Chapter 10
Analysis of Variance: Comparing More than Two Means

10.1 Introduction

Chapter 10 introduces the topics of design of experiments and analysis of variance (ANOVA) to the reader. The concept of the designed experiment is explained and the completely randomized, the randomized block design, and factorial designs are covered in the text. The goal of analysis of variance is to identify factors that contribute information to the response variable of interest. The combination of levels of the various factors are called treatments and the analysis of variance procedures discussed in the text attempt to detect differences in the mean response variable for the various treatments. Once detected, the text presents several methods of comparing the multiple means of the experiment.

Both **XLSTAT** and **Excel** offer the one-way and two-way studies presented in the text. Both procedures will be shown here. The **XLSTAT** technique is preferred over the **Excel** technique since **XLSTAT** also performs the multiple comparison procedures shown in Section 10.3 of the text. **Excel** does not offer these comparisons. Neither **XLSTAT** nor **EXCEL** provides analyses for the randomized block design discussed in the text.

We note here that the *A First Course in Statistics* text only includes the completely randomized design material in Chapter 7 of the text.

We will use the chapter examples that are given in the text to illustrate the model building and testing methods discussed above. The following examples from *Statistics* are solved with **Excel** and **XLSTAT** in this chapter.

Excel Companion		**Statistics**	
Exercise	**Page**	**Example**	**Excel File Name**
10.1	137	Example 10.4	GOLFCRD
10.2	140	Example 10.4	GOLFCRD
10.3	142	Example 10.10	GOLFAC1
10.4	146	Example 10.10	GOLFAC1

10.2 The Completely Randomized Design: Single Factor

The goal of analysis of variance is to compare the mean responses of the various treatments in an experimental design, where the treatments are the combinations of the levels of all the factors involved in the design. The simplest of all experimental designs involves using a single factor to compare values of a response variable. Since there is only one factor in the design, the various levels of the factor are the treatments in the design. The goal is to compare the means of the response variable for those treatments. This experimental design is the completely randomized design and can be analyzed in both **XLSTAT** and **Excel**. We illustrate with the following example.

Exercise 10.1: We use Example 10.4 found in the *Statistics* text.

Problem: Suppose the United States Golf Association (USGA) wants to compare the mean distances associated with four different brands of golf balls when struck with a driver. A completely randomized design is employed, with Iron Byron, the USGA's robotic golfer, using a driver to hit a random sample of 10 balls of each brand in a random sequence. The distance is recorded for each hit, and the results are shown in Table 15.1, organized by brand.

a. Set up the test to compare the mean distances for the four brands. Use $\alpha = .10$.
b. Use **XLSTAT** to obtain the test statistic and p-value. Interpret the results.
c. Use Tukey's multiple comparison procedure to rank the treatment means with an overall confidence level of 95%.

Table 10.1

Brand A	Brand B	Brand C	Brand D
251.2	263.2	2610.7	251.6
245.1	262.9	263.2	2410.6
2410.0	265.0	277.5	2410.4
251.1	254.5	267.4	242.0
260.5	264.3	270.5	246.5
250.0	257.0	265.5	251.3
253.9	262.8	270.7	261.8
244.6	264.4	272.9	2410.0
254.6	260.6	275.6	247.1
248.8	255.9	266.5	245.9

Solution:

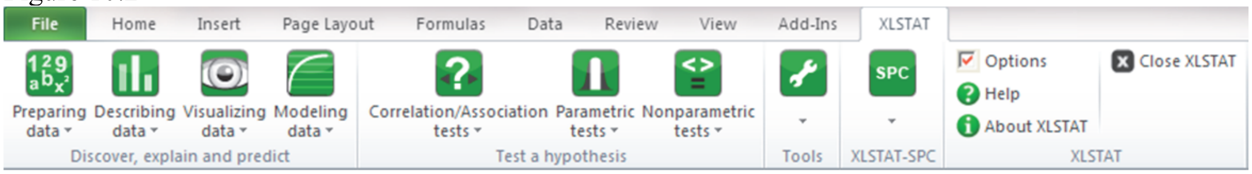
We solve Exercise 10.1 utilizing the **ANOVA** menu presented in **XLSTAT**. **Open** the data file **GOLFCRD** by following the directions found in the preface of this manual. If done correctly, the data should appear in a workbook similar to that shown in Figure 10.1.

Figure 10.1

	A	B
1	BRAND	DISTANCE
2	A	251.2
3	A	245.1
4	A	248
5	A	251.1
6	A	260.5
7	A	250
8	A	253.9
9	A	244.6
10	A	254.6
11	A	248.8
12	B	263.2
13	B	262.9
14	B	265

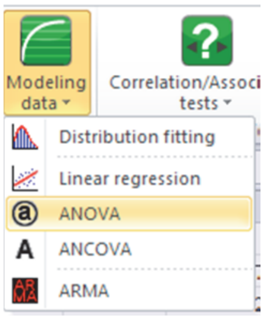
To conduct the desired analysis, we click on the **XLSTAT** tab at the top of the **Excel** workbook to access the **XLSTAT** menus shown in Figure 10.2.

