

```

/* MultiMath.sas */
%include 'readexplor.sas'; /* Creates data set explore */
title2 'Manova with proc glm and proc reg';

/* The data step continues ... */

if course2=. then c1=.; else if course2=1 then c1=1; else c1=0;
if course2=. then c2=.; else if course2=2 then c2=1; else c2=0;
if course2=. then c3=.; else if course2=3 then c3=1; else c3=0;
label c1 = 'Catch-up' c2 = 'Mainstream' c3 = 'Elite';

c1gpa = c1*hsgpa; c3gpa = c3*hsgpa;
c1calc = c1*hscal; c3calc = c3*hscal;

proc freq;
tables course2*tongue /nocol nopercnt chisq;

proc glm;
title3 'Illustrate 2-way Manova';
class course2 tongue;
model precalc calc = course2|tongue;
manova h = _all_;

proc glm;
title3 'Illustrate Multivariate Tests of Contrasts';
class course2;
model precalc calc = course2;
manova h = _all_;
means course2;
contrast 'Catch-up versus Elite' course2 1 -1 0;
contrast 'Catch-up versus Mainstream' course2 1 0 -1;
contrast 'Elite versus Mainstream' course2 0 1 -1;
manova h = _all_;

proc reg;
title3 'Test Parallel planes with proc reg';
model precalc calc = hsgpa hscal c1 c3 c1gpa c3gpa c1calc c3calc;
Interaction: test c1gpa=c3gpa=c1calc=c3calc=0;
Interaction: mtest c1gpa=c3gpa=c1calc=c3calc=0;

proc glm;
title3 'Test Parallel planes with proc glm';
class course;
model precalc calc = hsgpa hscal course hsgpa*course hscal*course;
manova h = _all_;

/* Drop the interaction */

proc reg;
title3 'Test Course Controlling for HS and HS Controlling for Course';
model precalc calc = hsgpa hscal c1 c3;
course: test c1=c3=0; course: mtest c1=c3=0;
High_School: test hsgpa=hscal=0; High_School: mtest hsgpa=hscal=0;

```

Manova with proc glm and proc reg

The FREQ Procedure

Table of course2 by tongue

course2
tongue(Mother Tongue (Eng or Other))

Frequency	English	Other	Total
Catch-up	45	11	56
	80.36	19.64	
Mainstrm	274	97	371
	73.85	26.15	
Elite	24	13	37
	64.86	35.14	
Total	343	121	464

Frequency Missing = 115

Statistics for Table of course2 by tongue

Statistic	DF	Value	Prob
Chi-Square	2	2.7784	0.2493
Likelihood Ratio Chi-Square	2	2.7559	0.2521
Mantel-Haenszel Chi-Square	1	2.7149	0.0994
Phi Coefficient		0.0774	
Contingency Coefficient		0.0772	
Cramer's V		0.0774	

Effective Sample Size = 464

Frequency Missing = 115

WARNING: 20% of the data are missing.

Prediction of Performance in First-year Calculus
Manova with proc glm and proc reg
Illustrate 2-way Manova

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The GLM Procedure

Class Level Information

Class	Levels	Values
course2	3	Catch-up Elite Mainstrm
tongue	2	English Other

Prediction of Performance in First-year Calculus
 Manova with proc glm and proc reg
 Illustrate 2-way Manova

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The GLM Procedure

Dependent Variable: precalc Number precalculus correct

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	121.480221	24.296044	8.79	<.0001
Error	458	1265.569348	2.763252		
Corrected Total	463	1387.049569			

R-Square	Coeff Var	Root MSE	precalc Mean
0.087582	37.60647	1.662303	4.420259

Source	DF	Type I SS	Mean Square	F Value	Pr > F
course2	2	115.6207881	57.8103940	20.92	<.0001
tongue	1	3.4979516	3.4979516	1.27	0.2611
course2*tongue	2	2.3614817	1.1807408	0.43	0.6525

Source	DF	Type III SS	Mean Square	F Value	Pr > F
course2	2	68.81324540	34.40662270	12.45	<.0001
tongue	1	0.96280170	0.96280170	0.35	0.5553
course2*tongue	2	2.36148170	1.18074085	0.43	0.6525

