1. An experiment is performed to compare the effect of five different drugs (A, B, C, D, E) on reduction of blood pressure of persons on a weight reducing diet. A Latin square design with person as rows and time as columns is used since the observations will vary over time as well as from person to person.

The row (person) totals are 249, 195, 205, 197, 196; the column (time) totals are 181, 179, 180, 251, 251 and the drug totals are 183, 255, 157, 251, 196. The sum of squares of all observations is 47292. The following output ought to be useful:

\[
\begin{array}{c|c|c|c|c}
\text{alpha} & \text{df1} & \text{df2} & \text{qtukey(1-alpha, df1, df2)} & \text{qf(1-alpha, df1, df2)} \\
0.05 & 4 & 12 & 4.198660 & 3.259167 \\
0.05 & 4 & 20 & 3.958293 & 2.866081 \\
0.05 & 5 & 12 & 4.507710 & 3.105875 \\
0.05 & 5 & 20 & 4.231857 & 2.710890 \\
0.01 & 4 & 12 & 5.501626 & 5.411951 \\
0.01 & 4 & 20 & 5.018016 & 4.430690 \\
0.01 & 5 & 12 & 5.836308 & 5.064343 \\
0.01 & 5 & 20 & 5.293253 & 4.102685 \\
\end{array}
\]

(a) Analyse the data as if it were a one-way layout, i.e. ignore the rows and columns:

\[
Y_{ij} = \mu_i + \epsilon_{ij}
\]

where \(Y_{ij}\) is the \(j\)-th observation receiving drug \(i\), and \(\epsilon_{ij}\) are i.i.d. \(N(0, \sigma^2)\), for \(i, j = 1, \ldots, 5\).
i. Obtain the (one-way) anova table (using Drugs as treatments).

ii. Obtain estimates of all unknown parameters.

iii. Obtain the standard error of a pairwise difference \( \hat{\mu}_i - \hat{\mu}_h \), for \( i \neq h \).

iv. Using the R output above, determine if any of the \( \hat{\mu}_i \)'s are significantly different at either the 0.05 or the 0.01 level, according to Tukey’s method for this model.

v. Compute a \( t \)-statistic for the particular contrast represented by \((2A+4C+E)/(7-(B+D))/2\). Noting that this has been determined by looking at the data (data-snooping), use Scheffé’s method to obtain an appropriate \( p \)-value to assess whether the corresponding population contrast is different from zero. Also compare this to the largest pairwise \( t \)-statistic.

(b) Repeat the above calculations, but this time adjust for rows and columns. You may exploit the fact that the design is orthogonal, and thus changes in residual sums of squares do not depend on the order in which each source of variation is fitted.

2. Each of 7 rats were exposed to 3 of 7 treatments (no more were possible per rat). Thus the treatments were assigned using an incomplete block design.

<table>
<thead>
<tr>
<th>Rat</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10.2</td>
<td>6.9</td>
<td>–</td>
<td>14.2</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>31.3</td>
</tr>
<tr>
<td>2</td>
<td>–</td>
<td>–</td>
<td>9.9</td>
<td>12.9</td>
<td>–</td>
<td>14.1</td>
<td>–</td>
<td>36.9</td>
</tr>
<tr>
<td>3</td>
<td>–</td>
<td>12.1</td>
<td>11.7</td>
<td>–</td>
<td>8.6</td>
<td>–</td>
<td>–</td>
<td>32.4</td>
</tr>
<tr>
<td>4</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>14.3</td>
<td>9.1</td>
<td>–</td>
<td>7.7</td>
<td>31.1</td>
</tr>
<tr>
<td>5</td>
<td>–</td>
<td>8.8</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>16.3</td>
<td>8.6</td>
<td>33.7</td>
</tr>
<tr>
<td>6</td>
<td>13.1</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>9.2</td>
<td>15.2</td>
<td>–</td>
<td>37.5</td>
</tr>
<tr>
<td>7</td>
<td>11.3</td>
<td>–</td>
<td>9.7</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>6.2</td>
<td>27.2</td>
</tr>
<tr>
<td>Total</td>
<td>34.6</td>
<td>27.8</td>
<td>31.3</td>
<td>41.4</td>
<td>26.9</td>
<td>45.6</td>
<td>22.5</td>
<td>230.1</td>
</tr>
</tbody>
</table>

Is the blocking design

(a) cyclically generated?

(b) balanced?