```
1          TITLE1 'Factorial ANOVA (CRD with factorial treatment arrangement)';
2          dm'log;clear;output;clear';
3
4          ODS HTML style=minimal body='C:\EXST 7005\SAS\Example06.html' ;
NOTE: Writing HTML Body file: C:\EXST 7005\SAS\Example06.html
5          ODS RTF style=minimal body='C:\EXST 7005\SAS\Example06.rtf';
NOTE: Writing RTF Body file: C:\EXST 7005\SAS\Example06.rtf
6          ODS PDF style=minimal body='C:\EXST 7005\SAS\Example06.PDF';
NOTE: Writing ODS PDF output to DISK destination
      "C:\EXST 7005\SAS\Example06.PDF", printer "PDF".
7
8         ****************************************************************;
9         *** Neter, Kutner, Nachtsheim, Wasserman  (1996) [CH19PR18.sas] ***;
10        *** Kidney failure patients on dialysis.  Amount of dialysis    ***;
11        *** needed depends on duration of treatment and weight gain     ***;
12        *** from fluid retention In this study the effect of these two  ***;
13        *** facters  was to be evaluated by examining the number of     ***;
14        *** days of hospitalization during the year.                    ***;
15        ****************************************************************;
16         options ps=256 ls=99 nocenter nodate nonumber nolabel;
17
18
19         data kidney; infile cards missover;
20              TITLE2 'Analysis of duration of patients stay in hospital';
21              LABEL days = 'Days in hospital during year';
22              LABEL duration = 'Duration of disease';
23              LABEL wtgain = 'Wt gain between visits (fluid retention)';
24              LABEL rep = 'Patient';
25         input days d w rep;
26             wtgain = 'Moderate';
27                if w = 1 then wtgain = 'Mild';
28                if w = 3 then wtgain = 'Severe';
29             duration = 'Short';
30                if d = 2 then duration = 'Long';
31         cards;
NOTE: The data set WORK.KIDNEY has 60 observations and 6 variables.
NOTE: DATA statement used (Total process time):
      real time           0.01 seconds
      cpu time            0.01 seconds
31       !        run;
92         ;
93         PROC PRINT DATA=kidney; TITLE3 'LISTING OF DATA'; RUN;
NOTE: There were 60 observations read from the data set WORK.KIDNEY.
NOTE: The PROCEDURE PRINT printed page 1.
NOTE: PROCEDURE PRINT used (Total process time):
      real time           0.10 seconds
      cpu time            0.03 seconds
```

Factorial ANOVA (CRD with factorial treatment arrangement)
Analysis of duration of patients stay in hospital
LISTING OF DATA

Obs	days	duration	wtgain	rep	d	w
1	0	Short	Mild	1	1	1
2	2	Short	Mild	2	1	1
3	1	Short	Mild	3	1	1
4	3	Short	Mild	4	1	1
5	0	Short	Mild	5	1	1
6	2	Short	Mild	6	1	1
7	0	Short	Mild	7	1	1
8	5	Short	Mild	8	1	1
9	6	Short	Mild	9	1	1
10	8	Short	Mild	10	1	1
11	2	Short	Moderate	1	1	2
12	4	Short	Moderate	2	1	2
13	7	Short	Moderate	3	1	2
14	12	Short	Moderate	4	1	2
15	15	Short	Moderate	5	1	2
16	4	Short	Moderate	6	1	2
17	3	Short	Moderate	7	1	2
18	1	Short	Moderate	8	1	2
19	5	Short	Moderate	9	1	2
20	20	Short	Moderate	10	1	2
21	15	Short	Severe	1	1	3
22	10	Short	Severe	2	1	3
23	8	Short	Severe	3	1	3
24	5	Short	Severe	4	1	3
25	25	Short	Severe	5	1	3
26	16	Short	Severe	6	1	3
27	7	Short	Severe	7	1	3