Figure 10.2



To conduct the desired test of hypothesis, we click on the **Modeling data** menu and select the **ANOVA** option shown in Figure 10.3.

Figure 10.3



This opens the **ANOVA** menu shown in Figures 10.4 - 10.5. We need to first specify the location of the data that is to be analyzed. In our data set, the data is located in columns A and B, rows 2 – 41, with row 1 being the variable labels. We note that the data in column A represents brand of club and the data in column B represent the corresponding golf ball distance. We specify the column **B** data in the **Quantitative** box and the column **A** data in the **Qualitative** box, and check the **Variable labels** box to in this menu.

Click on the **Outputs** tab (shown in Figure 10.5) to specify the type of output desired. To conduct the test of hypothesis to compare treatment means, we check the **Analysis of variance** box. To conduct the Tukey multiple comparisons of the treatment means, we check the **Use least squares** means and **Pairwise comparisons** boxes, and specify the **Tukey (HSD)** technique by checking the appropriate box. Click **OK** to conduct the desired analyses.

Figure 10.4

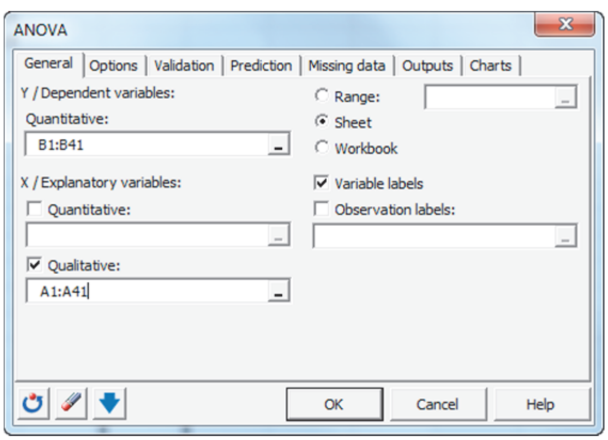
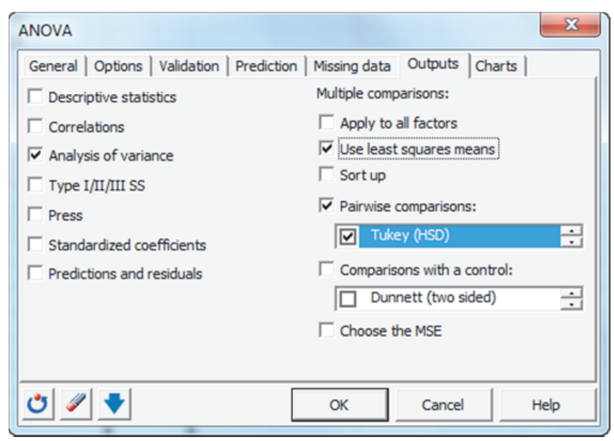


Figure 10.5



The XLSTAT output is shown in Figure 10.6.

Figure 10.6

Analysis of variance:

Source	DF	Sum of squares	Mean squares	F	Pr > F
Model	3	2794.3888	931.4629	43.9887	< 0.0001
Error	36	762.3010	21.1750		
Corrected Total	39	3556.6898			

BRAND / Tukey (HSD) / Analysis of the differences between the categories with a confidence interval of 95%:

Contrast	Difference	Standardized difference	Critical value	Pr > Diff	Significant
C vs D	20.6300	10.0247	2.6933	< 0.0001	Yes
C vs A	19.1700	9.3153	2.6933	< 0.0001	Yes
C vs B	8.8900	4.3199	2.6933	0.0007	Yes
B vs D	11.7400	5.7048	2.6933	< 0.0001	Yes
B vs A	10.2800	4.9954	2.6933	< 0.0001	Yes
A vs D	1.4600	0.7095	2.6933	0.8927	No
Tukey's d critical value:			3.8089		

Category	LS means	Groups		
C	269.9500	A		
B	261.0600		B	
A	250.7800			C
D	249.3200			C

We see that the printouts above contain both the test of hypothesis and multiple comparison information that we desire. We compare this printout to the information shown in the text. We note that the test of hypothesis information shown in the printout ($F = 43.9887$ and $p < .0001$) is identical to the information shown in the text. We also note that the Tukey results are identical as well.

