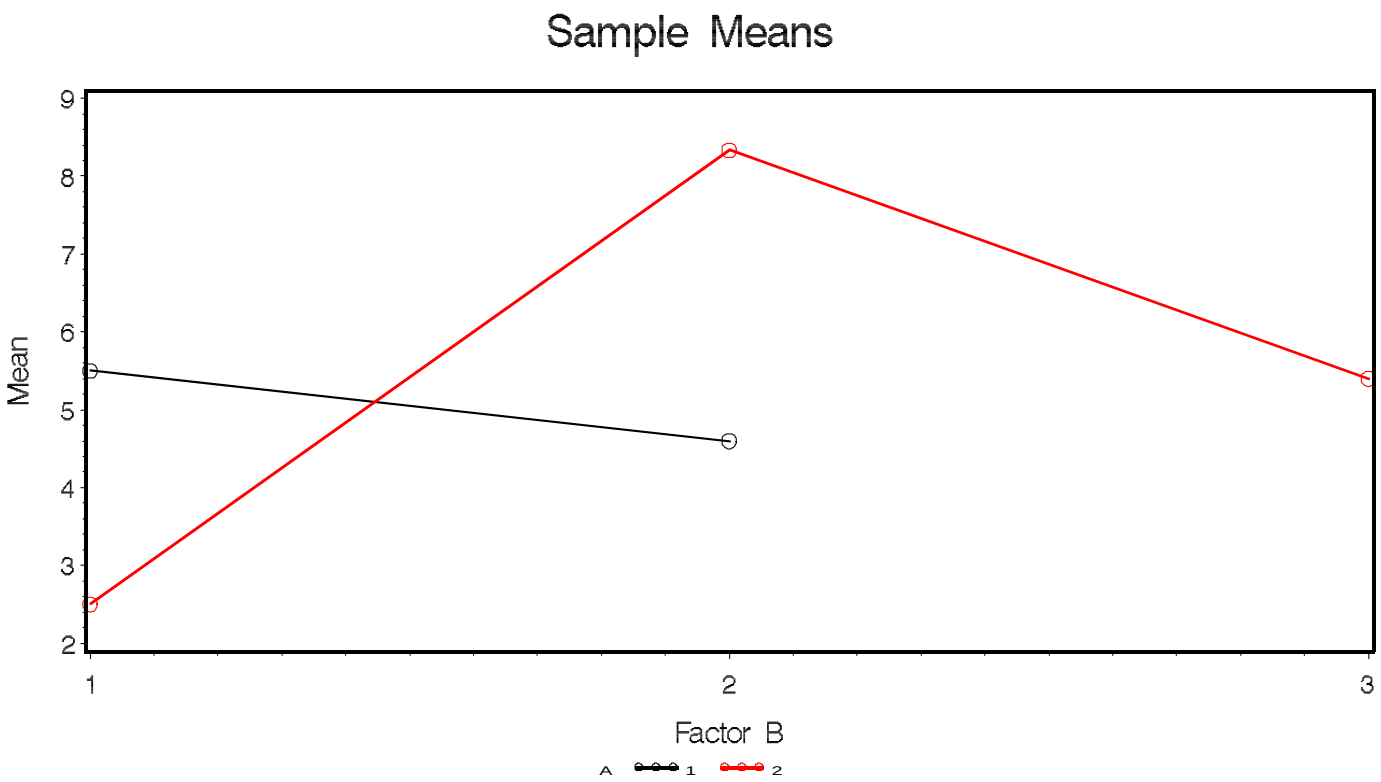
```
/* SAS code for analyzing data
   from the two factor experiment
   with no data for one combination
   of factors>  This code is posted
   as  littell.sas   */


data set1;
  input A B y;
  cards;
 1  1   5
 1  1   6
 1  2   2
 1  2   3
 1  2   5
 1  2   6
 1  2   7
 2  1   2
 2  1   3
 2  2   8
 2  2   8
 2  2   9
 2  3   4
 2  3   4
 2  3   6
 2  3   6
 2  3   7
run;


/*  Print the data  */

proc print data=set1;
run;
```

```
/* Compute sample means for all
   factor combinations with data.
   Make a profile plot. */

proc sort data=set1; by a b;
proc means data=set1 noprint; by a b;
  var Y;
  output out=means mean=my;
  run;

axis1 label=(f=swiss h=2.0)
      value=(f=swiss h=1.8)
      w=3.0;

axis2 label=(f=swiss h=2.0 a=90 r=0)
      value=(f=swiss h=1.8)
      w= 3.0;

SYMBOL1 V=circle H=2.0 w=3 l=1 i=join;
SYMBOL2 V=diamond H=2.0 w=3 l=3 i=join;

proc gplot data=means;
  plot my*b=a / vaxis=axis2 haxis=axis1;
  title ls=0.8in H=3.0 F=swiss "Sample Means";
       label my='Mean';
       label b = 'Factor B';
  footnote ls=0.4in '  ';
 run;
```