28	30	Short	Severe	8	1	3
29	3	Short	Severe	9	1	3
30	27	Short	Severe	10	1	3
31	0	Long	Mild	1	2	1
32	1	Long	Mild	2	2	1
33	1	Long	Mild	3	2	1
34	0	Long	Mild	4	2	1
35	4	Long	Mild	5	2	1
36	2	Long	Mild	6	2	1
37	7	Long	Mild	7	2	1
38	4	Long	Mild	8	2	1
39	0	Long	Mild	9	2	1
40	3	Long	Mild	10	2	1
41	5	Long	Moderate	1	2	2
42	3	Long	Moderate	2	2	2
43	2	Long	Moderate	3	2	2
44	0	Long	Moderate	4	2	2
45	1	Long	Moderate	5	2	2
46	1	Long	Moderate	6	2	2
47	3	Long	Moderate	7	2	2
48	6	Long	Moderate	8	2	2
49	7	Long	Moderate	9	2	2
50	9	Long	Moderate	10	2	2
51	10	Long	Severe	1	2	3
52	8	Long	Severe	2	2	3
53	12	Long	Severe	3	2	3
54	3	Long	Severe	4	2	3
55	7	Long	Severe	5	2	3
56	15	Long	Severe	6	2	3
57	4	Long	Severe	7	2	3
58	9	Long	Severe	8	2	3
59	6	Long	Severe	9	2	3
60	1	Long	Severe	10	2	3

```
94
95          PROC MIXED DATA=kidney; CLASS WTGAIN DURATION;
96               TITLE3 'Analysis of Variance done with PROC MIXED';
97             MODEL DAYS = WTGAIN DURATION WTGAIN*DURATION
                            / HType=3 ddfm=satterth outp=resids;
98             LSMEANS WTGAIN DURATION WTGAIN*DURATION / PDIFF ADJUST=TUKEY;
99            ods output diffs=ppp lsmeans=mmm;
100         **ods listing exclude diffs lsmeans; *this is now just a comment;
101         run;
NOTE: The data set WORK.MMM has 11 observations and 8 variables.
NOTE: The data set WORK.PPP has 19 observations and 12 variables.
NOTE: The data set WORK.RESIDS has 60 observations and 13 variables.
NOTE: The PROCEDURE MIXED printed page 2.
NOTE: PROCEDURE MIXED used (Total process time):
      real time           0.20 seconds
      cpu time            0.12 seconds
102         TITLE4 'Post hoc adjustment with macro by Arnold Saxton';
103         * SAS Macro by Arnold Saxton: Saxton, A.M. 1998.  A macro for;
104         * converting mean separation output to letter groupings in Proc Mixed.;
105         * In Proc. 23rd SAS Users Group Intl., SAS Inst, Cary, NC, pp1243-1246.;
106         %include 'C:\Geaghan\EXST\EXST7005New\Fall2003\SaS\pdmix800.sas';
734         %pdmix800(ppp,mmm,alpha=.01,sort=yes);
PDMIX800 03.26.2002 processing
4.3008418397
Tukey  values for wtgain  are 5.17691  (avg) 5.17691  (min) 5.17691  (max).
3.7759475003
Tukey  values for duration  are 3.71106  (avg) 3.71106  (min) 3.71106  (max).
5.018342024
Tukey  values for wtgain*duration  are 8.54265  (avg) 8.54265  (min) 8.54265
(max).
735         RUN;
736         QUIT;


Factorial ANOVA (CRD with factorial treatment arrangement)
Analysis of duration of patients stay in hospital
Analysis of Variance done with PROC MIXED

The Mixed Procedure

Model Information
Data Set                     WORK.KIDNEY
Dependent Variable           days
Covariance Structure         Diagonal
Estimation Method            REML
Residual Variance Method     Profile
Fixed Effects SE Method      Model-Based
Degrees of Freedom Method    Residual
```

Class Level Information

Class	Levels	Values
wtgain	3	Mild Moderate Severe
duration	2	Long Short

Dimensions

Covariance Parameters	1
Columns in X	12
Columns in Z	0
Subjects	1
Max Obs Per Subject	60

Number of Observations

Number of Observations Read	60
Number of Observations Used	60
Number of Observations Not Used	0

Covariance Parameter Estimates

Cov Parm	Estimate
Residual	28.9778

Fit Statistics

-2 Res Log Likelihood	348.9
AIC (smaller is better)	350.9
AICC (smaller is better)	350.9
BIC (smaller is better)	352.8

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
wtgain	2	54	13.12	<.0001
duration	1	54	7.21	0.0096
wtgain*duration	2	54	1.88	0.1622