As mentioned in the introduction, **XLSTAT** provides both the test of hypothesis and the multiple comparisons for the one-way study. We now illustrate how to use **Excel** to conduct the same test of hypothesis.

Exercise 10.2: We use Example 10.4 found in the *Statistics* text.

Problem: Suppose the United States Golf Association (USGA) wants to compare the mean distances associated with four different brands of golf balls when struck with a driver. A completely randomized design is employed, with Iron Byron, the USGA's robotic golfer, using a driver to hit a random sample of 10 balls of each brand in a random sequence. The distance is recorded for each hit, and the results are shown in Table 10.2, organized by brand.

a. Set up the test to compare the mean distances for the four brands. Use $\alpha = .10$.
b. Use **Excel** to obtain the test statistic and p-value. Interpret the results.

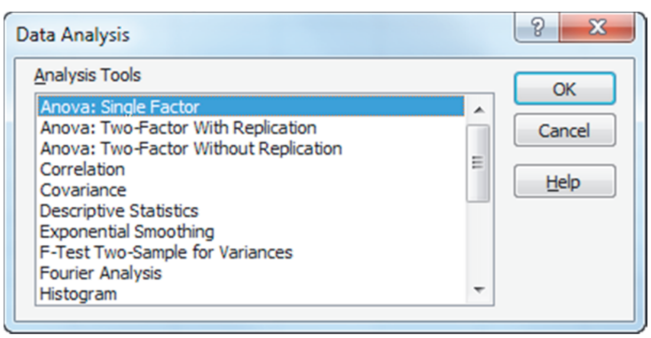
Table 10.2

Brand A	Brand B	Brand C	Brand D
251.2	263.2	2610.7	251.6
245.1	262.9	263.2	2410.6
2410.0	265.0	277.5	2410.4
251.1	254.5	267.4	242.0
260.5	264.3	270.5	246.5
250.0	257.0	265.5	251.3
253.9	262.8	270.7	261.8
244.6	264.4	272.9	2410.0
254.6	260.6	275.6	247.1
248.8	255.9	266.5	245.9

Solution:

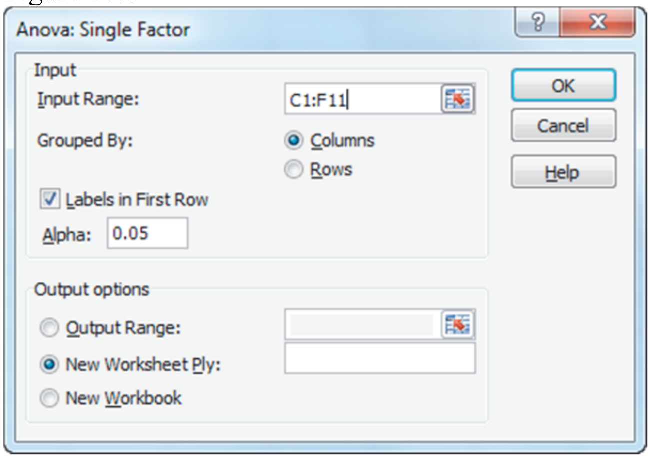
Open the Data File **GOLFCRD** by following the directions found in the preface of this manual. We click on the **Data** tab and then click on the **Analysis Icon** found in the **Analysis Group**. It should open the **Data Analysis** menu shown below. We highlight the **Anova: Single Factor** option and click **OK**.

Figure 10.7



Either type or click the rows and columns where the input data is located and enter this information into the **Input Range** area of the Anova: Single Factor menu (see Figure 10.8). Select the manner in which the data is grouped (**Columns** or **Rows**) and give a level of significance in the **Alpha** cell of the menu (e.g., .05). Specify the location of the computed output by selecting either the Output Range, **New Worksheet Ply**, or New Workbook option, and entering the corresponding cell or **name**. Click **OK**.

Figure 10.8



The ANOVA printout generated for the completely randomized design has two main components (see Figure 10.9). The first component is a statistical summary of the various treatments in the analysis. For each of the four brands of balls, **Excel** gives some summary information concerning the distances achieved by each. This information will be more useful after studying the multiple comparison of means material in Section 10.3 of the text.

Figure 10.9

Anova: Single Factor

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
BrandA	10	2507.8	250.78	22.42178
BrandB	10	2610.6	261.06	14.94711
BrandC	10	2699.5	269.95	20.25833
BrandD	10	2493.2	249.32	27.07289

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*
Between Groups	2794.389	3	931.4629	43.98875	3.97E-12
Within Groups	762.301	36	21.17503		
Total	3556.69	39			

The second component is called the analysis of variance table and is where the pertinent testing information will be found. To test whether the mean distances of the four means differ, we use the test statistic and p-value found in the Brand row of the printout (labeled on the **Excel** printout as the Between Groups row). We see that the test statistic is $F = 43.9887$ and the p-value is $p \approx 0$. Compare these values to the values found in the printout found in the text.

