4c. Answer for ANOVA Exercise

Q1

H0: All batteries have the same lifetime.
H1: At least two batteries have different lifetime.

From Figure 1.1, the boxplot shows there is no outliner.

Figure 1.1

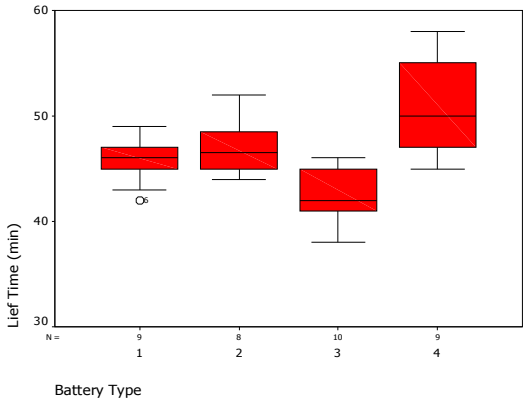


Figure 1.2

Descriptives

Lief Time (min)

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	9	45.67	2.24	.75	43.95	47.39	42	49
2	8	47.00	2.62	.93	44.81	49.19	44	52
3	10	42.40	2.46	.78	40.64	44.16	38	46
4	9	50.89	4.76	1.59	47.23	54.54	45	58
Total	36	46.36	4.38	.73	44.88	47.84	38	58

We assume all observations are independent.

Figure 1.3 shows variances are not the same ($p = 0.007$). Since the sample sizes of batteries are roughly the same, the assumption of same variances is not important in applying ANOVA. Therefore we can use ANOVA test to test the mean lifetimes.

Figure 1.3

Test of Homogeneity of Variances

Lief Time (min)

Levene Statistic	df1	df2	Sig.
4.777	3	32	.007

From Figure 1.4, Kolmogorov-Smirnov and Shapiro-Wilk tests show statistical insignificance in the normality. On the other words, the assumption on the normality of the observations is not rejected at significance level of 5%.

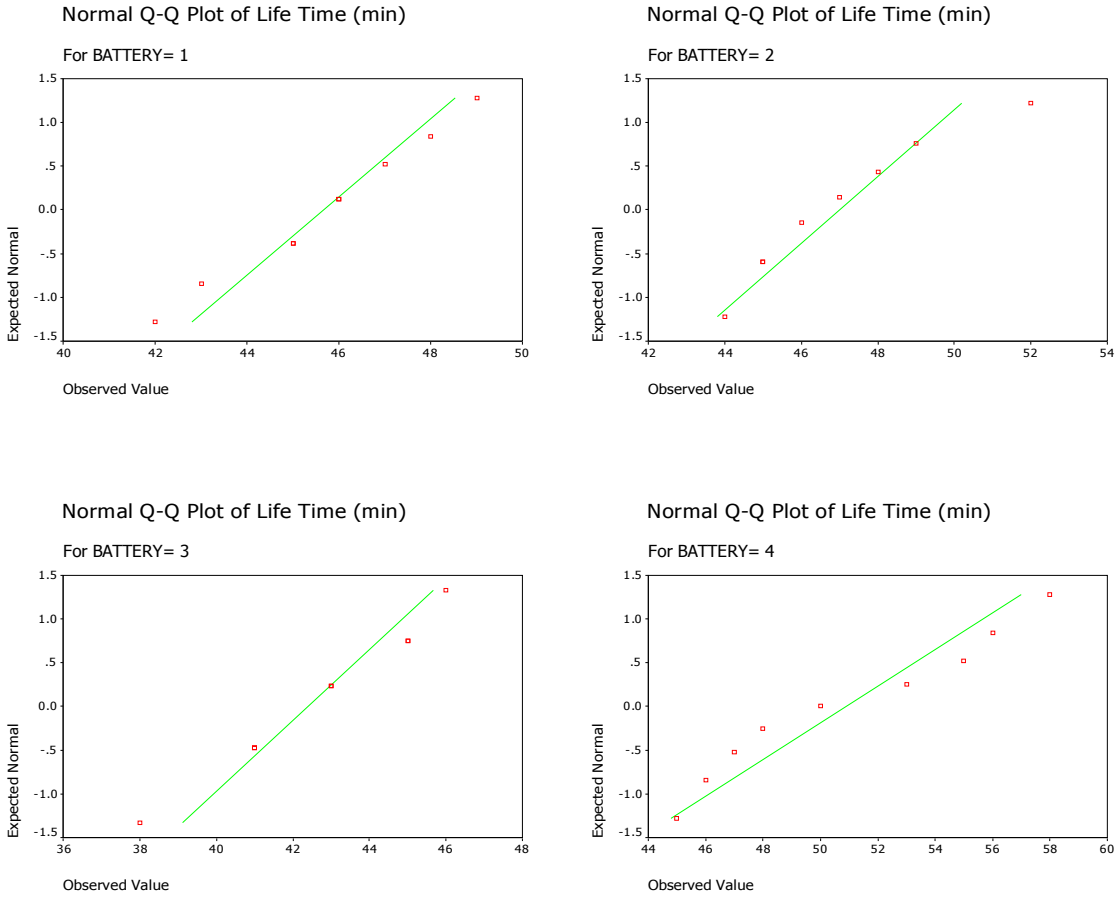
Figure 1.4

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Battery Type	Statistic	df	Sig.	Statistic	df	Sig.
Life Time (min)	1	.161	9	.200*	.972	9	.902
	2	.152	8	.200*	.932	8	.500
	3	.215	10	.200*	.924	10	.422
	4	.173	9	.200*	.932	9	.482

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction



Small values for the observed significance level ($p < 0.0005$) lead to reject the null hypothesis that lifetimes of all batteries are the same (Figure 1.5).

Figure 1.5

ANOVA

Lief Time (min)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	349.017	3	116.339	11.516	.000
Within Groups	323.289	32	10.103		
Total	672.306	35			

We would like to use Bonferroni procedure to find out which pairs are different in lifetime. From Figure 1.6, pairs of Batteries 1 & 4 ($p = 0.009$), 2 & 3 ($p = 0.027$) and 3 & 4 ($p < 0.0005$) are different in lifetime at significance level of 5%.

Figure 1.6

Multiple Comparisons

Dependent Variable: Lief Time (min)

Bonferroni

(I) Battery Type	(J) Battery Type	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1	2	-1.33	1.54	1.000	-5.68	3.01
	3	3.27	1.46	.194	-.84	7.37
	4	-5.22*	1.50	.009	-9.44	-1.01
2	1	1.33	1.54	1.000	-3.01	5.68
	3	4.60*	1.51	.027	.36	8.84
	4	-3.89	1.54	.102	-8.23	.45
3	1	-3.27	1.46	.194	-7.37	.84
	2	-4.60*	1.51	.027	-8.84	-.36
	4	-8.49*	1.46	.000	-12.60	-4.38
4	1	5.22*	1.50	.009	1.01	9.44
	2	3.89	1.54	.102	-.45	8.23
	3	8.49*	1.46	.000	4.38	12.60

*. The mean difference is significant at the .05 level.