```
/* x5_5.sas */
/* Purpose:  */

title1 'Example 5.5.';

data a;
  input time replicat weight1 weight2 weight3 weight4;
cards;
1 1 7.50 7.81 7.50 8.05
1 2 7.70 7.94 7.77 7.53
1 3 7.93 7.23 7.96 8.16
1 4 7.52 7.94 7.83 7.76
2 1 8.17 8.29 8.46 8.38
2 2 8.09 8.54 8.33 8.47
2 3 8.11 8.45 8.27 8.38
2 4 7.96 8.43 8.24 8.60
3 1 8.01 8.01 8.37 8.16
3 2 8.17 7.92 8.27 7.96
3 3 8.05 8.27 8.07 8.08
3 4 7.91 7.92 8.28 8.52
;

proc print;
title2 'List of data.';

data b; set a;
  machine=1; weight=weight1; output;
  machine=2; weight=weight2; output;
  machine=3; weight=weight3; output;
  machine=4; weight=weight4; output;
  keep time machine replicat weight;

proc print;
title2 'List of reorganised data.';

proc anova;
  class machine time replicat;
  model weight=time|machine;
  means time machine machine*time;
title2 'Analysis of systematic model using proc anova.';

proc glm;
  class machine time replicat;
  model weight=time|machine /solution;
  random time machine*time /test;
  means time machine machine*time;
title2 'Analysis of random model using proc glm.';

run;
```

Example 5.5.
List of data. 1

Obs	time	replicat	weight1	weight2	weight3	weight4
1	1	1	7.50	7.81	7.50	8.05
2	1	2	7.70	7.94	7.77	7.53
3	1	3	7.93	7.23	7.96	8.16
4	1	4	7.52	7.94	7.83	7.76
5	2	1	8.17	8.29	8.46	8.38
6	2	2	8.09	8.54	8.33	8.47
7	2	3	8.11	8.45	8.27	8.38
8	2	4	7.96	8.43	8.24	8.60
9	3	1	8.01	8.01	8.37	8.16
10	3	2	8.17	7.92	8.27	7.96
11	3	3	8.05	8.27	8.07	8.08
12	3	4	7.91	7.92	8.28	8.52

Example 5.5.
List of reorganised data. 2

Obs	time	replicat	machine	weight
1	1	1	1	7.50
2	1	1	2	7.81
3	1	1	3	7.50
4	1	1	4	8.05
5	1	2	1	7.70
6	1	2	2	7.94
7	1	2	3	7.77
8	1	2	4	7.53
9	1	3	1	7.93
10	1	3	2	7.23
11	1	3	3	7.96
12	1	3	4	8.16
13	1	4	1	7.52
14	1	4	2	7.94
15	1	4	3	7.83
16	1	4	4	7.76
17	2	1	1	8.17
18	2	1	2	8.29
19	2	1	3	8.46
20	2	1	4	8.38
21	2	2	1	8.09
22	2	2	2	8.54
23	2	2	3	8.33
24	2	2	4	8.47
25	2	3	1	8.11
26	2	3	2	8.45
27	2	3	3	8.27
28	2	3	4	8.38
29	2	4	1	7.96
30	2	4	2	8.43
31	2	4	3	8.24
32	2	4	4	8.60
33	3	1	1	8.01
34	3	1	2	8.01
35	3	1	3	8.37
36	3	1	4	8.16
37	3	2	1	8.17
38	3	2	2	7.92
39	3	2	3	8.27
40	3	2	4	7.96
41	3	3	1	8.05
42	3	3	2	8.27
43	3	3	3	8.07
44	3	3	4	8.08
45	3	4	1	7.91
46	3	4	2	7.92
47	3	4	3	8.28
48	3	4	4	8.52

Example 5.5. 3
Analysis of systematic model using proc anova.

The ANOVA Procedure

Class Level Information

Class	Levels	Values
machine	4	1 2 3 4
time	3	1 2 3
replicat	4	1 2 3 4

Number of Observations Read 48
Number of Observations Used 48

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Example 5.5. 4
Analysis of systematic model using proc anova.

The ANOVA Procedure

Dependent Variable: weight

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	3.20895625	0.29172330	8.23	<.0001
Error	36	1.27677500	0.03546597		
Corrected Total	47	4.48573125			

R-Square	Coeff Var	Root MSE	weight Mean
0.715370	2.334174	0.188324	8.068125

Source	DF	Anova SS	Mean Square	F Value	Pr > F
time	2	2.62640000	1.31320000	37.03	<.0001
machine	3	0.39072292	0.13024097	3.67	0.0209
machine*time	6	0.19183333	0.03197222	0.90	0.5046

Example 5.5. 5
Analysis of systematic model using proc anova.

The ANOVA Procedure

Level of time	N	weight Mean	weight Std Dev
1	16	7.75812500	0.24704166
2	16	8.32312500	0.17586809
3	16	8.12312500	0.17887496

Level of machine	N	weight Mean	weight Std Dev
1	12	7.92666667	0.23375719
2	12	8.06250000	0.36159055
3	12	8.11250000	0.29008228
4	12	8.17083333	0.32052396

Level of machine	Level of time	N	weight Mean	weight Std Dev
1	1	4	7.66250000	0.19972898
1	2	4	8.08250000	0.08845903
1	3	4	8.03500000	0.10754844
2	1	4	7.73000000	0.33891985
2	2	4	8.42750000	0.10340052
2	3	4	8.03000000	0.16552945
3	1	4	7.76500000	0.19364917
3	2	4	8.32500000	0.09746794
3	3	4	8.24750000	0.12658989
4	1	4	7.87500000	0.28524843
4	2	4	8.45750000	0.10404326
4	3	4	8.18000000	0.24110855

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Example 5.5. 6
Analysis of random model using proc glm.