Sample Means
Mean
9
8
7
6
5
4
3
2
1
2
3
Factor B
A
1
2

```
/* Perform analysis of variance where
   facror A is entered into the model
   before factor B.  Use the LSMEANS
   statement to compare means for
   different combinations of factor A
   and factor B.  */

proc glm data=set1;
  class A B;
  model y = A B A*B / solution ss1 ss2
          ss3 ss4 e e1 e2 e3 e4 p;
  means A B A*B;
  lsmeans A*B / pdiff tdiff stderr;
    estimate 'A1-A2' A 1 -1 / e;
    contrast 'A1-A2' A 1 -1 / e;
    estimate 'A1-A2 within B1'  A 1 -1
             A*B 1 0  -1 0 0 / e;
    estimate 'A1-A2 within B2'  A 1 -1
             A*B 0 1 0 -1 0 / e;
    estimate 'A1-A2 over B'  A 1 -1
             A*B .5 .5 -.5 -.5 0 / e;
    estimate 'B1-B2 over A'  B 1 -1 0
             A*B .5 -.5 .5 -.5 0 / e;
    estimate 'B3-.5(B1+B2) in A2' B -.5 -.5 1
             A*B 0 0 -.5 -.5 1 / e;
    estimate 'interaction' A*B 1 -1 -1 1 0 / e;
    run;
```

General Form of Estimable Functions

Effect		Coefficients
Intercept		L1
A	1	L2
A	2	L1-L2
B	1	L4
B	2	L5
B	3	L1-L4-L5
A*B	1 1	L7
A*B	1 2	L2-L7
A*B	2 1	L4-L7
A*B	2 2	-L2+L5+L7
A*B	2 3	L1-L4-L5

Type III Estimable Functions

		Coefficients		
Effect		A	B	A*B
Intercept		0	0	0
A	1	L2	0	0
A	2	-L2	0	0
B	1	0	L4	0
B	2	0	L5	0
B	3	0	-L4-L5	0
A*B	1 1	0.5*L2	0.25*L4-0.25*L5	L7
A*B	1 2	0.5*L2	-0.25*L4+0.25*L5	-L7
A*B	2 1	-0.5*L2	0.75*L4+0.25*L5	-L7
A*B	2 2	-0.5*L2	0.25*L4+0.75*L5	L7
A*B	2 3	0	-L4-L5	0

Type IV Estimable Functions

			------Coefficients------		
Effect			A	B	A*B
Intercept			0	0	0
A	1		L2	0	0
A	2		-L2	0	0
B	1		0	L4	0
B	2		0	L5	0
B	3		0	-L4-L5	0
A*B	1	1	0.5*L2	0	L7
A*B	1	2	0.5*L2	0	-L7
A*B	2	1	-0.5*L2	L4	-L7
A*B	2	2	-0.5*L2	L5	L7
A*B	2	3	0	-L4-L5	0

```
/*  Do everything with a one-factor ANOVA by
    combining the two factors into a single
    factor with 5 categories.  */


data set1; set set1;
  C=10*A+B;
  run;


proc glm data=set1;
  class C;
  model y = C / solution e e2;
  estimate 'C11-C21' C 1 0 -1 0 0;
  estimate 'C12-C22' C 0 1 0 -1 0;
  estimate '.5(C11+C12-C21+C22)' C .5 .5 -.5 -.5 0;
  estimate '.5(C11-C12+C21-C22)' C .5 -.5 .5 -.5 0;
  estimate 'C23-.5(C21+C22)' C 0 0 -.5 -.5 1;
  estimate 'C11-C12-C21+C22' C 1 -1 -1 1 0;
  lsmeans C / stderr tdiff pdiff;
  run;
```

General Form of Estimable Functions

Effect	Coefficients
Intercept	L1
C 11	L2
C 12	L3
C 21	L4
C 22	L5
C 23	L1-L2-L3-L4-L5

Type II Estimable Functions

	-Coefficients-
Effect	C
Intercept	0
C 11	L2
C 12	L3
C 21	L4
C 22	L5
C 23	-L2-L3-L4-L5

Dependent Variable: y

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	45.81568627	11.45392157	5.27	0.0110
Error	12	26.06666667	2.17222222		
Corrected Total	16	71.88235294			

Parameter	Estimate	Standard Error	t Value	Pr > |t|
C11-C21	3.00000000	1.47384606	2.04	0.0645
C12-C22	-3.73333333	1.07634498	-3.47	0.0046

.5(C11+C12-C21+C22)	-0.36666667	0.91251585	-0.40	0.6949
.5(C11-C12+C21-C22)	-2.46666667	0.91251585	-2.70	0.0192
C23-.5(C21+C22)	-0.01666667	0.94180186	-0.02	0.9862
C11-C12-C21+C22	6.73333333	1.82503171	3.69	0.0031

The GLM Procedure
Least Squares Means

C	y LSMEAN	Standard Error	Pr > |t|	LSMEAN Number
11	5.50000000	1.04216655	0.0002	1
12	4.60000000	0.65912400	<.0001	2
21	2.50000000	1.04216655	0.0336	3
22	8.33333333	0.85092542	<.0001	4
23	5.40000000	0.65912400	<.0001	5

Least Squares Means for Effect C
t for H0: LSMean(i)=LSMean(j) / Pr > |t|

Dependent Variable: y

i/j	1	2	3	4	5
1		0.729863	2.035491	-2.10589	0.081096
		0.4795	0.0645	0.0569	0.9367
2	-0.72986		1.703014	-3.46853	-0.85824
	0.4795		0.1143	0.0046	0.4076
3	-2.03549	-1.70301		-4.33566	-2.35178
	0.0645	0.1143		0.0010	0.0366
4	2.105892	3.468529	4.335661		2.725272
	0.0569	0.0046	0.0010		0.0184
5	-0.0811	0.858238	2.351781	-2.72527	
	0.9367	0.4076	0.0366	0.0184	