10.3 The Factorial Design

The next step in the experimental design process is to add a second factor to the design. One possible design that results is the factorial design. In **XLSTAT**, the data analysis procedure is found within the same menu as the completely randomized design. There are several more options that need to be specified, however. In **Excel**, the data analysis procedure that should be used is the **Anova: Two-Factor With Replication** procedure. This procedure allows both the factors to be analyzed as well as the interaction between them. We illustrate its use with the following example.

Exercise 10.3: We use Example 10.10 in the *Statistics* text.

Problem: Suppose the United States Golf Association (USGA) tests four different brands (A, B, C, and D) of golf balls and two different clubs (driver, five-iron) in a completely randomized design. Each of the eight Brand-Club combinations (treatments) is randomly and independently assigned to four experimental units, each experimental unit consisting of a specific position in the sequence of hits by Iron Byron. The distance response is recorded for each of the 32 hits, and the results are shown in Table 10.3.

a. Use **XLSTAT** to partition the Total Sum of Squares into the components necessary to analyze this 4x2 factorial experiment.
b. Follow the steps for analyzing a two-factor factorial experiment and interpret the results of your analysis. Use $\alpha = .10$ for the tests you conduct.
c. Conduct the appropriate multiple comparisons using the Tukey multiple comparison procedure using $\alpha = .10$.

Table 10.3

			BRAND		
		A	**B**	**C**	**D**
	DRIVER	226.4	2310.3	240.5	2110.8
	DRIVER	232.6	231.7	246.9	2210.7
	DRIVER	234.0	227.7	240.3	232.9
CLUB	**DRIVER**	220.7	237.2	244.7	237.6
	FIVE-IRON	163.8	184.4	1710.0	157.8
	FIVE-IRON	1710.4	180.6	1610.0	161.8
	FIVE-IRON	1610.6	1710.5	165.2	162.1
	FIVE-IRON	173.4	186.2	156.5	160.3

Solution:

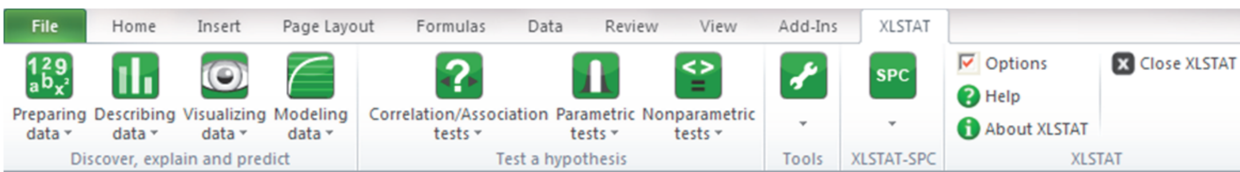
We solve Exercise 10.1 utilizing the **ANOVA** menu presented in **XLSTAT**. **Open** the data file **GOLFAC1** by following the directions found in the preface of this manual. If done correctly, the data should appear in a workbook similar to that shown in Figure 10.10.

Figure 10.10

	A	B
1	BRAND	DISTANCE
2	A	251.2
3	A	245.1
4	A	248
5	A	251.1
6	A	260.5
7	A	250
8	A	253.9
9	A	244.6
10	A	254.6
11	A	248.8
12	B	263.2
13	B	262.9
14	B	265

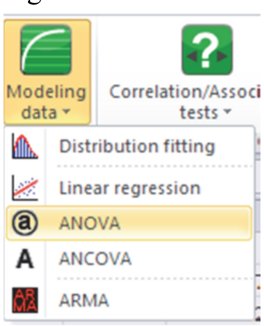
To conduct the desired analysis, we click on the **XLSTAT** tab at the top of the **Excel** workbook to access the **XLSTAT** menus shown in Figure 10.11.

Figure 10.11



To conduct the desired test of hypothesis, we click on the **Modeling data** menu and select the **ANOVA** option shown in Figure 10.12.

Figure 10.12



This opens the **ANOVA** menu shown in Figures 10.13-10.15. We need to first specify the location of the data that is to be analyzed. In our data set, the data is located in columns A thru C, rows 2 – 33, with row 1 being the variable labels. We note that the data in column A represents the type of club, the data in column B represents the brand of club, and the data in column C represent the corresponding golf ball distance. We specify the column C data in the **Quantitative** box and the columns A and B data in the **Qualitative** box, and check the **Variable labels** box to in this menu.

Click on the **Options** tab (shown in Figure 10.14) to specify the type of interactions that we want to allow in the analysis. Check the **Interactions/Level** box and indicate that we want to allow **2**–way interactions (between club and brand). Also enter the **Confidence interval (%)** level desired for the Tukey analysis. We enter **90**% for this analysis.