Prediction of Performance in First-year Calculus
 Manova with proc glm and proc reg
 Illustrate 2-way Manova

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The GLM Procedure

Dependent Variable: calc Number calculus correct

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	320.952595	64.190519	11.61	<.0001
Error	458	2532.786629	5.530102		
Corrected Total	463	2853.739224			

R-Square	Coeff Var	Root MSE	calc Mean
0.112467	70.17043	2.351617	3.351293

Source	DF	Type I SS	Mean Square	F Value	Pr > F
course2	2	306.8683948	153.4341974	27.75	<.0001
tongue	1	2.4674099	2.4674099	0.45	0.5045
course2*tongue	2	11.6167903	5.8083952	1.05	0.3507

Source	DF	Type III SS	Mean Square	F Value	Pr > F
course2	2	185.2852298	92.6426149	16.75	<.0001
tongue	1	13.1153973	13.1153973	2.37	0.1242
course2*tongue	2	11.6167903	5.8083952	1.05	0.3507

Prediction of Performance in First-year Calculus 5
 Manova with proc glm and proc reg
 Illustrate 2-way Manova

The GLM Procedure
 Multivariate Analysis of Variance

Characteristic Roots and Vectors of: E Inverse * H, where
 H = Type III SSCP Matrix for course2
 E = Error SSCP Matrix

Characteristic Root	Percent	Characteristic Vector precalc	V'EV=1 calc
0.08920429	99.94	0.01329343	0.01384304
0.00005401	0.06	-0.02837043	0.01728726

MANOVA Test Criteria and F Approximations for
 the Hypothesis of No Overall course2 Effect
 H = Type III SSCP Matrix for course2
 E = Error SSCP Matrix

S=2 M=-0.5 N=227.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.91805183	9.98	4	914	<.0001
Pillai's Trace	0.08195259	9.78	4	916	<.0001
Hotelling-Lawley Trace	0.08925830	10.19	4	547.36	<.0001
Roy's Greatest Root	0.08920429	20.43	2	458	<.0001

NOTE: F Statistic for Roy's Greatest Root is an upper bound.
 NOTE: F Statistic for Wilks' Lambda is exact.

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

Characteristic Root	Percent	Characteristic Vector precalc	V'EV=1 calc
0.00520013	100.00	-0.00203237	0.02046273
0.00000000	0.00	0.03126445	-0.00847088

MANOVA Test Criteria and Exact F Statistics for
the Hypothesis of No Overall tongue Effect

H = Type III SSCP Matrix for tongue

E = Error SSCP Matrix

S=1 M=0 N=227.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.99482677	1.19	2	457	0.3057
Pillai's Trace	0.00517323	1.19	2	457	0.3057
Hotelling-Lawley Trace	0.00520013	1.19	2	457	0.3057
Roy's Greatest Root	0.00520013	1.19	2	457	0.3057

Prediction of Performance in First-year Calculus

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Manova with proc glm and proc reg

Illustrate 2-way Manova

The GLM Procedure

Multivariate Analysis of Variance

Characteristic Roots and Vectors of: E Inverse * H, where

H = Type III SSCP Matrix for course2*tongue

E = Error SSCP Matrix

Characteristic Root	Percent	Characteristic Vector precalc	V'EV=1 calc
0.00725072	83.74	-0.02115546	0.02126034
0.00140756	16.26	0.02310937	0.00620298

MANOVA Test Criteria and F Approximations for the
Hypothesis of No Overall course2*tongue Effect

H = Type III SSCP Matrix for course2*tongue

E = Error SSCP Matrix

S=2 M=-0.5 N=227.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.99140601	0.99	4	914	0.4130
Pillai's Trace	0.00860411	0.99	4	916	0.4123
Hotelling-Lawley Trace	0.00865828	0.99	4	547.36	0.4132
Roy's Greatest Root	0.00725072	1.66	2	458	0.1912

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

NOTE: F Statistic for Wilks' Lambda is exact.

