning	284.13			
	residual				—
	total	3007.70			
Total		56758.71	30		

- (b) What conclusions can you draw about the presence or absence of treatment effects? Give reasons. [6]
- (c) Estimate the variance of the estimator of the difference between two sprays. Also estimate $\sigma^2(\rho_1 - \rho_2)$, where σ^2 is the variance of each observation, ρ_1 is the correlation between trees in the same part, and ρ_2 is the correlation between trees in different parts. You may use the fact that

$$\begin{aligned}\xi_{\text{parts}} &= \sigma^2(1 - \rho_1) + k\sigma^2(\rho_1 - \rho_2) \\ \xi_{\text{trees}} &= \sigma^2(1 - \rho_1),\end{aligned}$$

where ξ_{parts} is the stratum variance for parts, ξ_{trees} is the stratum variance for trees, and k is the number of trees per part. [6]

- (d) Now the researchers are planning to do another similar experiment next year, in a bigger orchard of 60 trees. Comment briefly on the advantages and disadvantages of each of the following suggested modifications to the previous design. In each case the sprays are randomly allocated to the same number of parts and the methods of pruning are randomly allocated to the same number of trees per part. (In any calculations, you may assume that the values of $\sigma^2(\rho_1 - \rho_2)$ and $\sigma^2(1 - \rho_1)$ are the same as in the previous experiment.)

- (i) Divide the orchard into 12 parts of 5 trees each.
- (ii) Divide the orchard into 6 parts of 10 trees each. [6]