Figure 10.13

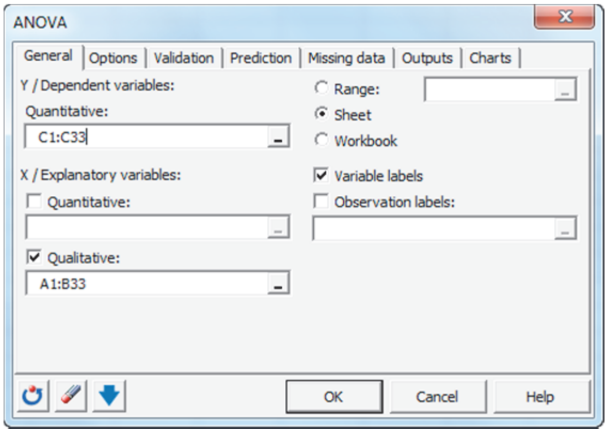
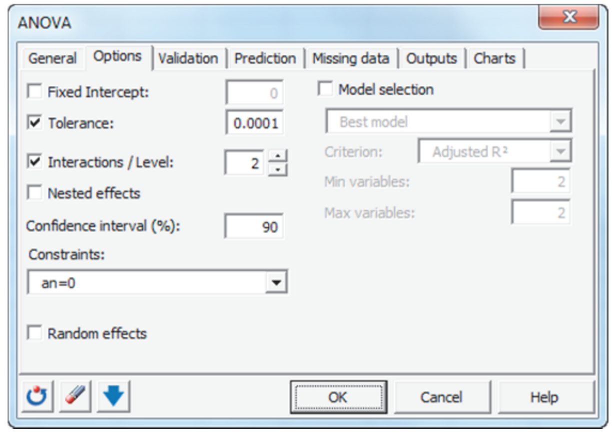
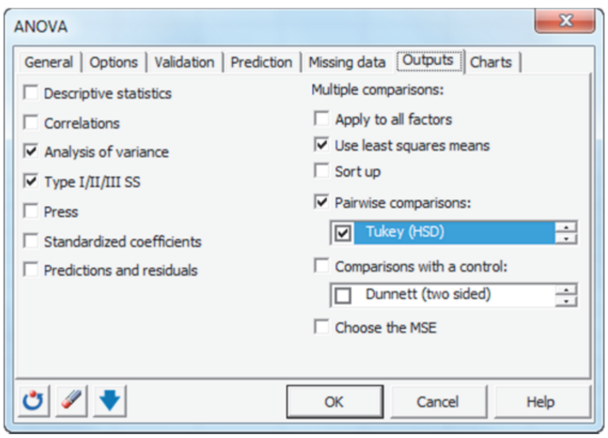


Figure 10.14



Click on the **Outputs** tab (shown in Figure 10.15) to specify the type of output desired. To conduct the test of hypothesis to test for interactions and/or main effects, we check the **Analysis of variance** and **Type I/II/II SS** boxes. To conduct the Tukey multiple comparisons of the treatment means, we check the **Use least squares** means and **Pairwise comparisons:** boxes, and specify the **Tukey (HSD)** technique by checking the appropriate box. Click **OK** to conduct the desired analyses.

Figure 10.15



XLSTAT provides a pop-up box that asked the user to identify the factors and interactions that tests are desired for. Check every box or click on the **All** button and click **OK**. A second pop-up box asks the user to identify the factors for conducting multiple comparisons. Again, check every box or click on the **All** button and click **OK**

Figure 10.16

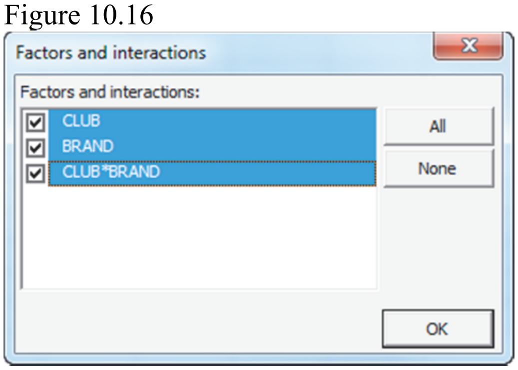
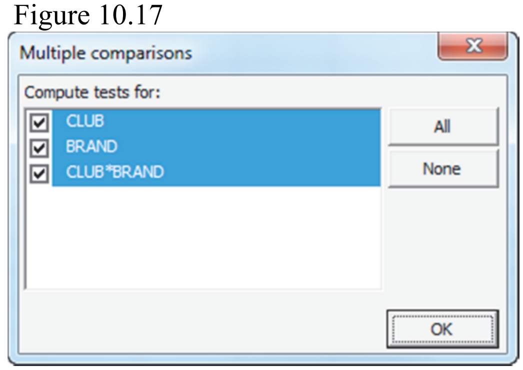


Figure 10.17



The XLSTAT output is shown in Figure 10.18.