Prediction of Performance in First-year Calculus 7
 Manova with proc glm and proc reg
 Illustrate Multivariate Tests of Contrasts

The GLM Procedure

Class Level Information

Class	Levels	Values
course2	3	Catch-up Elite Mainstrm

Number of Observations Read 579
 Number of Observations Used 471

Prediction of Performance in First-year Calculus 8
 Manova with proc glm and proc reg
 Illustrate Multivariate Tests of Contrasts

The GLM Procedure

Dependent Variable: precalc Number precalculus correct

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	127.329928	63.664964	23.13	<.0001
Error	468	1288.215719	2.752598		
Corrected Total	470	1415.545648			

R-Square 0.089951
 Coeff Var 37.65947
 Root MSE 1.659095
 precalc Mean 4.405520

Source	DF	Type I SS	Mean Square	F Value	Pr > F
course2	2	127.3299283	63.6649642	23.13	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
course2	2	127.3299283	63.6649642	23.13	<.0001

Prediction of Performance in First-year Calculus 9
 Manova with proc glm and proc reg
 Illustrate Multivariate Tests of Contrasts

The GLM Procedure

Dependent Variable: calc Number calculus correct

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	315.176692	157.588346	28.66	<.0001
Error	468	2573.154518	5.498193		
Corrected Total	470	2888.331210			

R-Square Coeff Var Root MSE calc Mean
0.109121 70.38951 2.344823 3.331210

Source	DF	Type I SS	Mean Square	F Value	Pr > F
course2	2	315.1766918	157.5883459	28.66	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
course2	2	315.1766918	157.5883459	28.66	<.0001

Prediction of Performance in First-year Calculus 10
Manova with proc glm and proc reg
Illustrate Multivariate Tests of Contrasts

The GLM Procedure
Multivariate Analysis of Variance

Characteristic Roots and Vectors of: E Inverse * H, where
H = Type III SSCP Matrix for course2
E = Error SSCP Matrix

Characteristic Root	Percent	Characteristic Vector precalc	V'EV=1 calc
0.15443692	99.43	0.01412446	0.01318294
0.00088831	0.57	-0.02755480	0.01749869

MANOVA Test Criteria and F Approximations for
the Hypothesis of No Overall course2 Effect
H = Type III SSCP Matrix for course2
E = Error SSCP Matrix

S=2 M=-0.5 N=232.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.86545437	17.49	4	934	<.0001
Pillai's Trace	0.13466436	16.89	4	936	<.0001
Hotelling-Lawley Trace	0.15532523	18.12	4	559.36	<.0001
Roy's Greatest Root	0.15443692	36.14	2	468	<.0001

NOTE: F Statistic for Roy's Greatest Root is an upper bound.
NOTE: F Statistic for Wilks' Lambda is exact.

Prediction of Performance in First-year Calculus 11
 Manova with proc glm and proc reg
 Illustrate Multivariate Tests of Contrasts

The GLM Procedure

Level of course2	N	-----precalc-----		-----calc-----	
		Mean	Std Dev	Mean	Std Dev
Catch-up	59	3.16949153	1.60980340	1.30508475	1.47688205
Elite	39	5.33333333	1.76714658	4.56410256	2.82651796
Mainstrm	373	4.50402145	1.65526528	3.52278820	2.40018833

Prediction of Performance in First-year Calculus 12
 Manova with proc glm and proc reg
 Illustrate Multivariate Tests of Contrasts

The GLM Procedure
 Multivariate Analysis of Variance

Characteristic Roots and Vectors of: E Inverse * H, where
 H = Type III SSCP Matrix for course2
 E = Error SSCP Matrix

Characteristic Root	Percent	Characteristic Vector	
		precalc	V'EV=1 calc
0.15443692	99.43	0.01412446	0.01318294
0.00088831	0.57	-0.02755480	0.01749869

MANOVA Test Criteria and F Approximations for
 the Hypothesis of No Overall course2 Effect
 H = Type III SSCP Matrix for course2
 E = Error SSCP Matrix

S=2 M=-0.5 N=232.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.86545437	17.49	4	934	<.0001
Pillai's Trace	0.13466436	16.89	4	936	<.0001
Hotelling-Lawley Trace	0.15532523	18.12	4	559.36	<.0001
Roy's Greatest Root	0.15443692	36.14	2	468	<.0001

NOTE: F Statistic for Roy's Greatest Root is an upper bound.
 NOTE: F Statistic for Wilks' Lambda is exact.

