STATISTICS FOR ENGINEERS
ASSIGNMENT 14
DECEMBER 3, 2010

This homework assignment primarily deals with Chapters 8 and 9. The problems are worth 2, 2, 3, and 3. You would be silly not to use the computer for this assignment.

Make sure you show your work.

Problem 14.1:

I would like to determine if the unemployment in the United States significantly differed from region to region. To answer this question, I decided to use a one-way analysis of variance procedure. In `R`, the function call I used was

```
summary(aov(unemp90 ~ region) )
```

As this is from the `crime` dataset, the `unemp90` variable is the unemployment rate in the state in 1990. The `region` variable is a categorical variable of the region in which the state is located. The following is the ANOVA table as displayed by `R`. Use it to answer the subsequent questions. In each answer you give, make sure you cite the correct information from the table, as well as answer using a complete thought.

```
            Df Sum Sq Mean Sq F value  Pr(>F)
region       8 18.655  2.3319  2.1296 0.05403 .
Residuals   42 45.991  1.0950
```

Questions:

(a) How many regions are there?

(b) How many data points are there?

(c) Does the unemployment rate significantly vary from region to region?

Problem 14.2:

Those who study statistical mechanics, thermodynamics, or chemistry define the total energy of a thermodynamic system as enthalpy. Thus, the units of enthalpy are the same as the units for energy, and its value is calculated by determining the energy flows in the system or experiment.

Let us conduct an experiment where we measure the enthalpy for table salt (NaCl) under a variety of methane concentrations. The table below gives the data. Note that there are four concentrations and there are four repeated measurements for each concentration.

Concentration (%)	Enthalpy			
5	1.62	1.60	1.62	1.66
10	2.69	2.66	2.72	2.73
15	3.56	3.45	3.65	3.52
20	3.35	3.18	3.40	3.06

Questions:

(a) Statistically speaking, is the enthalpy the same at all concentrations? Explain.

(b) Which pairs of concentrations, if any, can you conclude to have differing enthalpies?

Problem 14.3:

Using the `crime` data, and using the `census4` variable as the grouping (independent) variable and the `vcrime90` variable as the measurement (dependent) variable, calculate the following:

- grand mean
- SSTr
- SSE
- total sum of squares
- MSTr
- MSE
- total MS
- degrees of freedom for the treatment
- degrees of freedom for the error
- total degrees of freedom
- the test statistic
- the p-value

Now, create a boxplot of `vcrime90` by `census4`.

Finally, use Tukey's HSD procedure to determine which means are significantly different from the others ($\alpha = 0.05$, as usual).

PROBLEM 14.4:

Artificial joints consist of a ceramic ball mounted on a taper. The coefficient of friction determines both the ease of use of the joint and its effective lifetime. A two-factor experiment was performed trying to determine the effects of the taper material and the neck length on the coefficient of friction for the artificial joint. The resulting data is in the following table.

Taper Material	Neck Length	Coefficient of Friction				
CPTi-ZrO_2	Short	0.254	0.195	0.281	0.289	0.220
CPTi-ZrO_2	Medium	0.196	0.220	0.185	0.259	0.197
CPTi-ZrO_2	Long	0.329	0.481	0.320	0.296	0.178
TiAlloy-ZrO_2	Short	0.150	0.118	0.158	0.175	0.131
TiAlloy-ZrO_2	Medium	0.180	0.184	0.154	0.156	0.177
TiAlloy-ZrO_2	Long	0.178	0.198	0.201	0.199	0.210

Questions:

(a) Compute the main effects and interactions.

(b) Construct the ANOVA table.

(c) Is the additive model plausible (in a statistical sense)? Provide the value of the test-statistic and its p-value.

(d) Can the effect of taper material on the coefficient of friction be described by interpreting the main effects of the material? If so, do so. If not, explain why not.

(e) Can the effect of the neck length on the coefficient of friction be described by interpreting the main effects of the neck length? Do so. Make sure you determine which pairs of effects differs. Use Tukey's HSD procedure to do this.