Exam 1

Take-home portion

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1

First we load in the data:

```
frogs <- readxl::read_xlsx("Exams/Exam 1/2022 F E1 511 problem 1.xlsx")
```

In order to get a quick idea of the data, we make a boxplot, shown in Figure 1.

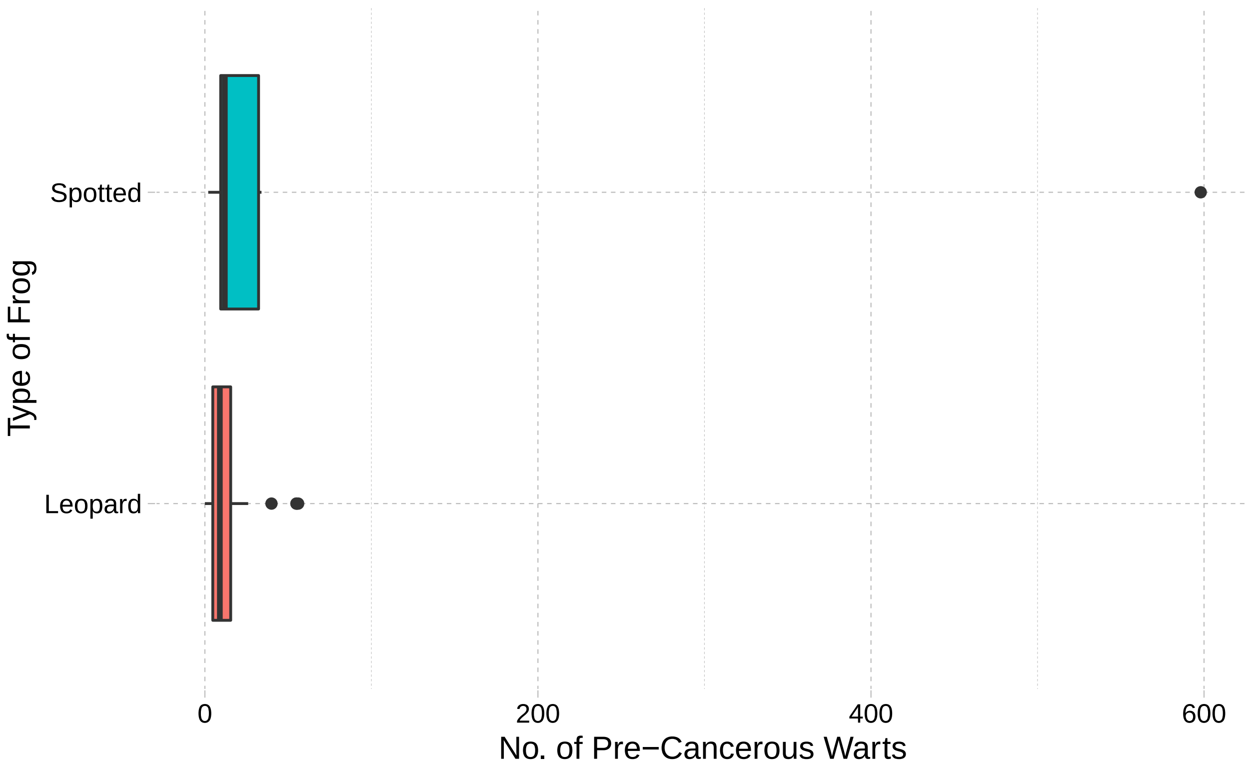

Figure 1: Original boxplot of pre-cancerous wart count by frog type

There is an odd observation of almost 600 pre-cancerous warts on a spotted frog. This is around 10 times greater than any other observation. It is clearly a mistake, as given the size of frogs (and warts) this would be impossible. We remove this observation and create a new boxplot (Figure 2).

