

**Durham/Newcastle Statistics Graduate Course**  
**Design of Experiments**  
**March 2012**

Exercise Sheet 3

In the data entered in Sheet 2, the ‘Other’ column refers to the person from whom the sample of skin was taken. It is anticipated that there will be substantial inter-person variation in the melanin concentration observed. Re-analyse the data, using people as blocks.

- Q1** Append the Block space and its projection matrix to those defined in sheet 2. Show again that the Sums of Squares add up. Make sure you compute the residual sum of squares.
- Q2** Show that the projection onto the block space, allowing for the general mean,  $P_{B_{perp}}$  is orthogonal to the projection onto  $W_T = V_T \cap V_0^\perp$ . Show that  $P_B$  and  $P_T$ , the projections onto the block and treatment spaces not allowing for the general mean, are not orthogonal. What is their product?
- Q3** Analyse these data using the usual ‘`lm()`’ command and compare. Comment on the result relative to that in Sheet 2.
- Q4** Extract the sum of squares for the contrast  $\tau_3 - \tau_1$ . What is the significance of this contrast?
- Q5** Make sure you understand what the estimates produced by `summary(lm(y~factor(Rx)+factor(Blocks)))` mean. Produce a confidence interval for  $\hat{\tau}_3 - \hat{\tau}_2$ .
- Q6** In the workspace `BIBD.RData` you will find a matrix `B`, which is the plot by block incidence matrix for a design with 21 units in 7 blocks of size 3. The treatment by unit incidence matrix is in `T`. Write the design in a more compact form and give some of its properties. Find  $P_B P_T$  and compare with your answer to question 2.
- Q7** The R workspace `Latin.Rdata`, available from the website of the course, contains the data from an experiment on the area of blister ( $\text{cm}^2$ ) following inoculation of irritants i,ii,...,vi to subjects 1-6 at sites a-f. The experiment was set out as a Latin square. Analyse the data using ‘`lm()`’, paying special attention to the description and interpretation of treatment effects.  
Data from chapter 9 of Armitage, Berry and Matthews, 2002