Do you always turn to the last page of a detective mystery first? Can’t wait to learn whether Little Nell will die? Even so, read this chapter only AFTER you’ve tried to do the exercises. (The proof will be if you’ve a sheet of paper in front of you on which you’ve written out the answers.)

The object of the exercises at the end of each of the preceding chapters is to prepare you for real-world applications. These exercises force you to think through the concepts while giving you the opportunity to work through, test, and modify the program listings before you apply them to your own data. No pain, no gain. Working through problems is the one sure way to gain reusable experience. Or to put it another way: Consult this chapter only AFTER you’ve tried to do the exercises.

Chapter 2

1, 3, 6. If you repeat your calculations you may get quite different results, since random samples are involved. In any event, the confidence interval must include the original estimate. Note in question 6 that the larger the original sample, the less variation from one set of bootstrap samples to another.

2. Adding $5''$ to every observation is equivalent to shifting the entire frequency distribution $5''$ to the right. Thus, the mean, the median, and every other percentile will increase by $5''$ while the variance will be left unchanged.

If you convert from feet to inches, you will need to multiply every observation by 12. The mean and standard deviation will be in inches also, so you will need to multiply their original values by 12. As the variance is the square of the standard deviation, you will need to multiply its former value by $12 \times 12 = 144$.

3. Combine the data from the various PPO’s to form a single sample.

6. Although it was suggested that you use as many different methods as possible, you should use and report only one in practice. The percentile bootstrap should never be used in practice; strictly a classroom tool, its sole virtue is that it is easy to explain. Which of the remaining bootstrap estimates you use will depend upon the circumstances.
7. As you are attempting to determine the precision of the original estimate and as precision is a function of sample size, your bootstrap samples should be the same size as the original sample.

Chapter 3

1. There are 8 choose 4 possible relabelings of which only one is more extreme than the one we observed.
2. Use the fact that the sum of all the observations in both samples and the sum of the squares of the observations in both samples are the same for all relabelings.
3. \( p \)-value close to 0.
4. These differences are paired and you would not use the same statistic as in exercise 4.
5. Presumably you are to test the hypothesis that the fuel additive described in Section 3.3.5 increases mileage by at least 10%. Add 10% to each of the control values. Then test the hypothesis that there is no difference against the one-sided alternative that the control values are greater.

Chapter 4

1.a. When the difference is zero, the power is identical with the significance level. When the difference is very large, the power is 1.
2. \( d \) is always true.
3. Both \( a \) and \( b \) are true.
4. You should always decide which statistic you will use before you look at the results of a statistical analysis. Otherwise, the true significance level will far exceed the hypothetical one. See Common Errors in Statistics (Wiley, 2003).
5. If you put a $2 bill in your pocket originally, you will always accept the $2 hypothesis so the significance level is zero. If you put a $20 bill in your pocket originally, you will reject the $2 hypothesis 50% of the time so the power is 50%.
6. a. par, b. par or perm, c: par, d: perm, e: par, f: par, g: perm rank, h: perm.
7. For \( n = 100 \), allowing one defective would result in a significance level of 1-\( p \text{binom}(1,100,.01) \) or 26% and a power of 1-\( p \text{binom}(1,100,.02) \) or 60%.
8. The paired test as it eliminates one major source of variation.
9. The width of confidence intervals is a decreasing function of sample size. The width of a confidence interval for the difference in means is a function of the size of the combined samples.

Chapter 5

2a. data= c( 221.1,224.2,217.8,208.8,206.9,205.9,211.1, 198.4,213.0,208.3,214.1,209.1,221.1,208.8, 211.1,224.2,206.9,198.4)
size=c(3,3,3,3,3,3)
> f1=F1(size,data)
> #Number MC of simulations determines precision of
  p-value
> MC = 1600
> cnt = 0
> for (i in 1:MC){
+ pdata = sample (data)
+ f1p=F1(size,pdata)
+ # counting number of rearrangements for which F1
  greater than or equal to original
+ if (f1 <= f1p) cnt=cnt+1
+ }
> cnt/N
[1] 0.448

4a. If the order in which plants (subjects, experimental units) are selected makes a
difference, then the two methods are not equivalent.

4b. Among the methods are using two coins to assign one of four treatments (HH, HT,
TH, and TT) and three coins to assign eight treatments. The six-sided die could
be used to assign three rows and two columns. Let 1, 2, and 3 assign to the first
column.

6. Subtract the initial weight from the final weight in each instance; then make an
unordered \( k \)-sample comparison of these differences.

8. 1

10. Weight your mean estimate in accordance with the relative sizes of the two popu-
lations. To create a confidence interval by bootstrap means, take separate bootstrap
samples from the Burb sample and from the City sample; form an estimate of
the mean again weighting the individual bootstrap means in accordance with the
relative sizes of the two populations.