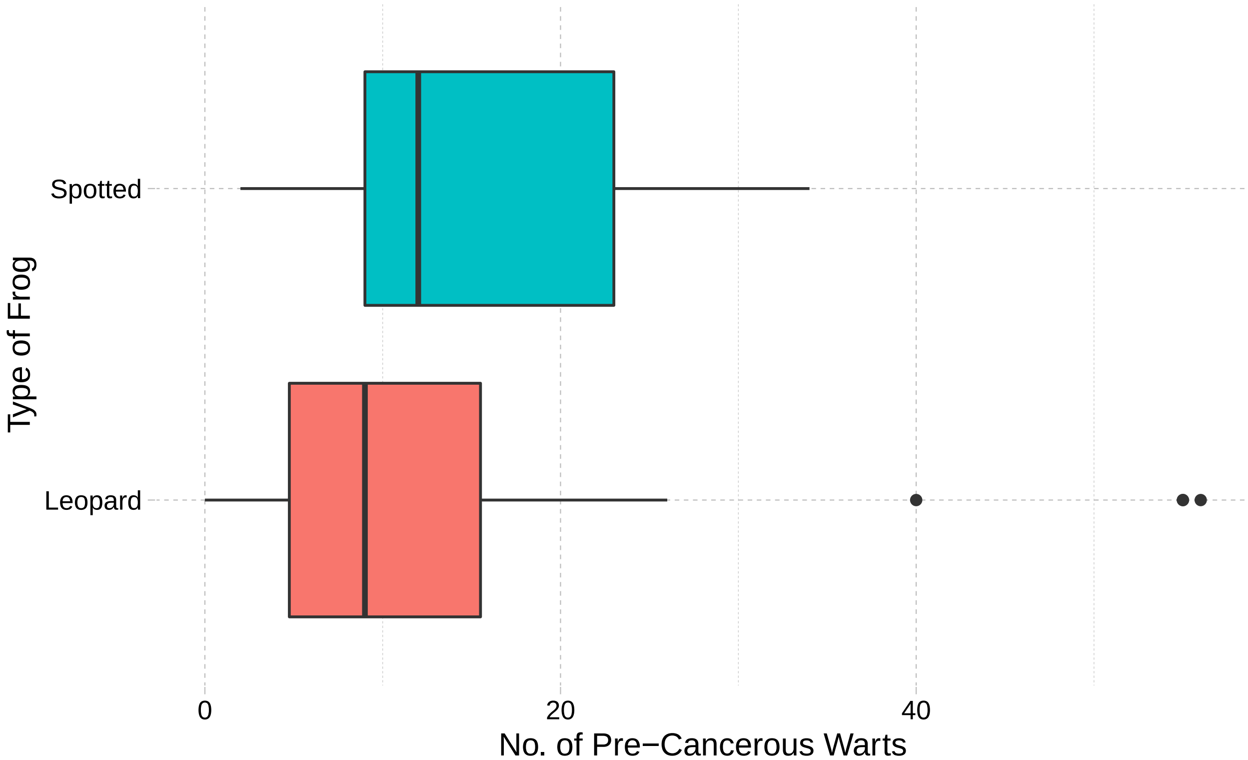

Figure 2: Fixed boxplot of pre-cancerous wart count by frog type

Table 1: t-Test Results for Pre-Cancerous Wart Count on Leopard and Spotted Frogs

Difference in Sample Means (Leopard — Spotted)	Degrees of Freedom	t-Statistic	p-Value
-2.06	45	-0.41	0.68

The hypothesis is that the spotted frogs on average have more pre-cancerous warts than the leopard frogs. From Figure 2 this seems like a reasonable claim, but in order to be sure we run a two-sample *t*-test on the data. This test is chosen since we are testing a difference in means, with the null hypothesis being that the difference in mean between the two types of frog is zero. We also assume that the two variances are equal and use a pooled standard deviation.

```
frog_test <- t.test(Count ~ Type, frogs2, var.equal = TRUE)
```

Table 1 shows the results of this test. The *p*-value is quite large, which indicates that there is no evidence that the alternative hypothesis (that there is a difference in wart count between the frog types) is correct. Because we are not accepting the alternative hypothesis, there are no inferences to be made.

2

Loading in the data:

```r
tires <- readxl::read_xlsx("Exams/Exam 1/2022 F E1 511 problem 2.xlsx")
```

Each car had two tires from both brands, but were not driven identically. Because of the paired nature of the data, a paired t-test is useful. A plot of the data is given in Figure 3, and a boxplot of the difference in tire wear in Figure 4.

