Solutions to Computer Exercise 4 (R)

1. From the Bartlett test for homogeneous variances (which maybe one should not use if residuals might deviate from normal distribution) we get for the various transformations

Transformation	Bartlett Chi-Square	df	P-value
none	6.27	2	0.043
square root	0.77	2	0.679
logarithm	1.16	2	0.559
inverse	18.85	2	0.00008

Based on Bartlett's test, both the square root and the logarithm seem to be acceptable. According to the Fligner-Killeen test (function `fligner.test`) it is OK to use the untransformed variable. As you can see from the boxcox plot, however, a power close to ½ (square-root) is the preferable transformation. Thus, you ought to use the square root. (the variance seems to increase slightly with the mean for the square root and to decrease slightly with the mean for the logarithm), whereas the inverse is worthless for these data. Make sure to verify these conclusions graphically.

One finds a significant effect of weed killer on square root transformed damage (F = 61.89, p < 0.000001). A Kruskal-Wallis nonparametric anova gives chi-squared = 20.165, df = 2, p = 0.00004. Thus, the conclusion is the same as using transformation: there is an effect of weed killer. (Weed killer 1 produces the least amount of damage).

2. First, the transformation trPSLen=1000000/PSLen^3 does a rather good job of producing homogeneous variances, and the distribution of residuals also looks OK for this transformation (although the residuals appear closer to normal for the inverse transformation). According to the Bartlett test, we cannot reject homogeneous variance for the trPSLen or the inverse transformation, and for the log transformation we come close to rejecting homogeneity (p = 0.059), but for the square root and for the untransformed variable, the variances are significantly heterogeneous between treatment groups. Overall, the trPSLen variable appears to be the one we should use.

Second, there is a highly significant effect of treatment on trPSLen ($F_{4,45}$ = 53.11, p < 0.000001).

Third, for the planned comparisons, we get the following

Comparison	contrast	t_{45}	p
(a)	-4, 1, 1, 1, 1	-12.05	<0.000001
(b)	0, 1, 1, 1, -3	-7.973	<0.000001
(c)	0, 1, 1, -2, 0	1.143	0.26
(d)	0, 1, -1, 0, 0	1.539	0.13

We can conclude that the control differs from the sugar treatments and that sucrose differs from the other sugars. However, there does not seem to be any difference between the monosaccharides, either mixed or pure.

Finally, a post hoc test with the Tukey method gives essentially the same conclusions about the effects of various sugars. The reason is that the significant effects were so strong that the additional power provided by planned comparisons was not needed in this case. Dunnett's test also shows that each treatment is significantly different from the control.

3. From a one-way anova, there is no significant effect of cation system on membrane potential ($F_{3,17}$ = 0.3937, p = 0.759). Using the log activity ratio as a covariate, the test for parallelism gives a p-value of 0.973 for the Cation-LogAR interaction term, so we should accept that there is a common regression slope. The ancova then tells us that the effect of cation system on membrane potential is highly significant ($F_{3,16}$ = 195.98, p < 0.000001). Also, there is a highly significant effect of LogAR on Pot ($F_{1,16}$ = 1853.3, p < 0.000001) with a common regression slope of 21.093.

The adjusted mean membrane potentials are as follows: Ca-Li 0.517; Ca-Na 13.861; Ca-K 21.713; Sr-Na 27.849.

4. The one-way anova shows no significant effect of sex on development time ($F_{1,10}$ = 0.9116, p = 0.362). Including the photoperiod as a covariate one instead finds a significant effect of sex on development time ($F_{1,9}$ = 10.752, p = 0.0095); the analysis of covariance seems OK since the regression slopes for females and males are not significantly different. The effect is an example of protandry, since males emerge on average 0.70 days before females (from `summary(fm2)`, you see that the effect of male sex is -0.6999, which means that males develop that faster than females).

5. First, from a one-way analysis of variance of log abdomen dry weight, one finds a significant effect of sex (p < 0.000001), with females having bigger abdomens. However, females are heavier than males (p = 0.0157) so the effect could simply be a result of sexual size dimorphism. Using log total dry weight as a covariate, it appears that the regression slopes for females and males are not parallel (p = 0.025).

Changing the sex of the male outlier in case 35 to female, one now accepts that the regression slopes are parallel (p = 0.26), with a common slope of 1.25. Females and males differ in log abdomen weight, controlling for log total dry weight (p < 0.000001), and females have proportionally heavier abdomens.