Figure 10.18

Analysis of variance:

Source	DF	Sum of squares	Mean squares	F	Pr > F
Model	7	33659.8088	4808.5441	140.3545	< 0.0001
Error	24	822.2400	34.2600		
Corrected Total	31	34482.0488			

Computed against model Y=Mean(Y)

Type III Sum of Squares analysis:

Source	DF	Sum of squares	Mean squares	F	Pr > F
CLUB	1	32093.1113	32093.1113	936.7516	< 0.0001
BRAND	3	800.7362	266.9121	7.7908	0.0008
CLUB*BRAND	3	765.9613	255.3204	7.4524	0.0011

CLUB*BRAND / Tukey (HSD) / Analysis of the differences between the categories with a confidence interval of 90%:

Category	LS means	Groups			
CLUB-DRIVER*BRAND-C	243.1000	A			
CLUB-DRIVER*BRAND-B	233.7250	A	B		
CLUB-DRIVER*BRAND-D	229.7500		B		
CLUB-DRIVER*BRAND-A	228.4250		B		
CLUB-5IRON*BRAND-B	182.6750			C	
CLUB-5IRON*BRAND-A	171.3000			C	D
CLUB-5IRON*BRAND-C	167.1750				D
CLUB-5IRON*BRAND-D	160.5000				D

We locate the Analysis of variance table and the Type III Sums of Squares analysis to find the test of hypothesis information that we desire. We compare this printout to the information shown in the text. We note that the test of hypothesis information shown in the printouts is identical to the information shown in the text. We also note that the Tukey results are presented for the 90% reliability level.

As mentioned in the introduction, **XLSTAT** provides both the test of hypothesis and the multiple comparisons for the one-way study. We now illustrate how to use **Excel** to conduct the same test of hypothesis.

Exercise 10.4: We use Example 10.10 in the *Statistics* text.

Problem: Suppose the United States Golf Association (USGA) tests four different brands (A, B, C, D) of golf balls and two different clubs (driver, five-iron) in a completely randomized design. Each of the eight Brand-Club combinations (treatments) is randomly and independently assigned to four experimental units, each experimental unit consisting of a specific position in the sequence of hits by Iron Byron. The distance response is recorded for each of the 32 hits, and the results are shown in Table 10.4.

a. Use **Excel** to partition the Total Sum of Squares into the components necessary to analyze this 4x2 factorial experiment.

b. Follow the steps for analyzing a two-factor factorial experiment and interpret the results of your analysis. Use $\alpha = .10$ for the tests you conduct.

Table 10.4

		BRAND			
		A	**B**	**C**	**D**
	DRIVER	226.4	2310.3	240.5	2110.8
	DRIVER	232.6	231.7	246.9	2210.7
	DRIVER	234.0	227.7	240.3	232.9
CLUB	**DRIVER**	220.7	237.2	244.7	237.6
	FIVE-IRON	163.8	184.4	1710.0	157.8
	FIVE-IRON	1710.4	180.6	1610.0	161.8
	FIVE-IRON	1610.6	1710.5	165.2	162.1
	FIVE-IRON	173.4	186.2	156.5	160.3

Solution:

Open the Data File **GOLFAC1** by following the directions found in the preface of this manual. By moving the data in the data set, we create a data set like the one shown in Figure 10.19.

Figure 10.19

	A	B	C	D	E
1	BRAND	A	B	C	D
2	Driver	226.4	238.3	240.5	219.8
3	Driver	232.6	231.7	246.9	228.7
4	Driver	234.0	227.7	240.3	232.9
5	Driver	220.7	237.2	244.7	237.6
6	5Iron	163.8	184.4	179.0	157.8
7	5Iron	179.4	180.6	168.0	161.8
8	5Iron	168.6	179.5	165.2	162.1
9	5Iron	173.4	186.2	156.5	160.3

We click on the **Data** tab and then click on the **Analysis Icon** found in the **Analysis Group**. It should open the **Data Analysis** menu shown in Figure 10.20. We highlight the **Anova: Two-Factor With Replication** option and click **OK**.