Least Squares Means

Effect	wtgain	duration	Estimate	Standard Error	DF	t Value	Pr > |t|
wtgain	Mild		2.4500	1.2037	54	2.04	0.0467
wtgain	Moderate		5.5000	1.2037	54	4.57	<.0001
wtgain	Severe		11.0500	1.2037	54	9.18	<.0001
duration		Long	4.4667	0.9828	54	4.54	<.0001
duration		Short	8.2000	0.9828	54	8.34	<.0001
wtgain*duration	Mild	Long	2.2000	1.7023	54	1.29	0.2017
wtgain*duration	Mild	Short	2.7000	1.7023	54	1.59	0.1186
wtgain*duration	Moderate	Long	3.7000	1.7023	54	2.17	0.0341
wtgain*duration	Moderate	Short	7.3000	1.7023	54	4.29	<.0001
wtgain*duration	Severe	Long	7.5000	1.7023	54	4.41	<.0001
wtgain*duration	Severe	Short	14.6000	1.7023	54	8.58	<.0001

Differences ofLeast Squares Means

Effect	wtgain	duration	_wtgain	_duration	Estimate	Standard Error	DF	t Value
wtgain	Mild		Moderate		-3.0500	1.7023	54	-1.79
wtgain	Mild		Severe		-8.6000	1.7023	54	-5.05
wtgain	Moderate		Severe		-5.5500	1.7023	54	-3.26
duration		Long		Short	-3.7333	1.3899	54	-2.69
wtgain*duration	Mild	Long	Mild	Short	-0.5000	2.4074	54	-0.21
wtgain*duration	Mild	Long	Moderate	Long	-1.5000	2.4074	54	-0.62
wtgain*duration	Mild	Long	Moderate	Short	-5.1000	2.4074	54	-2.12
wtgain*duration	Mild	Long	Severe	Long	-5.3000	2.4074	54	-2.20
wtgain*duration	Mild	Long	Severe	Short	-12.4000	2.4074	54	-5.15
wtgain*duration	Mild	Short	Moderate	Long	-1.0000	2.4074	54	-0.42
wtgain*duration	Mild	Short	Moderate	Short	-4.6000	2.4074	54	-1.91
wtgain*duration	Mild	Short	Severe	Long	-4.8000	2.4074	54	-1.99
wtgain*duration	Mild	Short	Severe	Short	-11.9000	2.4074	54	-4.94
wtgain*duration	Moderate	Long	Moderate	Short	-3.6000	2.4074	54	-1.50
wtgain*duration	Moderate	Long	Severe	Long	-3.8000	2.4074	54	-1.58

```
wtgain*duration   Moderate   Long       Severe     Short       -10.9000     2.4074     54     -4.53
wtgain*duration   Moderate   Short      Severe     Long         -0.2000     2.4074     54     -0.08
wtgain*duration   Moderate   Short      Severe     Short        -7.3000     2.4074     54     -3.03
wtgain*duration   Severe     Long       Severe     Short        -7.1000     2.4074     54     -2.95

Differences ofLeast Squares Means
Effect            wtgain     duration   _wtgain    _duration   Pr > |t|   Adjustment      Adj P

wtgain            Mild                  Moderate                0.0788   Tukey          0.1820
wtgain            Mild                  Severe                  <.0001   Tukey          <.0001
wtgain            Moderate              Severe                  0.0019   Tukey          0.0054
duration                     Long                 Short         0.0096   Tukey          0.0096
wtgain*duration   Mild       Long       Mild       Short       0.8362   Tukey          0.9999
wtgain*duration   Mild       Long       Moderate   Long        0.5359   Tukey          0.9888
wtgain*duration   Mild       Long       Moderate   Short       0.0388   Tukey          0.2935
wtgain*duration   Mild       Long       Severe     Long        0.0320   Tukey          0.2540
wtgain*duration   Mild       Long       Severe     Short       <.0001   Tukey          <.0001
wtgain*duration   Mild       Short      Moderate   Long        0.6795   Tukey          0.9983
wtgain*duration   Mild       Short      Moderate   Short       0.0613   Tukey          0.4069
wtgain*duration   Mild       Short      Severe     Long        0.0512   Tukey          0.3592
wtgain*duration   Mild       Short      Severe     Short       <.0001   Tukey          0.0001
wtgain*duration   Moderate   Long       Moderate   Short       0.1406   Tukey          0.6686
wtgain*duration   Moderate   Long       Severe     Long        0.1203   Tukey          0.6159
wtgain*duration   Moderate   Long       Severe     Short       <.0001   Tukey          0.0005
wtgain*duration   Moderate   Short      Severe     Long        0.9341   Tukey          1.0000
wtgain*duration   Moderate   Short      Severe     Short       0.0037   Tukey          0.0411
wtgain*duration   Severe     Long       Severe     Short       0.0047   Tukey          0.0507
```

```
Factorial ANOVA (CRD with factorial treatment arrangement)
Analysis of duration of patients stay in hospital
Analysis of Variance done with PROC MIXED
Post hoc adjustment with macro by Arnold Saxton

Effect=wtgain ADJUSTMENT=Tukey(P<.01) BYGROUP=1
Obs    wtgain      duration    Estimate      StdErr    MSGROUP
  1    Severe                   11.0500      1.2037       A
  2    Moderate                  5.5000      1.2037       B
  3    Mild                      2.4500      1.2037       B

Effect=duration ADJUSTMENT=Tukey(P<.01) BYGROUP=2
Obs    wtgain    duration    Estimate      StdErr    MSGROUP
  4               Short        8.2000      0.9828       A
  5               Long         4.4667      0.9828       B

Effect=wtgain*duration ADJUSTMENT=Tukey(P<.01) BYGROUP=3
Obs    wtgain      duration    Estimate      StdErr    MSGROUP
  6    Severe       Short       14.6000      1.7023       A
  7    Severe       Long         7.5000      1.7023       AB
  8    Moderate     Short        7.3000      1.7023       AB
  9    Moderate     Long         3.7000      1.7023       B
 10    Mild         Short        2.7000      1.7023       B
 11    Mild         Long         2.2000      1.7023       B
```

```
738        proc univariate data=resids normal plot; var resid;
739             TITLE4 'Univariate analysis of RESIDUALS';
740        run;
NOTE: The PROCEDURE UNIVARIATE printed page 4.
NOTE: PROCEDURE UNIVARIATE used (Total process time):
      real time           0.18 seconds
      cpu time            0.09 seconds
```

```
Factorial ANOVA (CRD with factorial treatment arrangement)
Analysis of duration of patients stay in hospital
Analysis of Variance done with PROC MIXED
Univariate analysis of RESIDUALS

The UNIVARIATE Procedure
Variable:  Resid

Moments
N                          60    Sum Weights                60
Mean                        0    Sum Observations            0
Std Deviation      5.14995475    Variance           26.5220339