12. Analyze as an ordered \( k \)-sample comparison. Would yours be a one-sided or a
two-sided test?

14. Analyze as an unordered \( k \)-sample comparison. Would yours be a one-sided or a
two-sided test?

15. 9!/3!^3; 6!/2!^3 \times 3! = 540.

Chapter 6

1. As we do not know the relative numbers of black and white births during the same
period, we cannot answer this question.

2. As we do not know the sizes of the two samples, we cannot answer this question.

4. Analyzing as a singly ordered table, we find a \( p \)-value close to 0.

6. Maybe. If both teams are in the same league, the entries would not be independent
and Fisher’s Exact Test would not be applicable.

9. Two rows and three ordered columns. A Monte Carlo is necessary due to the large
sample sizes. Association with the virus is significant at the 1% level.
11. Using either the Jonckheere–Terpstra test or the linear-by-linear association test for doubly ordered tables, differences among the rows are significant at the 1% level.

Chapter 7

4. As with most real-world data, we first need to reformat the observations so as to satisfy the requirements imposed by the software. Thus to use Blossom to obtain Hotelling’s-$T^2$ we have

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<th>hmpg</th>
<th>time</th>
<th>hrqi</th>
<th>smpg</th>
<th>srpi</th>
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<td>23</td>
<td>2</td>
<td>1</td>
<td>22.5</td>
<td>1</td>
</tr>
</tbody>
</table>

MRPP HMPG HRQI SMPG SRPI * TIME * ID

Probability (Pearson Type III) of a smaller or equal delta = 0.08

Chapter 8

2. a. positive linear
   b. + or − linear
   c. nonlinear
   d. negative log linear initially
e. nonlinear
f. negative log linear
g. exponential initially

8. Reserve the latest and most current observations for use in validation.
10. Compare with the answer you got for exercise 1 of Chapter 9.
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Glossary

**Accuracy** – An *accurate* estimate is close to the estimated quantity.

**Bootstrap Sample** – A sample taken at random and with replacement from an existing sample rather than from the population at large.

**Contingency Table** – The entries in a contingency table are the frequencies with which specific events were observed. The marginals of the contingency table are the frequencies with which various categories of events were observed. These categories may be ordered or unordered.

**Deterministic** – A phenomenon is *deterministic* when its outcome is totally predictable.

**Distribution-Free Methods** – Require no assumptions about or knowledge of the distribution of the observations. Permutation tests, the nonparametric bootstrap, and nonparametric decision trees are all distribution-free methods.

**Empirical Distribution Function** – The distribution function of the observations as distinguished from the distribution function of the population itself.

**Exchangeable Observations** – Their joint probability distribution remains unchanged by rearrangements of their labels.

**Experimental Design** – A division of an experiment into blocks based on the values of one or more factors. These values may be ordinal or categorical.

**Functional** – Any numeric characteristic of a population such as a percentile, a mean, a standard deviation, or a combination thereof.

**Nonparametric Tests** – A misnomer as many such tests concern parameters. Distribution-free test is what is usually intended by this expression.
**Parametric Methods** – Take advantage of our knowledge of the distribution of the observations. Rejection regions and confidence intervals of parametric procedures are based on this knowledge. If our assumptions concerning the distribution of the observations are in error then the corresponding parametric methods are in error.

**Permutation Distribution** – Should be called a rearrangement distribution as it consists of the values taken by a test statistic for each of the possible relabelings of a set of observations.

**Permutation Test** – The significance levels of a permutation test are established by reference to the permutation distribution of a test statistic.

**p-value** – A function of the sample and the sample statistic. Thus, it will vary from sample to sample.

**Power of a Test** – Defined as the probability of rejecting the hypothesis when a specific alternative is true. Thus the power is 1 minus the probability of making a Type II error.

**Precision** – Precise estimates take almost the same value from sample to sample. A precise interval estimate is a narrow one.

**Rank Test** – A permutation test in which the ranks of the observations rather than their original values are used.

**Resampling Method** – Any estimation, hypothesis testing, or modelling method that requires repeated resampling from the data at hand. Bootstrap, decision trees, and permutation tests are all resampling methods.

**Significance Level** – Defined as the probability of making a Type I error.

**Stochastic Outcomes** – May take any of a distribution of values. A “random fluctuation” is stochastic.

**Type I Error** – Made when we accept the alternative hypothesis and the primary hypothesis is true.

**Type II Error** – Made when we accept the primary hypothesis, yet the null hypothesis is true.

**Unbiased Confidence Interval** – A confidence interval that has a greater probability of containing the true value of a parameter than of any false value.

**Unbiased Test** – A hypothesis test that is more likely to reject any false hypothesis than any true one (if, that is, all the assumptions on which the test is based are satisfied).
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