Characteristic Roots and Vectors of: E Inverse * H, where
 H = Contrast SSCP Matrix for Catch-up versus Elite
 E = Error SSCP Matrix

Characteristic Root	Percent	Characteristic Vector	
		precalc	V'EV=1 calc

0.12709242	100.00	0.01508782	0.01255737
0.00000000	0.00	-0.02703933	0.01795290

MANOVA Test Criteria and Exact F Statistics for the Hypothesis
of No Overall Catch-up versus Elite Effect

H = Contrast SSCP Matrix for Catch-up versus Elite
E = Error SSCP Matrix

S=1 M=0 N=232.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.88723868	29.68	2	467	<.0001
Pillai's Trace	0.11276132	29.68	2	467	<.0001
Hotelling-Lawley Trace	0.12709242	29.68	2	467	<.0001
Roy's Greatest Root	0.12709242	29.68	2	467	<.0001

Prediction of Performance in First-year Calculus 13
Manova with proc glm and proc reg
Illustrate Multivariate Tests of Contrasts

The GLM Procedure
Multivariate Analysis of Variance

Characteristic Roots and Vectors of: E Inverse * H, where
H = Contrast SSCP Matrix for Catch-up versus Mainstream
E = Error SSCP Matrix

Characteristic Root	Percent	Characteristic Vector precalc	V'EV=1 calc
0.11799932	100.00	0.01294720	0.01391076
0.00000000	0.00	-0.02812716	0.01692586

MANOVA Test Criteria and Exact F Statistics for the Hypothesis
of No Overall Catch-up versus Mainstream Effect

H = Contrast SSCP Matrix for Catch-up versus Mainstream
E = Error SSCP Matrix

S=1 M=0 N=232.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.89445492	27.55	2	467	<.0001
Pillai's Trace	0.10554508	27.55	2	467	<.0001
Hotelling-Lawley Trace	0.11799932	27.55	2	467	<.0001
Roy's Greatest Root	0.11799932	27.55	2	467	<.0001

Characteristic Roots and Vectors of: E Inverse * H, where
H = Contrast SSCP Matrix for Elite versus Mainstream
E = Error SSCP Matrix

Characteristic Root	Percent	Characteristic Vector precalc	V'EV=1 calc
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0.02361023	100.00	0.01882973	0.00983690
0.00000000	0.00	-0.02458066	0.01957625

MANOVA Test Criteria and Exact F Statistics for the Hypothesis
of No Overall Elite versus Mainstream Effect

H = Contrast SSCP Matrix for Elite versus Mainstream

E = Error SSCP Matrix

S=1 M=0 N=232.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.97693435	5.51	2	467	0.0043
Pillai's Trace	0.02306565	5.51	2	467	0.0043
Hotelling-Lawley Trace	0.02361023	5.51	2	467	0.0043
Roy's Greatest Root	0.02361023	5.51	2	467	0.0043

Prediction of Performance in First-year Calculus 14

Manova with proc glm and proc reg

Illustrate Multivariate Tests of Contrasts

The GLM Procedure

Dependent Variable: precalc Number precalculus correct

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
Catch-up versus Elite	1	109.9364119	109.9364119	39.94	<.0001
Catch-up versus Mainstream	1	90.7264104	90.7264104	32.96	<.0001
Elite versus Mainstream	1	24.2835403	24.2835403	8.82	0.0031

Prediction of Performance in First-year Calculus 15

Manova with proc glm and proc reg

Illustrate Multivariate Tests of Contrasts

The GLM Procedure

Dependent Variable: calc Number calculus correct

Contrast	DF	Contrast SS	Mean Square	F Value	Pr > F
Catch-up versus Elite	1	249.3813737	249.3813737	45.36	<.0001
Catch-up versus Mainstream	1	250.5440215	250.5440215	45.57	<.0001
Elite versus Mainstream	1	38.2859950	38.2859950	6.96	0.0086