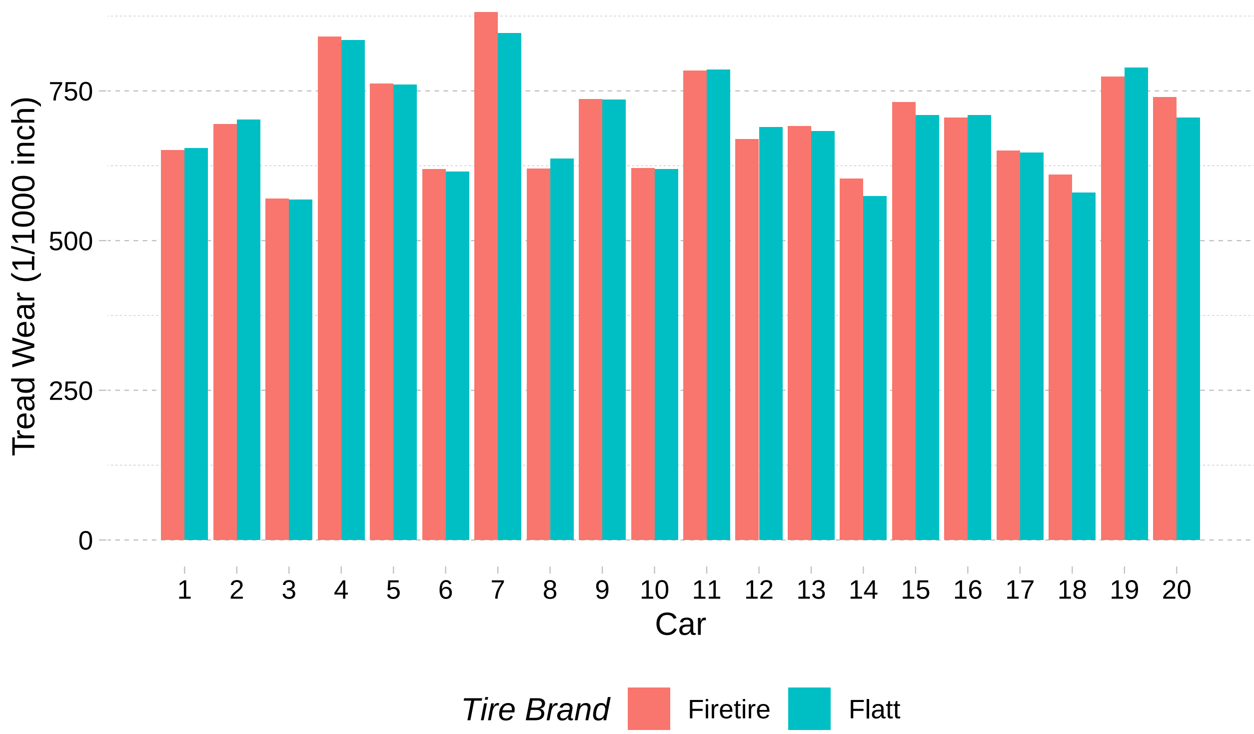

Figure 3: Plot of tire tread wear by brand and car.

