SAS Labs For Statistics 514

Design of Experiments

by

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SAS Lab 1 For Statistics 513

Topics:
How to use SAS
Chapter 16. Analysis of Factor Level Effects
Chapter 17. Single–Factor ANOVA Model and Tests

How To Use SAS

Getting onto both the Purdue North Central Windows version of SAS and the Purdue West Lafayette Distributed Academic Computing Services (DACS) version of SAS, typing in a program, as well as running, viewing, printing and saving the output from this program.

Purdue North Central Windows version of SAS.

- Log onto any of the Windows computers on the PNC campus. Locate and active "The SAS System For Windows". Open up this program.
- The PNC version of SAS is only accessible from computers on the PNC campus. The SAS program is *not* available over the Internet to your computer at home.
- This version of SAS also allows you to run, view and print the program and output from a SAS program. However, this version of SAS only allows you to save your program temporarily, for the current session. It is possible, though, to "select all", "copy" and "paste" both programs and output to your PNC computer account workspace.

Purdue West Lafayette DACS (Internet) version of SAS.

- Obtain an account username and password from the course instructor.
- Get on the Internet, go to the following link,

  http://apps.ics.purdue.edu/login.asp

  and then type in your username and password.
- Click on the "SAS" option.
- The advantage of the Purdue WL DACS version of SAS is that, of course, it is available over the Internet to your computer at home. The speed of this version of SAS depends not only on the speed of your computer, but, more importantly, on the speed of your Internet connection.

- This version of SAS also allows you to run, view and print the program and output from a SAS program *to your home computer*. However, SAS only allows you to save your program temporarily, for the current session. It is possible, though, to "select all", "copy" and "paste" both programs and output to your home computer.

A First Program

- All SAS programs are made available by clicking on the *boxed title* of each question. For example, in question 16.24, click on the boxed title,

  hw1-16-11-question-singleANOVA

  to bring up the SAS program for this problem.

- Once you open up the program, the steps used in SAS are the same whatever version of SAS you use, whether it is the PNC or Internet DACS version.

- When SAS first opens up, three windows, as well as a tool bar (at the top of the screen), appear. The three windows are

  - Contents of 'SAS Environment' (left side window)
  - Log (upper window)
  - Editor (lower window)

- At the bottom of the Editor window are three tabs: Output, Log and Editor. The Editor window tab is depressed and this window is also activated. Either clicking on these three tabs or clicking inside a window activates that window.

- *Edit Your Program.*
  Make sure the Editor window is activated. Black, blue, purple and green colors are "good" colors, and imply you are typing in the code properly. Red colors are "bad" and mean that you have made a mistake typing in the program code.

- *Run Your Program.*
  Once the program is complete, click on Run, then Submit (found in the toolbar at the top of the screen). If the program runs correctly, all three windows, Log, Editor and Contents of 'SAS Environment', disappear and are replaced by two windows, the Output (right window) and Results (left window). The *last page of the* output from the program will appear in the Output window. Move the side bar on the output window to view all of the output.

- *Debug Your Program.*
  If the program does not run correctly, click on the Log tab and have a look at where it went wrong.

- *Print your Output.*
  Either click on the printer icon or click on File, then Print, to print out the output.

- *Print your Program.*
  The SAS program can also be printed out. Activate the Editor window by clicking on the tab below the output window with the mouse and then print it out.

