Multivariate ANOVA and Regression

```
/* mathmv.sas   */
%include 'readmath.sas';
title2 'MANOVA';             options pagesize=500;
if ethnic ne 6; /* Otherwise, throw the case out */

/* Effect coding */

if ethnic=. then e1=.;
   else if ethnic=1 then e1=1;
   else if ethnic=5 then e1 = -1;
   else e1=0;
if ethnic=. then e2=.;
   else if ethnic=2 then e2=1;
   else if ethnic=5 then e2 = -1;
   else e2=0;
if ethnic=. then e3=.;
   else if ethnic=3 then e3=1;
   else if ethnic=5 then e3 = -1;
   else e3=0;
if ethnic=. then e4=.;
   else if ethnic=4 then e4=1;
   else if ethnic=5 then e4 = -1;
   else e4=0;

if sex = 'Female' then g = 1;
   else if sex = 'Male' then g = -1;

/* Interaction terms */
ge1 = g*e1 ; ge2 = g*e2 ; ge3 = g*e3; ge4 = g*e4;

proc freq;
     tables sex * g / norow nocol nopercent missing;

proc glm;
     title3 'Two-factor multivariate analysis of variance with proc glm';
     class ethnic sex;
     model hscalc hsengl hsgpa precalc calc grade = sex|ethnic;
     contrast 'East Indian vs. Eastern European' ethnic 0 1 -1 0 0;
     manova h = _all_;
     /* To see multivariate tests for the contrasts, put the manova
        statement after the contrast statements */
     means sex;
     lsmeans ethnic / pdiff adjust=bon;

proc reg;
     title3 'Multivariate regression with effect coding';
     model hscalc hsengl hsgpa precalc calc grade = e1-e4 g ge1-ge4;
     Sex: mtest g = 0;
     Ethnic: mtest e1=e2=e3=e4=0;
     Sex_x_Ethnic: mtest ge1=ge2=ge3=ge4=0;

/* Could have requested univariate tests with  test.
   Could do multivariate pairwise comparisons of marginal means with mtest,
   but it's clumsy with effect coding. Cell means coding would be better. */
```

MANOVA

The FREQ Procedure

Table of sex by g

```
          sex         g

          Frequency|        .|       -1|        1|   Total
          ---------+--------+--------+--------+
                   |     2 |      0 |      0 |       2
          ---------+--------+--------+--------+
          Female   |     0 |      0 |    257 |     257
          ---------+--------+--------+--------+
          Male     |     0 |    280 |      0 |     280
          ---------+--------+--------+--------+
          Total           2      280      257      539
```

MANOVA
Two-factor multivariate analysis of variance with proc glm

The GLM Procedure

Class Level Information

Class	Levels	Values
ethnic	5	Asian East Indian Eastern European European not Eastern Middle-Eastern and Pakistani
sex	2	Female Male

```
          Number of Observations Read         539
          Number of Observations Used         280
```

The GLM Procedure

Dependent Variable: hscalc   HS Calculus

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	2366.18173	262.90908	2.11	0.0286
Error	270	33568.66113	124.32837		
Corrected Total	279	35934.84286			

```
         R-Square      Coeff Var       Root MSE      hscalc Mean

         0.065846      14.19253        11.15026       78.56429


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

sex                        1       218.670737       218.670737       1.76    0.1859
ethnic                     4      1705.607133       426.401783       3.43    0.0094
ethnic*sex                 4       441.903861       110.475965       0.89    0.4712


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

sex                        1         0.779722         0.779722       0.01    0.9369
ethnic                     4      1717.147646       429.286911       3.45    0.0090
ethnic*sex                 4       441.903861       110.475965       0.89    0.4712


 Contrast                              DF    Contrast SS    Mean Square   F Value

 East Indian vs. Eastern European       1    817.5268571    817.5268571      6.58

                 Contrast                               Pr > F

                 East Indian vs. Eastern European       0.0109
```

              Gender, Ethnicity and Math performance   4
                                MANOVA
           Two-factor multivariate analysis of variance with proc glm

