Instructions:

1. You may use your formula sheet, a calculator, and the tables in the back of your text.
2. In order to get full credit, show as much of your work as possible.
3. Point values are given in parentheses.
4. Unless otherwise stated, use $\alpha = 0.05$ for all tests. Good luck!

1. (40) Engineers studied the effect of the composition of cement on heat evolved during hardening. Data were collected on the following variables.

- $y$: heat evolved per gram of cement (in calories)
- $x_1$: amount of tricalcium aluminate
- $x_2$: amount of tricalcium silicate
- $x_3$: amount of tetracalcium alumino ferrite
- $x_4$: amount of dicalcium silicate

Refer to the accompanying output to answer the following questions.

(a) (10) Does there appear to be a collinearity problem in these data?

(b) (30) Choose an appropriate regression model, and justify your choice.

(a) Yes, there is collinearity among the 4 independent variables. Two correlations are larger than 0.8 in absolute value, and in the full model, two variance inflation factors are more than 250.

(b) Two models are defensible, 2 and 3. Both have $R^2$ values close (or equal) to that of the full model. Also, the variable ($x_1$) entered on step 2 is highly significant, and the one ($x_2$) entered on step 3 has $p$-value of 0.052. If it is undesirable to avoid large VIFs, then model 2 might be preferable to 3.
The data in this problem are from a statement by Texaco, Inc. to the Air and Water Pollution Subcommittee of the Senate Public Works Committee on June 26, 1973. Mr. John McKinley, then President of Texaco, cited an automobile filter developed by Associated Octel Company as effective in reducing pollution. However, questions had been raised about the effects of filters on vehicle performance, fuel consumption, exhaust gas back pressure, and silencing. On the last question, he referred to the data in this problem as evidence that the silencing properties of the Octel filter were at least equal to those of standard silencers.

The response variable was noise level (in decibels) and two factors were of interest: vehicle size (small=1, medium=2 and large=3) and type of silencer (standard=1 and Octel filter=2). A CRD was conducted as follows. Twelve small vehicles were randomly selected from a pool of small vehicles. Six of these twelve were randomly selected and fitted with a standard silencer, and the other six were fitted with Octel filters. Exactly the same procedure was used for medium and large cars, resulting in a total of 36 cases and the following ANOVA table.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car size</td>
<td>26051.389</td>
<td>2</td>
<td>13025.694</td>
<td>199.119</td>
<td>0.0000</td>
</tr>
<tr>
<td>Silencers</td>
<td>1056.250</td>
<td>1</td>
<td>1056.250</td>
<td>16.146</td>
<td>0.0004</td>
</tr>
<tr>
<td>Interaction</td>
<td>804.167</td>
<td>2</td>
<td>402.083</td>
<td>6.146</td>
<td>0.0058</td>
</tr>
<tr>
<td>Error</td>
<td>1962.500</td>
<td>30</td>
<td>65.477</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>29874.306</td>
<td>35</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Treatment means and some SPSS output are provided in the accompanying handout. Also, a plot of treatment means is given on the last page of the exam and the LSD value for comparing two treatment means (at level 0.05) is 9.54. Provide a complete analysis of the data, stating your conclusions in the language of the problem.

The interaction is sig. at the 0.05 level. So, we will compare treatment means to investigate the nature of the interaction. The Octel filter leads to sig. less noise on average than the standard silencer only when used in medium sized cars. Also medium sized cars fitted with the standard silencer are noisier on average than any other combination of car size and silencer. Finally, large cars are significantly less noisy than small and medium, regardless of filter used.
3. (20) Researchers in a veterinary school wanted to compare the effects of three different diets for dogs. Measures of enzyme activity were obtained for each dog in the study before and after being fed a specific diet for three weeks. The response variable was the difference between before and after enzyme activities. Available for the study were three standard poodles, three dachshunds and three golden retrievers.

(a) (10) Which do you think is more appropriate for this study: a completely randomized design or a randomized block design? Justify your answer.

Randomized block. Although we can't be certain of this, there is the obvious possibility that "dog breed" has an effect on a dog's response to diet. If this is true, then an RBD will be a more effective way to detect differences between diets. Even if breed has no effect on response to diet, there is only a small liability associated with using an RBD.

(b) (10) Describe how the dogs would be assigned to diets for each of the designs mentioned in (a).

RBD: Randomly assign the three diets to the three poodles, and do the same for each of dachshunds and retrievers.

CRD: Randomly select 3 of the 9 dogs and assign them to diet 1. Randomly choose 3 of the 6 remaining dogs and assign them to diet 2. The 3 remaining dogs are assigned to diet 3.