- *Save your Output or Program.*
  Activate either the Output or Editor window, then either click on the save icon or click on File, then Save, to save either the output or program.

```
*16.10 PRODUCTIVITY IMPROVEMENT;
*SINGLE FACTOR ANOVA, PAGE 703;
DATA PRODUCT;
    INPUT IMPROVE FIRM CASE;
DATALINES;
7.6     1       1
8.2     1       2
6.8     1       3
5.8     1       4
6.9     1       5
6.6     1       6
6.3     1       7
7.7     1       8
6       1       9
6.7     2       1
8.1     2       2
9.4     2       3
8.6     2       4
7.8     2       5
7.7     2       6
8.9     2       7
7.9     2       8
8.3     2       9
8.7     2       10
7.1     2       11
8.4     2       12
8.5     3       1
9.7     3       2
10.1    3       3
7.8     3       4
9.6     3       5
9.5     3       6
;
SYMBOL1 V=dot C=BLACK I=R;
PROC GPLOT DATA=PRODUCT;
        TITLE '16.10(A) PLOT PRODUCTIVITY IMPROVEMENT, SINGLE FACTOR ANOVA, PAGE 703';
        PLOT IMPROVE*FIRM;
RUN;
PROC GLM DATA=PRODUCT;
        TITLE '16.10(D) PRODUCTIVITY IMPROVEMENT, SINGLE FACTOR ANOVA, PAGE 703';
        CLASS FIRM;
        MODEL IMPROVE = FIRM;
        OUTPUT OUT=PRODUCT2 p=pred R=RESID;
RUN;
PROC PRINT DATA=PRODUCT2;
        TITLE '16.10(B,C) PRODUCTIVITY IMPROVEMENT, RESIDUALS, PAGE 703';
        VAR FIRM CASE IMPROVE pred RESID;
RUN;
QUIT;
```

```
*16.11 Questionnaire color
*Single factor ANOVA, p 704;
data questionnaire;
    input response color replicate;
DATALINES;
28      1       1
26      1       2
31      1       3
27      1       4
35      1       5
34      2       1
29      2       2
25      2       3
31      2       4
29      2       5
31      3       1
25      3       2
27      3       3
29      3       4
28      3       5
;
symbol1 v=dot c=black i=r;
proc gplot data=questionnaire
        title '16.11(a) Percentage response vs color';
        plot response*color;
run;
proc glm data=questionnaire;
        title '16.11(b,c,d,e) Single factor ANOVA';
        class color;
        model response = color;
        output out=out p=pred r=resid;
run;
proc print data=out;
        title '16.11(b,c) Printout of predicted values, residuals';
        var color replicate response pred resid;
run;
quit;
```

```
*16.14 FILLING MACHINES, SINGLE FACTOR ANOVA, PAGE 705;
DATA FILL;
    INPUT DEVS MACHINE CASE;
DATALINES;
-0.14   1       1
0.2     1       2
0.07    1       3
0.18    1       4
0.38    1       5
0.1     1       6
-0.04   1       7
-0.27   1       8
0.27    1       9
-0.21   1       10
0.39    1       11
-0.07   1       12
-0.02   1       13
0.28    1       14
0.09    1       15
0.13    1       16
0.26    1       17
0.07    1       18
-0.01   1       19
-0.19   1       20
0.46    2       1
0.11    2       2
0.12    2       3
0.47    2       4
0.24    2       5
0.06    2       6
-0.12   2       7
0.33    2       8
0.06    2       9
-0.03   2       10
0.05    2       11
0.53    2       12
0.42    2       13
0.29    2       14
0.36    2       15
0.04    2       16
0.17    2       17
0.02    2       18
0.11    2       19
0.12    2       20
0.21    3       1
0.78    3       2
0.32    3       3
0.45    3       4
0.22    3       5
0.35    3       6
0.54    3       7
0.24    3       8
0.47    3       9
0.62    3       10
0.47    3       11
0.55    3       12
0.59    3       13
0.71    3       14
0.45    3       15
0.48    3       16
0.44    3       17
0.5     3       18
0.2     3       19
0.61    3       20
0.49    4       1
0.58    4       2
0.52    4       3
0.29    4       4
0.27    4       5
0.55    4       6
0.4     4       7
0.14    4       8
0.48    4       9
0.34    4       10
0.01    4       11
0.33    4       12
0.18    4       13
0.13    4       14
0.48    4       15
0.54    4       16
0.51    4       17
0.42    4       18
0.45    4       19
