Three-factor MANOVA on Math Data

```
/* mvmath.sas */
title2 'MANOVA';
%include 'readmath.sas';

proc glm;
     class sex ethnic tongue;
     model hscalc precalc calc grade = sex|ethnic|tongue;
     manova H = _all_;
     means sex;
```

First we get univariate output for each dependent variable – just show for precalc.

```
                    Gender, Ethnicity and Math performance                    3

                              The GLM Procedure

Dependent Variable: precalc   Number precalculus correct

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

Model                       20    89.0681730      4.4534086      1.75   0.0267

Error                      274   699.1216575      2.5515389

Corrected Total            294   788.1898305


             R-Square     Coeff Var      Root MSE    precalc Mean

             0.113003      33.02168      1.597354        4.837288


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

sex                          1    31.82149901    31.82149901     12.47   0.0005
ethnic                       5    15.66145709     3.13229142      1.23   0.2963
sex*ethnic                   5     8.50546181     1.70109236      0.67   0.6490
tongue                       1     1.24351391     1.24351391      0.49   0.4857
sex*tongue                   1     3.58997793     3.58997793      1.41   0.2366
ethnic*tongue                4    19.53460717     4.88365179      1.91   0.1083
sex*ethnic*tongue            3     8.71165605     2.90388535      1.14   0.3341


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

sex                          1    19.31797386    19.31797386      7.57   0.0063
ethnic                       5    14.17304748     2.83460950      1.11   0.3548
sex*ethnic                   5     6.92345172     1.38469034      0.54   0.7438
tongue                       1     6.43114547     6.43114547      2.52   0.1135
sex*tongue                   1     7.38806211     7.38806211      2.90   0.0900
ethnic*tongue                4    21.55359841     5.38839960      2.11   0.0796
sex*ethnic*tongue            3     8.71165605     2.90388535      1.14   0.3341
```

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 Root	Percent	Characteristic Vector V'EV=1 hscalc	precalc	calc	grade
0.03651271	100.00	-0.00107107	0.03385207	0.01029194	-0.00121054
0.00000000	0.00	0.00552150	-0.00199766	-0.00060734	0.00007144
0.00000000	0.00	-0.00332923	0.00062397	-0.00049007	0.00399576
0.00000000	0.00	-0.00097617	-0.02702827	0.02677931	0.00000000

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=1 N=134.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.96477350	2.47	4	271	0.0448
Pillai's Trace	0.03522650	2.47	4	271	0.0448
Hotelling-Lawley Trace	0.03651271	2.47	4	271	0.0448
Roy's Greatest Root	0.03651271	2.47	4	271	0.0448

None of the other multivariate tests is significant. For example,

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 N=134.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.92155732	1.12	20	899.76	0.3201
Pillai's Trace	0.08043445	1.12	20	1096	0.3168
Hotelling-Lawley Trace	0.08297815	1.12	20	588.8	0.3236
Roy's Greatest Root	0.04475190	2.45	5	274	0.0340

The GLM Procedure

Level of sex	N	hscalc Mean	hscalc Std Dev	precalc Mean	precalc Std Dev
Female	151	77.3311258	11.5526169	4.51655629	1.50932349
Male	144	79.5416667	11.0433823	5.17361111	1.70285594