Figure 10.20

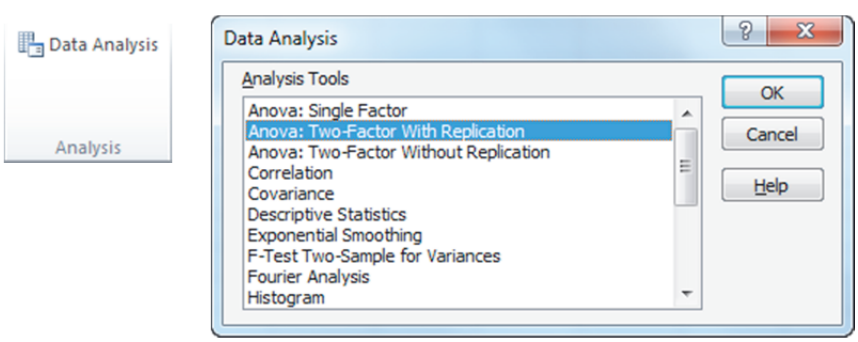
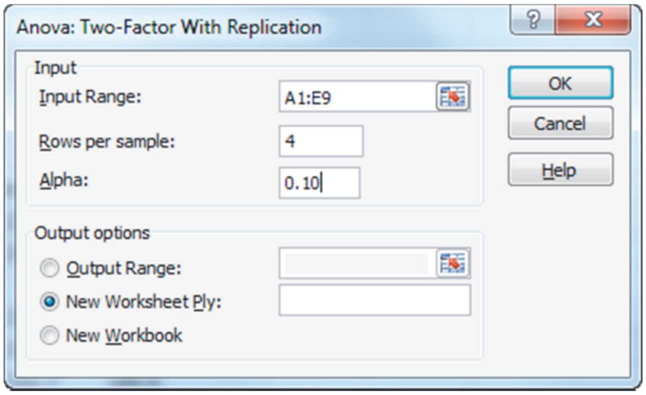


Figure 10.21



Either type or click the rows and columns where the input data is located and enter this information into the **Input Range** area of the Anova: Two Factor With Replication menu. Include the labels for the columns and rows of the factor when inputting the data range. Note that each Brand of golf ball includes four rows of data for each of the two Clubs tested. Enter the number of rows (e.g., 4) in the **Rows per Sample** area of the menu. Give a level of significance in the **Alpha** cell of the menu (e.g., .10). Specify the location of the computed output by selecting either the **Output Range**, New Worksheet Ply, or New Workbook option, and entering the corresponding **cell** or name. Click **OK**.

Figure 10.22

Anova: Two-Factor With Replication						
SUMMARY	A	B	C	D	Total	
Driver						
Count	4	4	4	4	16	
Sum	913.7	934.9	972.4	919	3740	
Average	228.425	233.725	243.1	229.75	233.75	
Variance	37.42917	24.46917	10.53333	57.21667	61.07067	
5Iron						
Count	4	4	4	4	16	
Sum	685.2	730.7	668.7	642	2726.6	
Average	171.3	182.675	167.175	160.5	170.4125	
Variance	44.52	9.929167	86.1225	3.86	98.19183	
Total						
Count	8	8	8	8		
Sum	1598.9	1665.6	1641.1	1561		
Average	199.8625	208.2	205.1375	195.125		
Variance	967.4827	759.3429	1688.454	1396.336		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	32093.11	1	32093.11	936.7516	9.63E-21	2.927117
Columns	800.7363	3	266.9121	7.790779	0.00084	2.32739
Interaction	765.9612	3	255.3204	7.452435	0.001079	2.32739
Within	822.24	24	34.26			
Total	34482.05	31				

We locate the Analysis of variance table at the bottom of the printout to find the test of hypothesis information that we desire. We compare this printout to the information shown in the text.

We note here one drawback associated with the **Excel** analysis for the completely randomized and factorial designs in the analysis of variance experiments. Excel offers the appropriate analyses for determining when differences exist between the treatment means for each of these two experimental designs, but does not offer any method to determine where the specific differences exists. **XLSTAT** offers options for conducting the multiple comparison procedures that enable the user to conduct the appropriate follow-up analysis for both the completely randomized and factorial designs. Consult Section 10.3 and the references at the end of the text for more information on this topic.

10.4 Technology Lab

The Technology Lab consists of problems for the student to practice the techniques presented in each lesson. Each problem is taken from the homework exercises within the *Statistics* text and includes an **Excel** data set (when applicable) that should be used to create the desired output. The completed output has been included with each problem so that the student can verify that he/she is generating the correct output.