The GLM Procedure

Class Level Information

Class	Levels	Values
machine	4	1 2 3 4
time	3	1 2 3
replicat	4	1 2 3 4

Number of Observations Read 48
Number of Observations Used 48

```
                        Example 5.5.                                  7
            Analysis of random model using proc glm.

                       The GLM Procedure

Dependent Variable: weight

                                        Sum of
 Source                      DF        Squares    Mean Square   F Value   Pr > F

 Model                       11     3.20895625     0.29172330      8.23   <.0001

 Error                       36     1.27677500     0.03546597

 Corrected Total             47     4.48573125


              R-Square     Coeff Var      Root MSE    weight Mean

              0.715370      2.334174      0.188324       8.068125


 Source                      DF      Type I SS    Mean Square   F Value   Pr > F

 time                         2     2.62640000     1.31320000     37.03   <.0001
 machine                      3     0.39072292     0.13024097      3.67   0.0209
 machine*time                 6     0.19183333     0.03197222      0.90   0.5046


 Source                      DF    Type III SS    Mean Square   F Value   Pr > F

 time                         2     2.62640000     1.31320000     37.03   <.0001
 machine                      3     0.39072292     0.13024097      3.67   0.0209
 machine*time                 6     0.19183333     0.03197222      0.90   0.5046


                                                Standard
   Parameter                 Estimate              Error    t Value    Pr > |t|

   Intercept              8.180000000 B      0.09416206      86.87      <.0001
   time         1        -0.305000000 B      0.13316526      -2.29      0.0280
   time         2         0.277500000 B      0.13316526       2.08      0.0443
   time         3         0.000000000 B       .                .         .
   machine      1        -0.145000000 B      0.13316526      -1.09      0.2834
   machine      2        -0.150000000 B      0.13316526      -1.13      0.2674
   machine      3         0.067500000 B      0.13316526       0.51      0.6153
   machine      4         0.000000000 B       .                .         .
   machine*time 1 1      -0.067500000 B      0.18832411      -0.36      0.7221
   machine*time 1 2      -0.230000000 B      0.18832411      -1.22      0.2299
   machine*time 1 3       0.000000000 B       .                .         .
   machine*time 2 1       0.005000000 B      0.18832411       0.03      0.9790
   machine*time 2 2       0.120000000 B      0.18832411       0.64      0.5280
   machine*time 2 3       0.000000000 B       .                .         .
   machine*time 3 1      -0.177500000 B      0.18832411      -0.94      0.3522
   machine*time 3 2      -0.200000000 B      0.18832411      -1.06      0.2953
   machine*time 3 3       0.000000000 B       .                .         .
   machine*time 4 1       0.000000000 B       .                .         .
   machine*time 4 2       0.000000000 B       .                .         .
   machine*time 4 3       0.000000000 B       .                .         .

NOTE: The X'X matrix has been found to be singular, and a generalized inverse
      was used to solve the normal equations.  Terms whose estimates are
```



```
      followed by the letter 'B' are not uniquely estimable.
```

```
                               Example 5.5.                                   8
                 Analysis of random model using proc glm.

                            The GLM Procedure

   Source                    Type III Expected Mean Square

   time                      Var(Error) + 4 Var(machine*time) + 16 Var(time)

   machine                   Var(Error) + 4 Var(machine*time) + Q(machine)

   machine*time              Var(Error) + 4 Var(machine*time)
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                               Example 5.5.                                   9
                 Analysis of random model using proc glm.

                            The GLM Procedure
          Tests of Hypotheses for Mixed Model Analysis of Variance

Dependent Variable: weight

 Source                     DF     Type III SS     Mean Square    F Value    Pr > F

 time                        2        2.626400        1.313200      41.07    0.0003
 machine                     3        0.390723        0.130241       4.07    0.0677

 Error                       6        0.191833        0.031972
 Error: MS(machine*time)


 Source                     DF     Type III SS     Mean Square    F Value    Pr > F

 machine*time                6        0.191833        0.031972       0.90    0.5046

 Error: MS(Error)           36        1.276775        0.035466
```



```
                               Example 5.5.                                  10
                 Analysis of random model using proc glm.

               Level of             ------------weight-----------
               time          N              Mean          Std Dev

               1            16        7.75812500       0.24704166
               2            16        8.32312500       0.17586809
               3            16        8.12312500       0.17887496


               Level of             ------------weight-----------
               machine       N              Mean          Std Dev

               1            12        7.92666667       0.23375719
               2            12        8.06250000       0.36159055
               3            12        8.11250000       0.29008228
               4            12        8.17083333       0.32052396


         Level of     Level of             ------------weight-----------
         machine      time          N              Mean          Std Dev

         1            1             4        7.66250000       0.19972898
         1            2             4        8.08250000       0.08845903
         1            3             4        8.03500000       0.10754844
         2            1             4        7.73000000       0.33891985
         2            2             4        8.42750000       0.10340052
         2            3             4        8.03000000       0.16552945
         3            1             4        7.76500000       0.19364917
         3            2             4        8.32500000       0.09746794
         3            3             4        8.24750000       0.12658989
         4            1             4        7.87500000       0.28524843
         4            2             4        8.45750000       0.10404326
         4            3             4        8.18000000       0.24110855
```