                        The GLM Procedure

Dependent Variable: hsengl   HS English

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

Model                      9     2500.90235       277.87804       4.18    <.0001

Error                    270    17969.06551        66.55209

Corrected Total          279    20469.96786


         R-Square      Coeff Var       Root MSE      hsengl Mean

         0.122174      10.58639        8.157947       77.06071


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

sex                        1      1044.361609     1044.361609      15.69    <.0001
ethnic                     4      1168.042892      292.010723       4.39    0.0019
ethnic*sex                 4       288.497851       72.124463       1.08    0.3649
```

Source	DF	Type III SS	Mean Square	F Value	Pr > F
sex	1	554.492662	554.492662	8.33	0.0042
ethnic	4	1035.021616	258.755404	3.89	0.0043
ethnic*sex	4	288.497851	72.124463	1.08	0.3649

Contrast	DF	Contrast SS	Mean Square	F Value
East Indian vs. Eastern European	1	344.0946069	344.0946069	5.17

Contrast	Pr > F
East Indian vs. Eastern European	0.0238

MANOVA
Two-factor multivariate analysis of variance with proc glm

The GLM Procedure

Dependent Variable: hsgpa   High School GPA

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	310.55623	34.50625	0.95	0.4841
Error	270	9830.58948	36.40959		
Corrected Total	279	10141.14571			

R-Square	Coeff Var	Root MSE	hsgpa Mean
0.030623	7.445488	6.034036	81.04286

Source	DF	Type I SS	Mean Square	F Value	Pr > F
sex	1	6.7744693	6.7744693	0.19	0.6666
ethnic	4	248.1632328	62.0408082	1.70	0.1494
ethnic*sex	4	55.6185313	13.9046328	0.38	0.8215

Source	DF	Type III SS	Mean Square	F Value	Pr > F
sex	1	13.9843931	13.9843931	0.38	0.5359
ethnic	4	258.7560068	64.6890017	1.78	0.1337
ethnic*sex	4	55.6185313	13.9046328	0.38	0.8215

Contrast	DF	Contrast SS	Mean Square	F Value

```
East Indian vs. Eastern European        1    241.1495391   241.1495391      6.62

                        Contrast                          Pr > F

                East Indian vs. Eastern European   0.0106
```

_____

                    Gender, Ethnicity and Math performance   6
                                      MANOVA
              Two-factor multivariate analysis of variance with proc glm

                                The GLM Procedure

Dependent Variable: precalc   Number precalculus correct

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

Model                        9    46.0428927    5.1158770      1.95   0.0452

Error                      270   707.8285359    2.6215872

Corrected Total            279   753.8714286
```

```
            R-Square     Coeff Var      Root MSE     precalc Mean

            0.061075     33.18864       1.619132       4.878571
```

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

sex                          1    29.76535946    29.76535946     11.35   0.0009
ethnic                       4     9.43315033     2.35828758      0.90   0.4647
ethnic*sex                   4     6.84438286     1.71109572      0.65   0.6254
```

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

sex                          1    21.38375900    21.38375900      8.16   0.0046
ethnic                       4     9.73726502     2.43431626      0.93   0.4478
ethnic*sex                   4     6.84438286     1.71109572      0.65   0.6254
```

```
 Contrast                          DF   Contrast SS   Mean Square  F Value

 East Indian vs. Eastern European   1    0.08600276    0.08600276     0.03

                        Contrast                          Pr > F

                East Indian vs. Eastern European   0.8564
```

MANOVA
Two-factor multivariate analysis of variance with proc glm

The GLM Procedure

Dependent Variable: calc   Number calculus correct

		Sum of			
Source	DF	Squares	Mean Square	F Value	Pr > F
Model	9	194.965740	21.662860	3.66	0.0002
Error	270	1597.744974	5.917574		
Corrected Total	279	1792.710714			

R-Square	Coeff Var	Root MSE	calc Mean
0.108755	61.30781	2.432606	3.967857

Source	DF	Type I SS	Mean Square	F Value	Pr > F
sex	1	52.1466798	52.1466798	8.81	0.0033
ethnic	4	103.9582307	25.9895577	4.39	0.0019
ethnic*sex	4	38.8608295	9.7152074	1.64	0.1640

Source	DF	Type III SS	Mean Square	F Value	Pr > F
sex	1	16.9584124	16.9584124	2.87	0.0916
ethnic	4	100.7932772	25.1983193	4.26	0.0023
ethnic*sex	4	38.8608295	9.7152074	1.64	0.1640