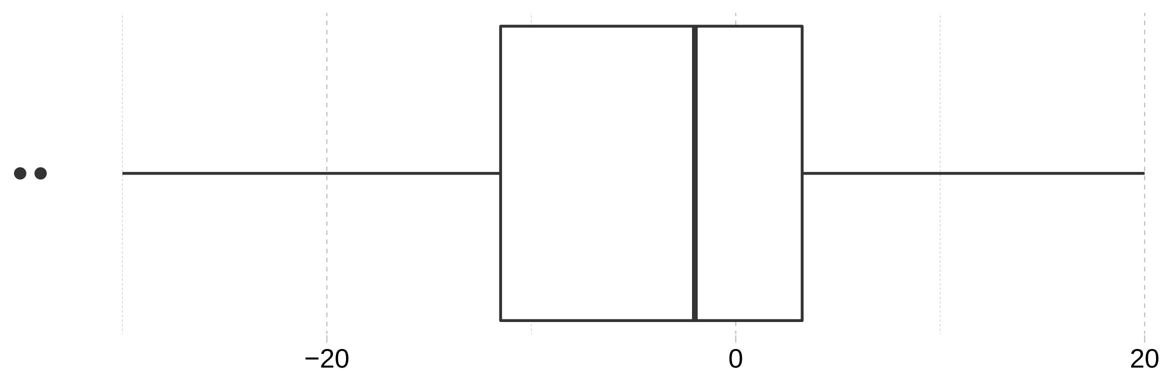

Figure 4: Difference in tire wear (Flatt - Firetire), 1/1000 inch

Based on this boxplot, it appears that Firetire tires wear more quickly than Flatt tires. But to see if this difference is significant, we run a paired t-test, the results of which are summarized in Table 2.

Based on this p-value, it is hard to conclude that there is a difference in tire wear. The evidence is quite weak.

Table 2: Paired t-Test Results for Tire Wear Comparison

Estimate (Flatt — Firetire)	Degrees of Freedom	t-Statistic	p-Value
-5.45	19	-1.48	0.15

3

We are testing the hypothesis that the weight gain of mice is affected by the difference in diet. A boxplot of the data is given in Figure 5.

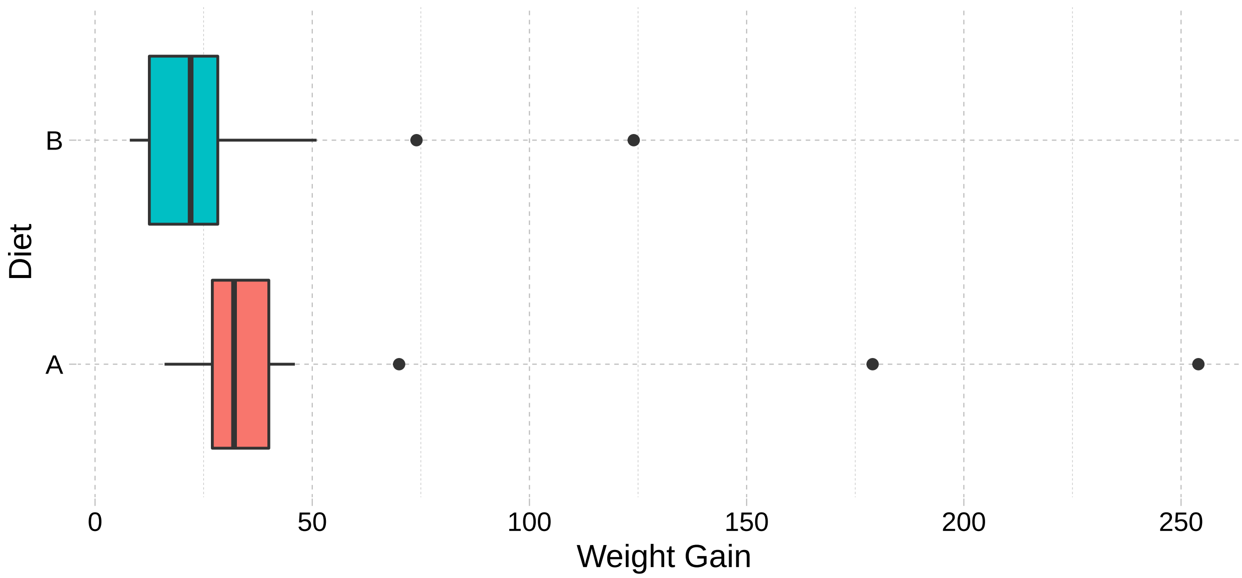

Figure 5: Boxplot of weight gain in mice by diet.

These data are quite skewed, and the group with the higher average has the larger spread. There are also several outliers (some quite extreme) with large values. This seems a good candidate for a log transformation. To be sure, running a *t*-test with the unaltered data gives the results found in Table 3, which are inconclusive.