0.2     4       20
-0.19   5       1
0.27    5       2
0.06    5       3
0.11    5       4
0.23    5       5
0.15    5       6
0.01    5       7
0.22    5       8
0.29    5       9
0.14    5       10
0.2     5       11
0.3     5       12
-0.11   5       13
0.27    5       14
-0.2    5       15
0.24    5       16
0.2     5       17
0.14    5       18
0.35    5       19
-0.18   5       20
0.05    6       1
-0.05   6       2
0.28    6       3
0.47    6       4
0.12    6       5
0.27    6       6
0.08    6       7
0.17    6       8
0.43    6       9
-0.07   6       10
0.2     6       11
0.01    6       12
0.1     6       13
0.16    6       14
-0.06   6       15
0.13    6       16
0.43    6       17
0.35    6       18
-0.09   6       19
0.05    6       20
;
proc shewhart data=fill;
        TITLE '16.14(A) BOXPLOTS OF DEVIATIONS FOR EACH MACHINE';
        boxchart DEVS*MACHINE / nolimits;
run;
PROC GLM DATA=FILL;
        TITLE '16.14(D) FILLING MACHINE DEVIATIONS, SINGLE FACTOR ANOVA';
        CLASS MACHINE;
        MODEL DEVS = MACHINE;
        OUTPUT OUT=FILL2 p=pred R=RESID;
RUN;
PROC PRINT DATA=FILL2;
        TITLE '16.14(B,C) FILLING MACHINE DEVIATIONS RESIDUALS, PAGE 705';
        VAR MACHINE CASE devs pred RESID;
RUN;
QUIT;
```

```
*16.24 Questionnaire color
*Regression form of ANOVA;
data questionnaire;
     input response color replicate;
                    int = 1;
                    if color = 1 then x1 = 1;
                    if color = 2 then x1 = 0;
                    if color = 3 then x1 = -1;
                    if color = 1 then x2 = 0;
                    if color = 2 then x2 = 1;
                    if color = 3 then x2 = -1;
DATALINES;
28        1         1
26        1         2
31        1         3
27        1         4
35        1         5
34        2         1
29        2         2
25        2         3
31        2         4
29        2         5
31        3         1
25        3         2
27        3         3
29        3         4
28        3         5
;
proc glm data=questionnaire;
          title '16.24(c) Single factor ANOVA';
          model response = x1 x2;
          output out=out p=pred r=resid;
run;
proc print data=out;
          title '16.11(b,c) Printout of predicted values, residuals';
          var x1 x2 response pred resid;
run;
quit;
```

```
*16.8 Single Factor ANOVA;
data drugs;
        input response drug case;
datalines;
5.90 1 1
5.92 1 2
5.91 1 3
5.89 1 4
5.88 1 5
5.51 2 1
5.50 2 2
5.50 2 3
5.49 2 4
5.50 2 5
5.01 3 1
5.00 3 2
4.99 3 3
4.98 3 4
5.02 3 5
;
symbol1 v=dot c=black i=r;
proc gplot data=drugs;
        title 'plot of drug responses';
        plot response*drug;
run;
proc glm data=drugs;
        title 'single factor ANOVA, drugs';
        class drug;
        model response = drug;
        output out=drugsout p=pred r=resid;
run;
proc print data=drugsout;
        title 'response, predicted and residuals';
        var drug case response pred resid;
run;
data rats;
        input count location case;
datalines;
3 1 1
5 1 2
7 1 3
4 1 4
1 2 1
3 2 2
2 2 3
5 3 1
8 3 2
9 3 3
8 3 4
10 3 5
;
symbol1 v=dot c=black i=r;
proc gplot data=rats;
        title 'plot of rat counts versus city location';
        plot count*location;
run;
proc glm data=rats;
        title 'single factor ANOVA, rats';
        class location;
        model count = location;
        output out=rats2out p=pred r=resid;
run;
proc print data=rats2out;
        title 'response, predicted and residuals';
        var location case count pred resid;
run;
quit;
```

```
*16.8 Single Factor ANOVA;
data drugs;
        input response drug case;
        int = 1;
        if drug = 1 then x1 = 1;
        if drug = 2 then x1 = 0;
        if drug = 3 then x1 = -1;
        if drug = 1 then x2 = 0;
        if drug = 2 then x2 = 1;