Contrast	DF	Contrast SS	Mean Square	F Value
East Indian vs. Eastern European	1	14.71662724	14.71662724	2.49

Contrast	Pr > F
East Indian vs. Eastern European	0.1160

MANOVA
Two-factor multivariate analysis of variance with proc glm

The GLM Procedure

Dependent Variable: grade   Final mark (if any)

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	6544.18313	727.13146	2.20	0.0224
Error	270	89271.30259	330.63445		
Corrected Total	279	95815.48571			

R-Square	Coeff Var	Root MSE	grade Mean
0.068300	29.92793	18.18336	60.75714

Source	DF	Type I SS	Mean Square	F Value	Pr > F
sex	1	51.918770	51.918770	0.16	0.6922
ethnic	4	3916.518972	979.129743	2.96	0.0203
ethnic*sex	4	2575.745384	643.936346	1.95	0.1029

Source	DF	Type III SS	Mean Square	F Value	Pr > F
sex	1	32.408985	32.408985	0.10	0.7545
ethnic	4	3580.224686	895.056171	2.71	0.0307
ethnic*sex	4	2575.745384	643.936346	1.95	0.1029

Contrast	DF	Contrast SS	Mean Square	F Value
East Indian vs. Eastern European	1	2141.898637	2141.898637	6.48

Contrast	Pr > F
East Indian vs. Eastern European	0.0115

                              MANOVA
        Two-factor multivariate analysis of variance with proc glm

                          The GLM Procedure
                    Multivariate Analysis of Variance

        Characteristic Roots and Vectors of: E Inverse * H, where
                  H = Type III SSCP Matrix for sex
                      E = Error SSCP Matrix

| Characteristic | | Characteristic Vector V'EV=1 | | | |
Root	Percent	hscalc calc	hsengl grade	hsgpa	precalc
0.08622236	100.00	-0.00104785 0.00647759	-0.00669145 -0.00147850	0.00489662	0.02599616
0.00000000	0.00	0.00547593 -0.00010633	0.00010984 0.00002427	-0.00008038	-0.00042674
0.00000000	0.00	-0.00119027 0.02805444	0.00123553 0.00026267	-0.00175041	-0.01955675
0.00000000	0.00	-0.00485940 -0.00024393	-0.00413322 0.00035016	0.01564808	-0.00681662
0.00000000	0.00	-0.00110636 -0.00295865	-0.00001262 0.00424706	-0.00709214	0.00227501
0.00000000	0.00	-0.00149918 0.00000000	0.00548449 0.00000000	-0.00125457	0.02719987

                MANOVA Test Criteria and Exact F Statistics
                 for the Hypothesis of No Overall sex Effect
                      H = Type III SSCP Matrix for sex
                        E = Error SSCP Matrix

                   S=1   M=2   N=131.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.92062181	3.81	6	265	0.0012
Pillai's Trace	0.07937819	3.81	6	265	0.0012
Hotelling-Lawley Trace	0.08622236	3.81	6	265	0.0012
Roy's Greatest Root	0.08622236	3.81	6	265	0.0012

```
                Characteristic Roots and Vectors of: E Inverse * H, where
                        H = Type III SSCP Matrix for ethnic
                              E = Error SSCP Matrix

Characteristic              Characteristic Vector  V'EV=1
       Root   Percent         hscalc          hsengl        hsgpa        precalc
                               calc            grade

   0.10368765   56.81      0.00272585      -0.00423316   -0.00128019    0.00075650
                           0.01593342       0.00007187
   0.06149679   33.69      0.00188703       0.00652808   -0.00457843   -0.01165718
                           0.00450553       0.00203217
   0.01169956    6.41     -0.00043004      -0.00530231    0.01254985   -0.01403723
                          -0.00969004       0.00013128
   0.00563092    3.09     -0.00484688      -0.00179879    0.00164592    0.01723305
                          -0.00287452       0.00294502
   0.00000000    0.00     -0.00486404      -0.00118013    0.00687414   -0.02275369
                           0.02138127      -0.00045663
   0.00000000    0.00     -0.00112188      -0.00044623    0.00968088    0.02648979
                           0.00208390      -0.00271695


                   MANOVA Test Criteria and F Approximations for
                     the Hypothesis of No Overall ethnic Effect
                          H = Type III SSCP Matrix for ethnic
                                E = Error SSCP Matrix

                         S=4      M=0.5     N=131.5

Statistic                        Value     F Value    Num DF    Den DF    Pr > F

Wilks' Lambda                 0.83896715      1.99        24    925.68    0.0032
Pillai's Trace                0.16904423      1.97        24      1072    0.0036
Hotelling-Lawley Trace        0.18251491      2.01        24    617.74    0.0032
Roy's Greatest Root           0.10368765      4.63         6       268    0.0002

        NOTE: F Statistic for Roy's Greatest Root is an upper bound.
```

```
              Characteristic Roots and Vectors of: E Inverse * H, where
                     H = Type III SSCP Matrix for ethnic*sex
                            E = Error SSCP Matrix
```