1. **Is honey a cough remedy?** Pediatric researchers at Pennsylvania State University carried out a designed study to test whether a teaspoon of honey before bed calms a child's cough and published their results in *Archives of Pediatrics and Adolescent Medicine* (Dec., 2007). A sample of 105 children who were ill with an upper respiratory tract infection and their parents participated in the study. On the first night, the parents rated their children's cough symptoms on a scale of 0 (no problems at all) to 6 (extremely severe) in five different areas. The total symptoms score (ranging from 0 to 30 points) was the variable of interest for the 105 patients. On the second night, the parents were instructed to give their sick child a dosage of liquid "medicine" prior to bedtime. Unknown to the parents, some were give a dosage of dextromethorphan (DM) – an over-the-counter cough medicine – while others were give a similar dose of honey. Also, a third group of parents (The control group) gave their sick children no dosage at all. Again, the parents rated their children's cough symptoms, and the improvement in total cough symptoms score was determined for each child. The data (improvement scores) for the study are shown on the next page and saved in the HONEYCOUGH data file. The goal of the researchers was to compare the mean improvement scores for the three treatments.

a. Conduct the test of interest to the researchers.
b. Perform a Tukey analysis of the treatment means to determine if differences exist between them.

XLSTAT Output

Analysis of variance:

Source	DF	Sum of squares	Mean squares	F	Pr > F
Model	2	318.5091	159.2546	17.5096	< 0.0001
Error	102	927.7194	9.0953		
Corrected Total	104	1246.2286			

Computed against model Y=Mean(Y)

Treatment / Tukey (HSD) / Analysis of the differences between the categories with a confidence interval of 90%:

Contrast	Difference	Standardized difference	Critical value	Pr > Diff	Significant
H vs C	4.2008	5.9073	2.0757	< 0.0001	Yes
H vs DM	2.3810	3.2537	2.0757	0.0044	Yes
DM vs C	1.8198	2.5202	2.0757	0.0352	Yes
Tukey's d critical value:			2.9355		

Category	LS means	Groups		
H	10.7143	A		
DM	8.3333		B	
C	6.5135			C

2. **Eyewitnesses and mugshots.** When an eyewitness to a crime examines a set of mugshots at a police station, the photos are usually presented in groups (e.g., 6 mugshots at a time). Criminologists at Niagara University investigated whether mugshot group size has an effect on the selections made by eyewitnesses (*Applied Psychology in Criminal Justice,* April, 2010). A sample of 90 college students were shown a video of a simulated theft. Shortly thereafter, each student was shown 180 mugshots and asked to select a photo which most closely resembled the thief. (Multiple photos could be selected.) The students were randomly assigned to view either 3, 6, or 12 mugshots at a time. Within each mugshot group size, the students were further randomly divided into three sets. In the first set, the researchers focused on the selections made in the first 60 photos shown; in the second set, the focus was on the selections made in the middle 60 photos shown; and, in the third set, selections made in the last 60 photos were recorded. The dependent variable of interest was the number of mugshot selections. Simulated data for this 3x3 factorial ANOVA, with Mugshot Group Size at 3 levels (3, 6, or 12 photos) and Photo Set at 3 levels (first 60, middle 60, and last 60) are saved in the MUGSHOT data file. Fully analyze the data for the researchers. In particular, the researchers want to know if mugshot group size has an effect on the mean number of selection, and, if so, which group size leads to the most selections. Also, are there a higher number of selections made in the first 60, middle 60, or last 60 photos viewed?

XLSTAT Output

Analysis of variance:

Source	DF	Sum of squares	Mean squares	F	Pr > F
Model	8	85.0000	10.6250	10.5598	< 0.0001
Error	81	81.5000	1.0062		
Corrected Total	89	166.5000			

Computed against model Y=Mean(Y)

Type I Sum of Squares analysis:

Source	DF	Sum of squares	Mean squares	F	Pr > F
GROUP	2	15.2667	7.6333	7.5865	0.0010
SET	2	62.6000	31.3000	31.1080	< 0.0001
GROUP*SET	4	7.1333	1.7833	1.7724	0.1424

GROUP / Tukey (HSD) / Analysis of the differences between the categories with a confidence interval of 95%:

Contrast	Difference	Standardized difference	Critical value	Pr > Diff	Significant
3 vs 6	0.9667	3.7324	2.3877	0.0010	Yes
3 vs 12	0.7333	2.8315	2.3877	0.0160	Yes
12 vs 6	0.2333	0.9009	2.3877	0.6413	No
Tukey's d critical value:			3.3768		

Category	LS means	Groups	
3	2.4000	A	
12	1.6667		B
6	1.4333		B

SET / Tukey (HSD) / Analysis of the differences between the categories with a confidence interval of 95%:

Contrast	Difference	Standardized difference	Critical value	Pr > Diff	Significant
FIRST vs LAST	1.9000	7.3361	2.3877	< 0.0001	Yes
FIRST vs MIDDLE	1.6000	6.1777	2.3877	< 0.0001	Yes
MIDDLE vs LAST	0.3000	1.1583	2.3877	0.4814	No
Tukey's d critical value:			3.3768		

Category	LS means	Groups	
FIRST	3.0000	A	
MIDDLE	1.4000		B
LAST	1.1000		B