        if drug = 3 then x2 = -1;
datalines;
5.90 1 1
5.92 1 2
5.91 1 3
5.89 1 4
5.88 1 5
5.51 2 1
5.50 2 2
5.50 2 3
5.49 2 4
5.50 2 5
5.01 3 1
5.00 3 2
4.99 3 3
4.98 3 4
5.02 3 5
;
proc glm data=drugs;
        title 'regression of single factor ANOVA';
        model response = x1 x2;
        output out=drugsout p=pred r=resid;
run;
proc print data=drugsout;
        title 'response, predicted and residuals';
        var int x1 x2 response pred resid;
run;
data rats;
        input count location case;
        int = 1;
        if location = 1 then x1 = 1;
        if location = 2 then x1 = 0;
        if location = 3 then x1 = -1;
        if location = 1 then x2 = 0;
        if location = 2 then x2 = 1;
        if location = 3 then x2 = -1;
datalines;
3 1 1
5 1 2
7 1 3
4 1 4
1 2 1
3 2 2
2 2 3
5 3 1
8 3 2
9 3 3
8 3 4
10 3 5
;
proc glm data=rats;
        title 'regression of single factor ANOVA, rats';
        model count = x1 x2;
        output out=rats2out p=pred r=resid;
run;
proc print data=rats2out;
        title 'response, predicted and residuals';
        var int x1 x2 count pred resid;
run;
quit;
```

```
*17.9 PRODUCTIVITY IMPROVEMENT, FACTOR LEVEL EFFECTS, PAGE 749;
DATA PRODUCT;
    INPUT IMPROVE FIRM CASE;
DATALINES;
7.6     1       1
8.2     1       2
6.8     1       3
5.8     1       4
6.9     1       5
6.6     1       6
6.3     1       7
7.7     1       8
6       1       9
6.7     2       1
8.1     2       2
9.4     2       3
8.6     2       4
7.8     2       5
7.7     2       6
8.9     2       7
7.9     2       8
8.3     2       9
8.7     2       10
7.1     2       11
8.4     2       12
8.5     3       1
9.7     3       2
10.1    3       3
7.8     3       4
9.6     3       5
9.5     3       6
;
*17.9(A) PRODUCTIVITY IMPROVEMENT, MEANS, PAGE 749;
PROC MEANS DATA=PRODUCT MEAN;
        TITLE '17.9(A) PRODUCTIVITY IMPROVEMENT, MEANS';
        VAR IMPROVE;
        BY FIRM;
RUN;
*17.9(B) PRODUCTIVITY IMPROVEMENT, MSE FROM ANOVA, PAGE 749;
PROC ANOVA DATA=PRODUCT;
        TITLE '17.9(B) PRODUCTIVITY IMPROVEMENT, MSE FROM ANOVA';
        CLASS FIRM;
        MODEL IMPROVE = FIRM;
RUN;
*17.9(C),(D) PRODUCTIVITY IMPROVEMENT, CONTRAST MU2 - MU1 AND TUKEY PAIRWISE, PAGE 749;
PROC ANOVA DATA=PRODUCT;
        TITLE '17.9(D) PRODUCTIVITY IMPROVEMENT, CONTRAST MU2 - MU1 AND TUKEY PAIRWISE';
        CLASS FIRM;
        MODEL IMPROVE = FIRM;
        MEANS FIRM / LSD ALPHA = 0.05;
        MEANS FIRM / TUKEY ALPHA = 0.1;
RUN;
QUIT;
```

```
*17.15, Productivity improvement;
*Analysis of factor level effects;
data product;
        input improve firm case;
datalines;
7.6     1       1
8.2     1       2
6.8     1       3
5.8     1       4
6.9     1       5
6.6     1       6
6.3     1       7
7.7     1       8
6       1       9
6.7     2       1
8.1     2       2
9.4     2       3
8.6     2       4
7.8     2       5
7.7     2       6
8.9     2       7
7.9     2       8
8.3     2       9
8.7     2       10
7.1     2       11
8.4     2       12
8.5     3       1
9.7     3       2
10.1    3       3
7.8     3       4
9.6     3       5
9.5     3       6
;
PROC MEANS DATA=PRODUCT MEAN;
        TITLE '17.9(a,b) contrast CIs info';
        VAR IMPROVE;
        BY FIRM;
RUN;
PROC ANOVA DATA=PRODUCT;
        TITLE '17.9(a,b) more contrast CIs info';
        CLASS FIRM;
        MODEL IMPROVE = FIRM;
RUN;
PROC ANOVA DATA=PRODUCT;
        TITLE '17.9(c) CONTRAST MU2 - MU1 AND scheffe';
        CLASS FIRM;
        MODEL IMPROVE = FIRM;
        MEANS FIRM / scheffe ALPHA = 0.1;
RUN;
QUIT;
```

```
*17.24 FILLING MACHINES, quadratic;
DATA FILL;
    INPUT DEVS MACHINE CASE;
                if machine = 1 then time = 0.4;
                if machine = 2 then time = 3.7;
                if machine = 3 then time = 6.1;
                if machine = 4 then time = 5.3;