Characteristic Root	Percent	Characteristic Vector V'EV=1			
		hscalc calc	hsengl grade	hsgpa	precalc
0.05516306	54.16	-0.00291912 -0.01751101	0.00390201 0.00233464	-0.00019476	-0.00251432
0.03684967	36.18	0.00005559 0.00089462	-0.00258102 0.00354182	-0.00367955	0.00274690
0.00562644	5.52	-0.00212360 0.00021177	-0.00071505 -0.00098763	0.01002039	0.02642413
0.00421094	4.13	0.00389838 -0.00553579	-0.00055111 -0.00020833	0.00491846	-0.02111850
0.00000000	0.00	-0.00283691 0.02235021	0.00283783 0.00099237	0.00085207	-0.02462521
0.00000000	0.00	0.00482767 -0.00042135	0.00791970 0.00064575	-0.01359704	0.00924282

```
                    MANOVA Test Criteria and F Approximations for
                   the Hypothesis of No Overall ethnic*sex Effect
                       H = Type III SSCP Matrix for ethnic*sex
                              E = Error SSCP Matrix

                         S=4      M=0.5     N=131.5
```

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.90511340	1.12	24	925.68	0.3154
Pillai's Trace	0.09760746	1.12	24	1072	0.3161
Hotelling-Lawley Trace	0.10185012	1.12	24	617.74	0.3153
Roy's Greatest Root	0.05516306	2.46	6	268	0.0246

```
           NOTE: F Statistic for Roy's Greatest Root is an upper bound.
```

```
              Characteristic Roots and Vectors of: E Inverse * H, where
                H = Contrast SSCP Matrix for East Indian vs. Eastern European
                             E = Error SSCP Matrix

Characteristic              Characteristic Vector   V'EV=1
      Root    Percent         hscalc          hsengl         hsgpa         precalc
                               calc            grade

   0.04950287   100.00      0.00259378      0.00433692    -0.00196799    -0.01528737
                            0.00552882      0.00176564
   0.00000000     0.00     -0.00503484     -0.00584212     0.01649742     0.00059942
                           -0.00021679     -0.00006923
   0.00000000     0.00     -0.00052411      0.00087943    -0.00223403     0.03735389
                            0.00120380      0.00038444
   0.00000000     0.00     -0.00209716     -0.00120886    -0.00012113    -0.01303408
                            0.02821491     -0.00043535
   0.00000000     0.00     -0.00259135     -0.00005018    -0.00653748    -0.00711757
                           -0.00311283      0.00411777
   0.00000000     0.00     -0.00401506      0.00618877     0.00000000     0.00000000
                            0.00000000      0.00000000


              MANOVA Test Criteria and Exact F Statistics for the Hypothesis
                   of No Overall East Indian vs. Eastern European Effect
                H = Contrast SSCP Matrix for East Indian vs. Eastern European
                             E = Error SSCP Matrix

                        S=1      M=2      N=131.5

Statistic                        Value     F Value    Num DF    Den DF    Pr > F

Wilks' Lambda                  0.95283208      2.19        6       265     0.0447
Pillai's Trace                 0.04716792      2.19        6       265     0.0447
Hotelling-Lawley Trace         0.04950287      2.19        6       265     0.0447
Roy's Greatest Root            0.04950287      2.19        6       265     0.0447
```