Table 3: t-Test Results for Mice Diet Comparison

Estimate (Diet A — Diet B)	Degrees of Freedom	t-Statistic	p-Value
23	38	1.59	0.12

A boxplot of the log-transformed data is given in Figure 6, and the associated *t*-test results are given in Table 4. These results show strong evidence of significance, and back-transforming the data gives us 95% confidence that the ratio $\frac{median_{DietA}}{median_{DietB}}$ is between 1.14 and 2.76.

However, an analysis of the difference in *means* was asked for, and so we return to the original, unaltered data and see what effect the outliers have. I removed all values greater than 100, as the observations greater than this are quite extreme outliers (the outliers less than 100 are more believable). The results of the *t*-test with these outliers removed are given in Table 5.

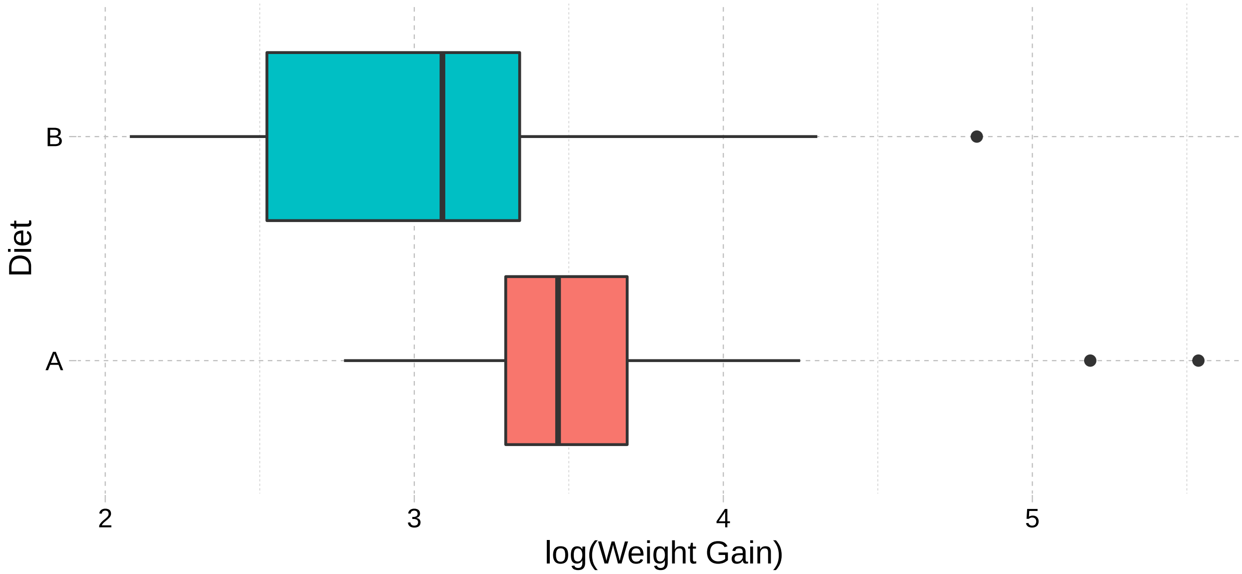

Figure 6: Boxplot of log of weight gain in mice by diet.

Table 4: t-Test Results for Log Mice Diet Comparison

Estimate (log(Diet A) — log(Diet B))	Degrees of Freedom	t-Statistic	p-Value
0.57	37.72	2.62	0.01

Table 5: Results for Mice Diet Comparison with no Outliers

Estimate (Diet A — Diet B)	Degrees of Freedom	t-Statistic	p-Value
9.71	32.84	2.1	0.04

With the outliers greater than 100 removed, the results are now significant at the $\alpha = 0.05$ level. Considering this and that the log-transformed data also showed a significant difference, I'm inclined to interpret the extreme outliers as erroneous (or at least non-representative), and conclude that there is a difference. However, a more thorough investigation into the cause and validity of these outliers would be wise.

4

The data on the two different teaching methods is very nicely distributed, as can be seen in Figure 7. As such, the standard *t*-test should be an effective tool. The results of the *t*-test can be seen in Table 6.