                if machine = 5 then time = 1.4;
                if machine = 6 then time = 2.1;
                time2 = time*time;
DATALINES;
-0.14   1   1
0.2     1   2
0.07    1   3
0.18    1   4
0.38    1   5
0.1     1   6
-0.04   1   7
-0.27   1   8
0.27    1   9
-0.21   1   10
0.39    1   11
-0.07   1   12
-0.02   1   13
0.28    1   14
0.09    1   15
0.13    1   16
0.26    1   17
0.07    1   18
-0.01   1   19
-0.19   1   20
0.46    2   1
0.11    2   2
0.12    2   3
0.47    2   4
0.24    2   5
0.06    2   6
-0.12   2   7
0.33    2   8
0.06    2   9
-0.03   2   10
0.05    2   11
0.53    2   12
0.42    2   13
0.29    2   14
0.36    2   15
0.04    2   16
0.17    2   17
0.02    2   18
0.11    2   19
0.12    2   20
0.21    3   1
0.78    3   2
0.32    3   3
0.45    3   4
0.22    3   5
0.35    3   6
0.54    3   7
0.24    3   8
0.47    3   9
0.62    3   10
0.47    3   11
0.55    3   12
0.59    3   13
0.71    3   14
0.45    3   15
0.48    3   16
0.44    3   17
0.5     3   18
0.2     3   19
0.61    3   20
0.49    4   1
0.58    4   2
0.52    4   3
0.29    4   4
0.27    4   5
0.55    4   6
0.4     4   7
0.14    4   8
0.48    4   9
0.34    4   10
0.01    4   11
0.33    4   12
0.18    4   13
0.13    4   14
0.48    4   15
0.54    4   16
0.51    4   17
0.42    4   18
0.45    4   19
0.2     4   20
-0.19   5   1
0.27    5   2
0.06    5   3
0.11    5   4
0.23    5   5
0.15    5   6
0.01    5   7
0.22    5   8
0.29    5   9
0.14    5   10
0.2     5   11
0.3     5   12
-0.11   5   13
0.27    5   14
-0.2    5   15
0.24    5   16
0.2     5   17
0.14    5   18
0.35    5   19
-0.18   5   20
0.05    6   1
-0.05   6   2
0.28    6   3
0.47    6   4
0.12    6   5
0.27    6   6
0.08    6   7
0.17    6   8
0.43    6   9
-0.07   6   10
0.2     6   11
0.01    6   12
0.1     6   13
0.16    6   14
-0.06   6   15
0.13    6   16
0.43    6   17
0.35    6   18
-0.09   6   19
0.05    6   20
;
PROC GLM DATA=FILL;
        TITLE '17.24(a) quadratic regression';
        MODEL DEVS = time time2;
        OUTPUT OUT=FILL2 p=pred R=RESID;
RUN;
PROC PRINT DATA=FILL2;
        TITLE '17.24(b) quadratic regression RESIDUALS';
        VAR time time2 devs pred RESID;
RUN;
PROC GLM DATA=FILL;
        TITLE '17.24(c) lack of fit, quadratic test';
        CLASS MACHINE;
        MODEL DEVS = MACHINE;
RUN;
QUIT;
```

```
*17.3 Contrasts;
data drugs;
        input response drug case;
        response2 = response - 5.898;
datalines;
5.90 1 1
5.92 1 2
5.91 1 3
5.89 1 4
5.88 1 5
5.51 2 1
5.50 2 2
5.50 2 3
5.49 2 4
5.50 2 5
5.01 3 1
5.00 3 2
4.99 3 3
4.98 3 4
5.02 3 5
;
proc glm data=drugs;
        title 'd1 = 5.898?, drugs';
        class drug;
        model response2 = drug;
        estimate 'd1 = 5.898?' intercept 1 drug 1;
run;
proc glm data=drugs;
        title 'other contrasts, drugs';
        class drug;
        model response = drug;
        lsmeans drug / pdiff;
        contrast 'd1 vs d2' drug 1 -1 0;
        contrast 'd1 vs d2 and d3' drug 1 -0.5 -0.5;
        estimate 'd1 vs d2' drug 1 -1 0;
        estimate 'd1 vs d2 and d3' drug 1 -0.5 -0.5;
run;
quit;
```

```
*17.5 Tukey pairwise comparisons;
data cotton;
        do cottontype = 1 to 5;
                do case = 1 to 6;
        input strength @;
                                output;
                end;
        end;
datalines;
7   7 15 11  9 10
12 17 12 18 18 16
14 18 18 19 19 17
19 25 22 19 23 24
 7 10 11 15 11 14
;
proc glm data=cotton;
        title 'tukey pairwise comparison, drugs';
        class cottontype;
        model strength = cottontype;
        means cottontype / tukey alpha = 0.05;
        means cottontype / tukey alpha = 0.05 cldiff;
run;
quit;
```

```
*17.6 Scheffe multiple contrasts;
data cotton;
        do cottontype = 1 to 5;
                do case = 1 to 6;