Summarizing the univariate tests,

```
hscalc    HS Calculus

Source                          DF    Type III SS    Mean Square   F Value   Pr > F
ethnic                          4     1717.147646    429.286911    3.45      0.0090

hsengl    HS English
sex                             1      554.492662    554.492662    8.33      0.0042
ethnic                          4     1035.021616    258.755404    3.89      0.0043

hsgpa    High School GPA – nothing

precalc    Number precalculus correct
sex                             1      21.38375900    21.38375900   8.16      0.0046

calc    Number calculus correct
ethnic                          4     100.7932772    25.1983193    4.26      0.0023

grade    Final mark
ethnic                          4     3580.224686    895.056171    2.71      0.0307
```

```
Level of             -----------hscalc-----------    -----------hsengl-----------
sex          N           Mean         Std Dev            Mean          Std Dev

Female      143       77.6993007    11.4289199       78.9510490     6.93564854
Male        137       79.4671533    11.2354815       75.0875912     9.62340472

Level of             -----------hsgpa-----------    -----------precalc----------
sex          N           Mean         Std Dev            Mean          Std Dev

Female      143       81.1951049    5.81846658        4.55944056    1.51342526
Male        137       80.8839416    6.25853809        5.21167883    1.71254307

Level of             -----------calc------------    ------------grade-----------
sex          N           Mean         Std Dev            Mean          Std Dev

Female      143       3.54545455    2.34589024       60.3356643     17.3241442
Male        137       4.40875912    2.65561211       61.1970803     19.7680816
```

MANOVA
Two-factor multivariate analysis of variance with proc glm

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

ethnic	hscalc LSMEAN	LSMEAN Number
Asian	80.6121053	1
East Indian	81.7711670	2
Eastern European	74.8000000	3
European not Eastern	76.4410672	4
Middle-Eastern and Pakistani	80.8311404	5

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

Dependent Variable: hscalc

i/j	1	2	3	4	5
1		1.0000	0.2303	0.2076	1.0000
2	1.0000		0.1088	0.0932	1.0000
3	0.2303	0.1088		1.0000	0.4103
4	0.2076	0.0932	1.0000		0.5949
5	1.0000	1.0000	0.4103	0.5949	

ethnic	hsengl LSMEAN	LSMEAN Number
Asian	74.1257895	1
East Indian	79.8226545	2
Eastern European	75.3000000	3
European not Eastern	78.0609591	4
Middle-Eastern and Pakistani	76.7171053	5