These results show strong evidence that there is a difference in scores based on the training method, and that Method B yields higher scores than Method A.

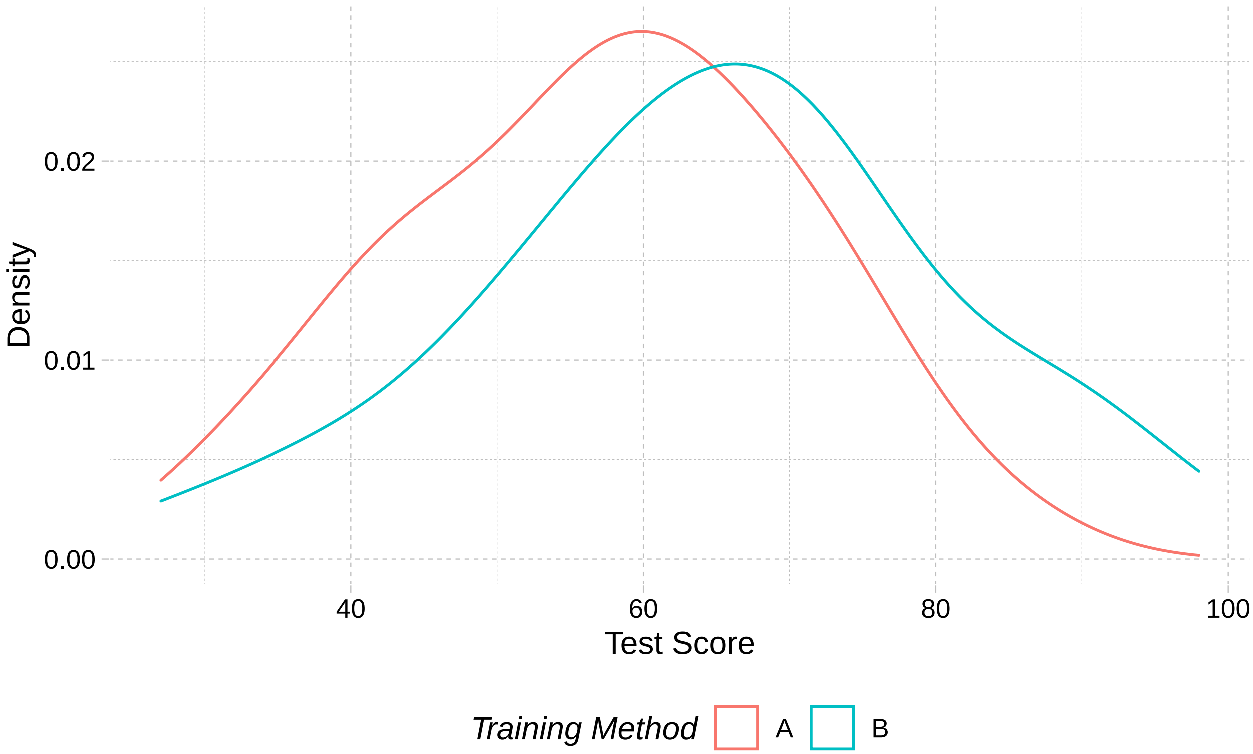

Figure 7: Kernel density plot of scores based on training method.

Table 6: Comparison of Training Methods (t-test)

Estimate (Method A — Method B)	Degrees of Freedom	t-Statistic	p-Value
-7.71	65.83	-2.16	0.03

5

My three T/F questions for Chapter 1 of the book are:

- A group of volunteers are randomly assigned either a treatment or a placebo, and there is a significant difference in the outcomes between the two groups. We can conclude that the treatment caused the difference in outcomes. (T/F)
- A group of volunteers are randomly assigned either a treatment or a placebo, and there is a significant difference in the outcomes between the two groups. Therefore, we can conclude that the treatment will be effective for the population at large. (T/F)
- The results of an analysis with the null hypothesis $\mu_2 - \mu_1 \neq 0$ gives a p-value of 0.024. This means that there is a 2.4% chance the true difference in means is equal to 0. (T/F)