1. Exercise 11.8 (page 472).
In an experiment, rats were subjected to differing levels of stress to measure the effect on lymphocytes (cells/ml $\times 10^{-6}$) in blood.

Solution:

(a) **Construct the ANOVA table.**

Source	df	SS	MS	F
Between	3	89.036	29.68	3.84
Within	44	340.24	7.73	
Total	47	429.276		

Using R the p-value is 0.0159 which is statistically significant at the 0.05 level.

(b) **Compute the pooled standard deviation.** $s_{\text{pooled}} = \sqrt{340.24/44} = 2.78$.

2. Exercise 11.12 (page 474).
Computer output from experiment on yield of oats for different varieties.

Solution:

(a) **How many varieties were there?** There were 3 varieties (3-1=2).

(b) **State the conclusion of the ANOVA.** The data is consistent with no difference in mean yield for the different varieties of oats ($p = 0.68$, F-test from one-way ANOVA).

(c) **What is the pooled standard deviation?** $s_{\text{pooled}} = \sqrt{95.5342} = 9.77$.

3. Analyze the data in Exercise 11.26 (page 495) using both the Newman-Keuls method and the Bonferroni method.
Data is on selenium levels in cattle after one year. There is a control group and three different treatment groups.

Solution: *The Newman-Keuls method.*

We rank the means from smallest to largest.

A	D	B	C
0.8	5.0	5.4	6.2

Here is the table of critical values ($\alpha = 0.05$). There are 140 denominator degrees of freedom, but we use 120 as the closest tabulated value. The scale factor is $\sqrt{2.071/36} = 0.24$.

i	2	3	4
q_i	2.80	3.36	3.68
R_i	0.67	0.81	0.88

Treatment C is signifcantly larger than all of the others, as the actual differences in means exceeds the threshold values in each case.

Treatments B and D are not statistically significantly different, but treatment D is larger than treatment A.

The B-B-B-B-B-Bonferroni method.

There are 6 pairwise comparisons. We will call a difference in sample means significant if it is significant at the $0.05/6$ level. This is equivalent to computing the margin of error for a $99\frac{1}{6}\%$ confidence interval. The critical t value is:

```
> tcrit <- qt(1 - 0.05/12, 140)
> tcrit

[1] 2.676265
```

The margin of error is $2.6763 \times \sqrt{2.071}\sqrt{\frac{1}{36}+\frac{1}{36}} = 0.908$.

Using this, we cannot distinguish between D and B or between B and C, but the other four pairwise differences are significant.

The Bonferroni method is more conservative than Neuman-Keuls. Notice that 0.91 is larger than any of the critical values in the Newman-Keuls method.

4. Use R to carry parts of Exercises 11.31 through 11.36. The actual commands you could use for this are in the file anova.pdf that you can find with a link next to where you found this assignment. Answer the questions in that document, but do not include all of the graphs or output unless specified.

Question 1. Do the groups have similar centers? Do the groups have similar amounts of variability?

Solution: The group with both polutants present has lower yields and lower variability than the other three groups.

Question 2. Record these values in a table.

Solution: Ozone/Sulfur Dioxide

Group	absent/absent	absent/present	present/absent	present/present
n	3	3	3	3
mean	1.587	1.417	1.34	0.7
SD	0.237	0.181	0.213	0.056

Question 3. Summarize the results of this test in the context of the problem. Is the test significant at the $\alpha = 0.05$ level?

Solution: There is very strong evidence that the mean yields under the four treatments are not identical. The test is significant at the $\alpha = 0.05$ level (by a lot).

Question 4. Refer to the boxplots made previously. Does this plot indicate that the assumption of normality might be suspect? Does this plot indicate that the assumption of equal variances might be suspect?

Solution: The normality assumption is probably not too bad. The plots do not show extreme skewness or large outliers. The assumption of equal population variances is more suspect. The last group shows substantiall less spread than the first three groups.

Question 5. Refer to the residual plot. Does this plot indicate that variability is related to the mean value?

Solution: There is a wedge-shaped pattern to the residuals — larger residuals are present in the groups with the larger means.

Question 6. Do the residuals look normally distributed?

Solution: The normal probability plot is fairly straight considering the sample size.

Question 7. Do these plots indicate that the variablity within each sample are more equal for the transformed data?

Solution: The last group still has the smallest variance, but the differences are not as large as with the untransformed data.