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

Dependent Variable: hsengl

i/j	1	2	3	4	5
1		0.0062	1.0000	0.0296	1.0000
2	0.0062		0.2376	1.0000	1.0000
3	1.0000	0.2376		1.0000	1.0000
4	0.0296	1.0000	1.0000		1.0000
5	1.0000	1.0000	1.0000	1.0000	

```
                                        LSMEAN
          ethnic                    hsgpa LSMEAN     Number

          Asian                        80.9545263         1
          East Indian                  82.9407323         2
          Eastern European             79.1545833         3
          European not Eastern         80.8086626         4
          Middle-Eastern  and Pakistani 80.7532895        5


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

                    Dependent Variable: hsgpa

   i/j         1           2           3           4           5

     1                 1.0000      1.0000      1.0000      1.0000
     2     1.0000                  0.1060      0.5393      1.0000
     3     1.0000      0.1060                  1.0000      1.0000
     4     1.0000      0.5393      1.0000                  1.0000
     5     1.0000      1.0000      1.0000      1.0000


                                  precalc      LSMEAN
          ethnic                   LSMEAN      Number

          Asian                        5.02947368         1
          East Indian                  5.04233410         2
          Eastern European             4.97083333         3
          European not Eastern         4.64235056         4
          Middle-Eastern  and Pakistani 5.06359649        5


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

                   Dependent Variable: precalc

   i/j         1           2           3           4           5

     1                 1.0000      1.0000      1.0000      1.0000
     2     1.0000                  1.0000      1.0000      1.0000
     3     1.0000      1.0000                  1.0000      1.0000
     4     1.0000      1.0000      1.0000                  1.0000
     5     1.0000      1.0000      1.0000      1.0000
```

```
                                                 LSMEAN
            ethnic                     calc LSMEAN    Number

            Asian                       4.49052632       1
            East Indian                 4.56864989       2
            Eastern European            3.63333333       3
            European not Eastern        3.30563999       4
            Middle-Eastern  and Pakistani  4.76973684    5


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

                  Dependent Variable: calc

   i/j        1            2            3            4            5

    1                   1.0000       1.0000       0.0270       1.0000
    2      1.0000                    1.0000       0.0479       1.0000
    3      1.0000       1.0000                    1.0000       0.7732
    4      0.0270       0.0479       1.0000                    0.0413
    5      1.0000       1.0000       0.7732       0.0413


                                                 LSMEAN
            ethnic                    grade LSMEAN    Number

            Asian                      62.2147368       1
            East Indian                68.0629291       2
            Eastern European           56.7791667       3
            European not Eastern       58.0878082       4
            Middle-Eastern  and Pakistani  61.5285088   5


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

                  Dependent Variable: grade

   i/j        1            2            3            4            5

    1                   1.0000       1.0000       1.0000       1.0000
    2      1.0000                    0.1148       0.0290       1.0000
    3      1.0000       0.1148                    1.0000       1.0000
    4      1.0000       0.0290       1.0000                    1.0000
    5      1.0000       1.0000       1.0000       1.0000
```

```
                          The REG Procedure
                           Model: MODEL1
                Dependent Variable: hscalc HS Calculus

        Number of Observations Read                 539
        Number of Observations Used                 280
        Number of Observations with Missing Values  259


                       Analysis of Variance

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

Model                   9  2366.18173    262.90908      2.11    0.0286
Error                 270     33569      124.32837
Corrected Total       279     35935


          Root MSE              11.15026   R-Square    0.0658
          Dependent Mean        78.56429   Adj R-Sq    0.0347
          Coeff Var             14.19253


                       Parameter Estimates

                                    Parameter     Standard
Variable   Label              DF     Estimate        Error   t Value

Intercept  Intercept           1     78.89110      0.77026    102.42
e1                             1      1.72101      1.35279      1.27
e2                             1     -4.09110      1.79869     -2.27
e3                             1     -2.45003      1.13407     -2.16
e4                             1      1.94004      1.76888      1.10
g                              1     -0.06100      0.77026     -0.08
ge1                            1     -2.51111      1.35279     -1.86
ge2                            1      0.76100      1.79869      0.42
ge3                            1     -0.22134      1.13407     -0.20
ge4                            1      1.31319      1.76888      0.74

                       Parameter Estimates

           Variable    Label              DF   Pr > |t|

           Intercept   Intercept           1   <.0001
           e1                              1   0.2044
           e2                              1   0.0237
           e3                              1   0.0316
           e4                              1   0.2737
           g                               1   0.9369
           ge1                             1   0.0645
           ge2                             1   0.6726
           ge3                             1   0.8454
           ge4                             1   0.4585
```

                          MANOVA
              Multivariate regression with effect coding

                        The REG Procedure
                         Model: MODEL1
               Dependent Variable: hsengl HS English

       Number of Observations Read   539
       Number of Observations Used   280
       Number of Observations with Missing Values   259

                    Analysis of Variance

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

Model   9   2500.90235   277.87804   4.18   <.0001
Error   270   17969   66.55209
Corrected Total   279   20470

            Root MSE   8.15795   R-Square   0.1222
            Dependent Mean   77.06071   Adj R-Sq   0.0929
            Coeff Var   10.58639

                      Parameter Estimates

                                       Parameter   Standard
Variable   Label   DF   Estimate   Error   t Value

Intercept   Intercept   1   76.80530   0.56355   136.29
e1   1   -2.67951   0.98975   -2.71
e2   1   -1.50530   1.31599   -1.14
e3   1   1.25566   0.82973   1.51
e4   1   -0.08820   1.29418   -0.07
g   1   1.62668   0.56355   2.89
ge1   1   1.36753   0.98975   1.38
ge2   1   1.07332   1.31599   0.82
ge3   1   0.39173   0.82973   0.47
ge4   1   -1.59378   1.29418   -1.23