Skewness           0.75823095    Kurtosis           1.26399843
Uncorrected SS         1564.8    Corrected SS           1564.8
Coeff Variation             .    Std Error Mean      0.6648563

Basic Statistical Measures
    Location                     Variability
Mean      0.00000     Std Deviation            5.14995
Median   -0.70000     Variance                26.52203
Mode     -2.70000     Range                   27.00000
                      Interquartile Range      5.00000

NOTE: The mode displayed is the smallest of 2 modes with a count of 3.

Tests for Location: Mu0=0
Test           -Statistic-    -----p Value------
Student's t    t         0    Pr > |t|    1.0000
Sign           M        -5    Pr >= |M|   0.2451
Signed Rank    S       -89    Pr >= |S|   0.5169

Tests for Normality
Test                   --Statistic---    -----p Value------
Shapiro-Wilk           W     0.954062    Pr < W      0.0243
Kolmogorov-Smirnov     D     0.098822    Pr > D      0.1496
Cramer-von Mises       W-Sq  0.162545    Pr > W-Sq   0.0171
Anderson-Darling       A-Sq   0.96946    Pr > A-Sq   0.0149

Quantiles (Definition 5)
Quantile      Estimate
100% Max          15.4
99%               15.4
95%               11.4
90%                6.4
75% Q3             2.3
50% Median        -0.7
25% Q1            -2.7
10%               -5.8
5%                -7.1
1%               -11.6
0% Min           -11.6

Extreme Observations
----Lowest----        ----Highest---
Value      Obs        Value      Obs
-11.6       29          7.7       15
 -9.6       24         10.4       25
 -7.6       27         12.4       30
 -6.6       23         12.7       20
 -6.5       60         15.4       28
```

```
   Stem Leaf  Boxplot
     14 4                        1     0
     12 47                       2     0
     10 4                        1     0
      8                          
      6 57                       2     |
      4 57833                    5     |
      2 33533                    5  +-----+
      0 345834588                9  |  +  |
     -0 775227777532            12  *-----*
     -2 7533777773222           13  +-----+
     -4 3653                     4     |
     -6 6653                     4     |
     -8 6                        1     |
    -10 6                        1     0
         ----+----+----+----+
```

```
                    Normal Probability Plot
     15+                                                  *
       |                                              * *    ++
       |                                             *   ++++
       |                                            ++++
       |                                        +**+
       |                                    +****
       |                                ++****
       |                            ++****
       |                         ******
       |                    ******
       |                 ***++
       |            **+**+
       |          *+++
     -11+  *+++
         +----+----+----+----+----+----+----+----+----+----+
             -2        -1         0        +1        +2
```

```
751        PROC GLM DATA=kidney; CLASS WTGAIN DURATION;
752           TITLE3 'Example of a 2 way ANOVA done with PROC GLM';
753           MODEL DAYS = WTGAIN DURATION WTGAIN*DURATION  / SS3;
754           LSMEANS WTGAIN DURATION WTGAIN*DURATION / PDIFF STDERR ADJUST=TUKEY;
755           output out=next residual=e;
756        RUN;
756      !      QUIT;
NOTE: The data set WORK.NEXT has 60 observations and 7 variables.
NOTE: The PROCEDURE GLM printed pages 5-9.
NOTE: PROCEDURE GLM used (Total process time):
      real time           0.32 seconds
      cpu time            0.15 seconds
757
758        ods html close;
759        ods rtf close;
760        ods PDF close;
NOTE: ODS PDF printed 18 pages to C:\EXST 7005\SAS\Example06.PDF.
761
762        run;
763        quit;
```

```
Factorial ANOVA (CRD with factorial treatment arrangement)
Analysis of duration of patients stay in hospital
Example of a 2 way ANOVA done with PROC GLM

The GLM Procedure

Class Level Information
Class         Levels    Values
wtgain             3    Mild Moderate Severe

duration           2    Long Short

Number of Observations Read          60
Number of Observations Used          60
```


```
Factorial ANOVA (CRD with factorial treatment arrangement)
Analysis of duration of patients stay in hospital
Example of a 2 way ANOVA done with PROC GLM

The GLM Procedure
```


```
Dependent Variable: days

                                   Sum of
Source                     DF         Squares     Mean Square    F Value    Pr > F
Model                       5     1078.533333      215.706667       7.44    <.0001
Error                      54     1564.800000       28.977778
Corrected Total            59     2643.333333

R-Square     Coeff Var      Root MSE     days Mean
0.408020      84.99633      5.383101      6.333333

Source                     DF     Type III SS     Mean Square    F Value    Pr > F
wtgain                      2     760.4333333     380.2166667      13.12    <.0001
duration                    1     209.0666667     209.0666667       7.21    0.0096
wtgain*duration             2     109.0333333      54.5166667       1.88    0.1622
```


```
The GLM Procedure
```


```
Least Squares Means
Adjustment for Multiple Comparisons: Tukey

                                Standard                   LSMEAN
wtgain       days LSMEAN           Error    Pr > |t|      Number

Mild           2.4500000       1.2036980      0.0467           1
Moderate       5.5000000       1.2036980      <.0001           2
Severe        11.0500000       1.2036980      <.0001           3

    Least Squares Means for effect wtgain
     Pr > |t| for H0: LSMean(i)=LSMean(j)

           Dependent Variable: days

i/j              1            2            3
   1                      0.1820       <.0001
   2         0.1820                    0.0054
   3         <.0001       0.0054
```

