QBS 120 - Problem Set 7

1. (Based on Rice 10.26) Hampson and Walker also made measurements of the heats of sublimation of rhodium and iridium. Do the following calculations for each of the two given sets of data:

```
> iridium.data = c(136.6, 145.2, 151.5, 162.7, 159.1, 159.8, 160.8, 173.9, 160.1,
+ 160.4, 161.1, 160.6, 160.2, 159.5, 160.3, 159.2, 159.3, 159.6,
+ 160.0, 160.2, 160.1, 160.0, 159.7, 159.5, 159.5, 159.6, 159.5)
> rhodium.data = c(126.4, 135.7, 132.9, 131.5, 131.1, 131.1, 131.9, 132.7,
+ 133.3, 132.5, 133.0, 133.0, 132.4, 131.6, 132.6, 132.2,
+ 131.3, 131.2, 132.1, 131.1, 131.4, 131.2, 131.1, 131.1,
+ 134.2, 133.8, 133.3, 133.5, 133.4, 133.5, 133.0, 132.8,
+ 132.6, 133.3, 133.5, 133.5, 132.3, 132.7, 132.9, 134.1)
```

   (a) Plot a histogram of the data.

   (b) Plot the eCDFs with 95% confidence bands (you may use the ecdf.ksC() function in the R sfsmisc library)

   (c) Plot the kernel density estimate.

   (d) Plot the observations in the order of the experiment.

   (e) Does that statistical model of iid measurement errors seem reasonable? Explain.

   (f) Find the mean, 10% and 20% trimmed means, and median and compare them.

   (g) Find the standard error of the sample mean and a corresponding 90% confidence interval. Overlay this CI on a density plot.

   (h) Use the bootstrap to approximate the sampling distribution of the 10% and 20% trimmed means and median. Plot the kernel density estimates of these bootstrap distributions in a single plot. Compute the standard errors and compare.

   (i) Find approximate 90% CIs based on the trimmed means and median and compare to the intervals for the mean.

2. (Based on Rice 11.21) A study was done to compare the performances of engine bearings made of different compounds. Ten bearings of each type were tested. The following table gives the times until failure (in millions of cycles):

```
> type.I.failure.times = c(3.03, 5.53, 5.6, 9.3, 9.92, 12.51, 12.95, 15.21, 16.04, 16.84)
> type.II.failure.times = c(3.19, 4.26, 4.47, 4.53, 4.67, 4.69, 12.78, 6.79, 9.37, 12.75)
```

   (a) Use normal theory to test the hypothesis that there is no difference between the type types of bearings (you can use pt() but not t.test()).

(b) Test the same hypothesis using a nonparametric method (use just pnorm() to evaluate using the normal approximation for the rank sum and compare that result to the exact distribution using wilcox.test()).

(c) Which of the methods, parametric or nonparametric, do you think is better in this case?

(d) Estimate π, the probability that a type I bearing will outlast a type II bearning?

(e) Use the bootstrap to estimate the sampling distribution of $\hat{\pi}$ and its SE (visualize the bootstrap distribution using both a kernel density plot probability plot relative to normal distribution and comment on the bootstrap distribution.)

(f) Use the bootstrap to find an approximate 90% CI for π (compute using both the basic and percentile bootstrap CI methods).

3. (Based on Rice 11.25) Referring to Example A in Section 11.2.1:

   (a) If the smallest observation for method B is made arbitrarily small, will the t test still reject?

   (b) If the largest observation for method B is made arbitrarily large, will the t test still reject?

   (c) Answer the same questions for the Mann-Whitney test.

4. (Based on Rice 11.36) Lin, Sutton and Qurashi compared microbiological and hydroxylamine methods for the analysis of ampicillin dosages. In one series of experiments, pairs of tablets were analyzed by the two methods. The data in the following table give the percentages of the claimed amount of ampicillin found by the two methods in several pairs of tablets.

```
> data = data.frame(
+        micro=c(97.2, 105.8, 99.5, 100, 93.8, 79.2, 72,
+                72, 69.5, 20.5, 95.2, 90.8, 96.2, 96.2, 91),
+        hydro=c(97.2, 97.8, 96.2, 101.8, 88, 74, 75, 67.5, 65.8,
+                21.2, 94.8, 95.8, 98, 99, 100.2))
> data

   micro hydro
1   97.2  97.2
2  105.8  97.8
3   99.5  96.2
4  100.0 101.8
5   93.8  88.0
6   79.2  74.0
7   72.0  75.0
8   72.0  67.5
9   69.5  65.8
10  20.5  21.2
11  95.2  94.8
12  90.8  95.8
13  96.2  98.0
14  96.2  99.0
15  91.0 100.2
```

(a) What are $\bar{X} - \bar{Y}$ and $s_{\bar{X}-\bar{Y}}$?

(b) If the pairing had been erroneously ignored and it had been assumed that the two samples were independent, what would have been the estimate of the SD of $\bar{X} - \bar{Y}$?

(c) Analyze the data to determine if there is a systematic difference between the two methods.