                      Parameter Estimates

        Variable   Label   DF   Pr > |t|

        Intercept   Intercept   1   <.0001
        e1   1   0.0072
        e2   1   0.2537
        e3   1   0.1314
        e4   1   0.9457
        g   1   0.0042
        ge1   1   0.1682
        ge2   1   0.4154
        ge3   1   0.6372
        ge4   1   0.2192

```
                       The REG Procedure
                        Model: MODEL1
               Dependent Variable: hsgpa High School GPA

         Number of Observations Read                   539
         Number of Observations Used                   280
         Number of Observations with Missing Values    259


                       Analysis of Variance

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

Model                    9    310.55623      34.50625       0.95   0.4841
Error                  270   9830.58948      36.40959
Corrected Total        279        10141


              Root MSE               6.03404   R-Square     0.0306
              Dependent Mean        81.04286   Adj R-Sq    -0.0017
              Coeff Var              7.44549


                       Parameter Estimates

                                          Parameter     Standard
Variable   Label                  DF       Estimate        Error    t Value

Intercept  Intercept               1       80.92236      0.41683     194.14
e1                                 1        0.03217      0.73207       0.04
e2                                 1       -1.76778      0.97337      -1.82
e3                                 1       -0.11370      0.61371      -0.19
e4                                 1       -0.16907      0.95724      -0.18
g                                  1        0.25833      0.41683       0.62
ge1                                1       -0.32486      0.73207      -0.44
ge2                                1        0.81625      0.97337       0.84
ge3                                1        0.27586      0.61371       0.45
ge4                                1       -0.03662      0.95724      -0.04

                       Parameter Estimates

         Variable   Label                  DF   Pr > |t|

         Intercept  Intercept               1    <.0001
         e1                                 1    0.9650
         e2                                 1    0.0705
         e3                                 1    0.8532
         e4                                 1    0.8599
         g                                  1    0.5359
         ge1                                1    0.6576
         ge2                                1    0.4024
         ge3                                1    0.6534
         ge4                                1    0.9695
```

```
                     The REG Procedure
                      Model: MODEL1
        Dependent Variable: precalc Number precalculus correct

        Number of Observations Read                     539
        Number of Observations Used                     280
        Number of Observations with Missing Values      259


                     Analysis of Variance

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

Model                9     46.04289       5.11588       1.95    0.0452
Error              270    707.82854       2.62159
Corrected Total    279    753.87143


            Root MSE              1.61913    R-Square    0.0611
            Dependent Mean        4.87857    Adj R-Sq    0.0298
            Coeff Var            33.18864


                     Parameter Estimates

                                      Parameter     Standard
Variable   Label                DF     Estimate        Error   t Value

Intercept  Intercept             1      4.94972      0.11185     44.25
e1                               1      0.07976      0.19644      0.41
e2                               1      0.02112      0.26119      0.08
e3                               1     -0.30737      0.16468     -1.87
e4                               1      0.11388      0.25686      0.44
g                                1     -0.31944      0.11185     -2.86
ge1                              1     -0.23003      0.19644     -1.17
ge2                              1     -0.10972      0.26119     -0.42
ge3                              1      0.15328      0.16468      0.93
ge4                              1      0.17251      0.25686      0.67

                     Parameter Estimates

        Variable    Label              DF   Pr > |t|

        Intercept   Intercept           1   <.0001
        e1                              1   0.6851
        e2                              1   0.9356
        e3                              1   0.0631
        e4                              1   0.6579
        g                               1   0.0046
        ge1                             1   0.2426
        ge2                             1   0.6748
        ge3                             1   0.3528
        ge4                             1   0.5024
```

```
                              MANOVA
              Multivariate regression with effect coding

                          The REG Procedure
                            Model: MODEL1
              Dependent Variable: calc Number calculus correct

                          Analysis of Variance

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

Model                    9     194.96574      21.66286       3.66   0.0002
Error                  270    1597.74497       5.91757
Corrected Total        279    1792.71071


            Root MSE              2.43261    R-Square     0.1088
            Dependent Mean        3.96786    Adj R-Sq     0.0790
            Coeff Var            61.30781


                        Parameter Estimates

                                   Parameter      Standard
Variable    Label             DF    Estimate        Error   t Value

Intercept   Intercept          1     4.15358      0.16804     24.72
e1                             1     0.33695      0.29513      1.14
e2                             1    -0.52024      0.39241     -1.33
e3                             1    -0.84794      0.24742     -3.43
e4                             1     0.61616      0.38591      1.60
g                              1    -0.28448      0.16804     -1.69
ge1                            1    -0.64605      0.29513     -2.19
ge2                            1    -0.18219      0.39241     -0.46
ge3                            1     0.05820      0.24742      0.24
ge4                            1     0.26474      0.38591      0.69

                        Parameter Estimates

            Variable    Label             DF   Pr > |t|

            Intercept   Intercept          1    <.0001
            e1                             1    0.2546
            e2                             1    0.1860
            e3                             1    0.0007
            e4                             1    0.1115
            g                              1    0.0916
            ge1                            1    0.0295
            ge2                            1    0.6428
            ge3                            1    0.8142
            ge4                            1    0.4933

_____

              Gender, Ethnicity and Math performance              17
                              MANOVA
              Multivariate regression with effect coding
```

```
                        The REG Procedure
                        Model: MODEL1
              Dependent Variable: grade Final mark (if any)


                        Analysis of Variance

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

Model                    9  6544.18313     727.13146      2.20   0.0224
Error                  270      89271     330.63445
Corrected Total        279      95815


          Root MSE             18.18336   R-Square    0.0683
          Dependent Mean       60.75714   Adj R-Sq    0.0372
          Coeff Var            29.92793


                       Parameter Estimates

                                     Parameter     Standard
Variable   Label                DF    Estimate        Error   t Value

Intercept  Intercept             1    61.33463      1.25611     48.83
e1                               1     0.88011      2.20607      0.40
e2                               1    -4.55546      2.93322     -1.55
e3                               1    -3.24682      1.84939     -1.76
e4                               1     0.19388      2.88462      0.07
g                                1     0.39327      1.25611      0.31
ge1                              1    -1.96800      2.20607     -0.89
ge2                              1    -0.21410      2.93322     -0.07
ge3                              1     0.50305      1.84939      0.27
ge4                              1     6.66156      2.88462      2.31

                       Parameter Estimates

         Variable   Label              DF   Pr > |t|

         Intercept  Intercept           1   <.0001
         e1                             1   0.6902
         e2                             1   0.1216
         e3                             1   0.0803
         e4                             1   0.9465
         g                              1   0.7545
         ge1                            1   0.3731
         ge2                            1   0.9419
         ge3                            1   0.7858
         ge4                            1   0.0217
```