        input strength @;
                                output;
                end;
        end;
datalines;
7   7 15 11  9 10
12 17 12 18 18 16
14 18 18 19 19 17
19 25 22 19 23 24
 7 10 11 15 11 14
;
proc glm data=cotton;
        title 'Scheffe multiple contrasts, cotton';
        class cottontype;
        model strength = cottontype;
        contrast 'L1'   cottontype -0.25 -0.25 -0.25 -0.25 1;
        estimate 'L1'   cottontype -0.25 -0.25 -0.25 -0.25 1;
        contrast 'L2'   cottontype 0 1 -1 0 0;
        estimate 'L2'   cottontype 0 1 -1 0 0;
        contrast 'L3'   cottontype -1 0 0 1 0;
        estimate 'L3'   cottontype -1 0 0 1 0;
        contrast 'L4'   cottontype -0.5 0.5 0.5 -0.5 0;
        estimate 'L4'   cottontype -0.5 0.5 0.5 -0.5 0;
run;
quit;
```

```
*17.7 Bonferroni multiple contrasts;
data cotton;
        do cottontype = 1 to 5;
                do case = 1 to 6;
        input strength @;
                                output;
                end;
        end;
datalines;
7   7 15 11  9 10
12 17 12 18 18 16
14 18 18 19 19 17
19 25 22 19 23 24
 7 10 11 15 11 14
;
proc glm data=cotton;
        title 'Bonferroni multiple contrasts, cotton';
        class cottontype;
        model strength = cottontype;
        contrast 'L1'   cottontype -0.25 -0.25 -0.25 -0.25 1;
        estimate 'L1'   cottontype -0.25 -0.25 -0.25 -0.25 1;
        contrast 'L2'   cottontype 0 1 -1 0 0;
        estimate 'L2'   cottontype 0 1 -1 0 0;
        contrast 'L3'   cottontype -1 0 0 1 0;
        estimate 'L3'   cottontype -1 0 0 1 0;
        contrast 'L4'   cottontype -0.5 0.5 0.5 -0.5 0;
        estimate 'L4'   cottontype -0.5 0.5 0.5 -0.5 0;
run;
quit;
```

```
*17.8 Holm multiple contrasts;
data cotton;
        do cottontype = 1 to 5;
                do case = 1 to 6;
        input strength @;
                                output;
                end;
        end;
datalines;
7   7 15 11  9 10
12 17 12 18 18 16
14 18 18 19 19 17
19 25 22 19 23 24
 7 10 11 15 11 14
;
proc glm data=cotton;
        title 'Holm multiple contrasts, cotton';
        class cottontype;
        model strength = cottontype;
        contrast 'L1'   cottontype -0.25 -0.25 -0.25 -0.25 1;
        estimate 'L1'   cottontype -0.25 -0.25 -0.25 -0.25 1;
        contrast 'L2'   cottontype 0 1 -1 0 0;
        estimate 'L2'   cottontype 0 1 -1 0 0;
        contrast 'L3'   cottontype -1 0 0 1 0;
        estimate 'L3'   cottontype -1 0 0 1 0;
        contrast 'L4'   cottontype -0.5 0.5 0.5 -0.5 0;
        estimate 'L4'   cottontype -0.5 0.5 0.5 -0.5 0;
run;
quit;
```

```
*17.9 Quadratic regression;
data cotton;
        do cottontype = 1 to 5;
                do case = 1 to 6;
        input strength @;
                        if cottontype = 1 then percentcotton = 5;
                        if cottontype = 2 then percentcotton = 10;
                        if cottontype = 3 then percentcotton = 15;
                        if cottontype = 4 then percentcotton = 20;
                        if cottontype = 5 then percentcotton = 25;
                        if cottontype = 6 then percentcotton = 30;
                        percentcotton2 = percentcotton*percentcotton;
                                output;
                end;
        end;
datalines;
7  7 15 11  9 10
12 17 12 18 18 16
14 18 18 19 19 17
19 25 22 19 23 24
 7 10 11 15 11 14
;
proc glm data=cotton;
        title 'quadratic regression';
        model strength = percentcotton percentcotton2;
        output out=cotton2 p=pred r=resid;
run;
proc print data=cotton2;
        title 'quadratic regression residuals';
        var percentcotton percentcotton2 strength pred resid;
run;
proc glm data=cotton;
        title 'ANOVA, for lack of fit';
        class cottontype;
        model strength = cottontype;
run;
quit;
```