Homework #5 Abbreviation: KNNL5 refers to the textbook by Kutner, Nachtsheim, Neter and Li.

Instructions: This homework is on analysis of data from a two-way factorial experiment. You will need to provide R code. For your homework submission, prepare a computer document, for example a Word or pdf file, and upload it on Canvas. See HomeworkInstructions.pdf on how to incorporate R code, output, and graphs into your homework document.

This homework is based on KNNL5 Problems 19.14, 19.15, 19.32 **Hay fever relief**. A research laboratory was developing a new compound for the relief of severe cases of hay fever. In an experiment with 36 volunteers, the amounts of the two active ingredients (factors A and B) in the compound were varied at three levels each. Randomization was used in assigning four volunteers to each of the nine treatments. The data are in `CH19PR14.txt`.

Do the following for this analysis:

1 Use R to read in the data and set it up for analysis.

2 Fit the two-way ANOVA model with interaction. This is the model that is usually written:

$$Y_{ijk} = \mu_{..} + \alpha_i + \beta_j + (\alpha\beta)_{ij} + \epsilon_{ijk}, i = 1, \ldots, a; j = 1, \ldots, b; k = 1, \ldots, n$$

with the usual constraints on the α_is, β_j's and $(\alpha\beta)_{ij}$'s.

3 Obtain the plot of studentized residuals vs. fitted values. What assumptions of the model can be checked with this plot? What are your findings?

4 Obtain the normal quantile-quantile plot of studentized residuals. Does the normality assumption appear reasonable here?

5 Obtain a plot of estimated treatment level means. Does your graph suggest that any factor effects are present? Explain briefly. Note: Use plot.design in R, e.g. (with obvious variable names)

```
plot.design(relief ~ A*B, data = hay }
```

6 Obtain an interaction plot; put the levels of Factor A on the horizontal axis. Does this plot suggest that there is an interaction between the two factors? Explain your answer.

7 Obtain the analysis of variance table.

8 Test whether or not the two factors interact. What is your conclusion about whether the interaction term can be dropped from the model?

9 Regardless of your decision from the previous part, for this part of the analysis, leave the interaction term in the model, and estimate the following six contrasts. Use the Scheffé multiple comparison procedure with a 90 percent family confidence coefficient. Interpret your findings.

$$
\begin{aligned}
L_1 &= \frac{\mu_{12} + \mu_{13}}{2} - \mu_{11} \\
L_2 &= \frac{\mu_{22} + \mu_{23}}{2} - \mu_{21} \\
L_3 &= \frac{\mu_{32} + \mu_{33}}{2} - \mu_{31} \\
L_4 &= L_2 - L_1 \\
L_5 &= L_3 - L_1 \\
L_6 &= L_3 - L_2
\end{aligned}
$$