Gender, Ethnicity and Math performance   18
                        MANOVA
             Multivariate regression with effect coding

```
                    The REG Procedure
                  Multivariate Test: Sex

          Multivariate Statistics and Exact F Statistics

                  S=1     M=2     N=131.5

Statistic                     Value    F Value   Num DF   Den DF   Pr > F

Wilks' Lambda              0.92062181     3.81        6      265   0.0012
Pillai's Trace             0.07937819     3.81        6      265   0.0012
Hotelling-Lawley Trace     0.08622236     3.81        6      265   0.0012
Roy's Greatest Root        0.08622236     3.81        6      265   0.0012
```

```
                         MANOVA
            Multivariate regression with effect coding

                    The REG Procedure
                     Model: MODEL1
                  Multivariate Test: Ethnic

          Multivariate Statistics and F Approximations

                  S=4     M=0.5     N=131.5

Statistic                     Value    F Value   Num DF   Den DF   Pr > F

Wilks' Lambda              0.83896715     1.99       24   925.68   0.0032
Pillai's Trace             0.16904423     1.97       24     1072   0.0036
Hotelling-Lawley Trace     0.18251491     2.01       24   617.74   0.0032
Roy's Greatest Root        0.10368765     4.63        6      268   0.0002

        NOTE: F Statistic for Roy's Greatest Root is an upper bound.
```

```
                    The REG Procedure
                     Model: MODEL1
                Multivariate Test: Sex_x_Ethnic

          Multivariate Statistics and F Approximations

                  S=4     M=0.5     N=131.5

Statistic                     Value    F Value   Num DF   Den DF   Pr > F

Wilks' Lambda              0.90511340     1.12       24   925.68   0.3154
Pillai's Trace             0.09760746     1.12       24     1072   0.3161
Hotelling-Lawley Trace     0.10185012     1.12       24   617.74   0.3153
Roy's Greatest Root        0.05516306     2.46        6      268   0.0246

        NOTE: F Statistic for Roy's Greatest Root is an upper bound.
```