Factorial ANOVA (CRD with factorial treatment arrangement)
Analysis of duration of patients stay in hospital
Example of a 2 way ANOVA done with PROC GLM

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey

duration	days LSMEAN	Standard Error	H0:LSMEAN=0 Pr > |t|	H0:LSMean1=LSMean2 Pr > |t|
Long	4.46666667	0.98281531	<.0001	0.0096
Short	8.20000000	0.98281531	<.0001	

The GLM Procedure
Least Squares Means
Adjustment for Multiple Comparisons: Tukey

wtgain	duration	days LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
Mild	Long	2.2000000	1.7022860	0.2017	1
Mild	Short	2.7000000	1.7022860	0.1186	2
Moderate	Long	3.7000000	1.7022860	0.0341	3
Moderate	Short	7.3000000	1.7022860	<.0001	4
Severe	Long	7.5000000	1.7022860	<.0001	5
Severe	Short	14.6000000	1.7022860	<.0001	6

Least Squares Means for effect wtgain*duration
Pr > |t| for H0: LSMean(i)=LSMean(j)

Dependent Variable: days

i/j	1	2	3	4	5	6
1		0.9999	0.9888	0.2935	0.2540	<.0001
2	0.9999		0.9983	0.4069	0.3592	0.0001
3	0.9888	0.9983		0.6686	0.6159	0.0005
4	0.2935	0.4069	0.6686		1.0000	0.0411
5	0.2540	0.3592	0.6159	1.0000		0.0507
6	<.0001	0.0001	0.0005	0.0411	0.0507	