Prediction of Performance in First-year Calculus 16

Manova with proc glm and proc reg

Test Parallel planes with proc reg

The REG Procedure

Model: MODEL1

Dependent Variable: precalc Number precalculus correct

Number of Observations Read	579
Number of Observations Used	375
Number of Observations with Missing Values	204

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	190.07839	23.75980	9.81	<.0001
Error	366	886.31095	2.42161		
Corrected Total	374	1076.38933			

Root MSE	1.55615	R-Square	0.1766
Dependent Mean	4.59467	Adj R-Sq	0.1586
Coeff Var	33.86870		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value
Intercept	Intercept	1	-1.80811	1.20575	-1.50
hsgpa	High School GPA	1	0.05344	0.01884	2.84
hscalc	HS Calculus	1	0.02766	0.00918	3.01
c1	Catch-up	1	-3.73461	6.14730	-0.61
c3	Elite	1	-3.42358	3.56319	-0.96
c1gpa		1	0.04412	0.08835	0.50
c3gpa		1	0.01052	0.05720	0.18
c1calc		1	0.00047099	0.04041	0.01
c3calc		1	0.03971	0.04366	0.91

Parameter Estimates

Variable	Label	DF	Pr > t
Intercept	Intercept	1	0.1346
hsgpa	High School GPA	1	0.0048
hscalc	HS Calculus	1	0.0028
c1	Catch-up	1	0.5439
c3	Elite	1	0.3373
c1gpa		1	0.6178
c3gpa		1	0.8542
c1calc		1	0.9907
c3calc		1	0.3638

Prediction of Performance in First-year Calculus
 Manova with proc glm and proc reg
 Test Parallel planes with proc reg

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

Number of Observations Read	579
Number of Observations Used	375
Number of Observations with Missing Values	204

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	531.33495	66.41687	13.63	<.0001
Error	366	1783.76905	4.87369		
Corrected Total	374	2315.10400			

Root MSE	2.20764	R-Square	0.2295
Dependent Mean	3.58400	Adj R-Sq	0.2127
Coeff Var	61.59717		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value
Intercept	Intercept	1	-6.10872	1.71054	-3.57
hsgpa	High School GPA	1	0.05590	0.02673	2.09
hscal	HS Calculus	1	0.06886	0.01302	5.29
c1	Catch-up	1	2.42545	8.72088	0.28
c3	Elite	1	0.12792	5.05493	0.03
c1gpa		1	0.05214	0.12534	0.42
c3gpa		1	-0.08720	0.08115	-1.07
c1calc		1	-0.11514	0.05733	-2.01
c3calc		1	0.09003	0.06194	1.45

Parameter Estimates

Variable	Label	DF	Pr > t
Intercept	Intercept	1	0.0004
hsgpa	High School GPA	1	0.0372
hscal	HS Calculus	1	<.0001
c1	Catch-up	1	0.7811
c3	Elite	1	0.9798
c1gpa		1	0.6777
c3gpa		1	0.2833
c1calc		1	0.0453
c3calc		1	0.1470

Prediction of Performance in First-year Calculus
 Manova with proc glm and proc reg
 Test Parallel planes with proc reg

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The REG Procedure
 Model: MODEL1

Test Interaction results

Dependent Variable	Source	DF	Mean Square	F Value	Pr > F
precalc	Numerator	4	1.27593	0.53	0.7160
	Denominator	366	2.42161		

calc	Numerator	4	8.06705	1.66	0.1598
	Denominator	366	4.87369		

Prediction of Performance in First-year Calculus 19
 Manova with proc glm and proc reg
 Test Parallel planes with proc reg

The REG Procedure
 Model: MODEL1
 Multivariate Test: Interaction

Multivariate Statistics and F Approximations

S=2 M=0.5 N=181.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.97529374	1.15	8	730	0.3283
Pillai's Trace	0.02481515	1.15	8	732	0.3276
Hotelling-Lawley Trace	0.02522048	1.15	8	519.11	0.3288
Roy's Greatest Root	0.01949287	1.78	4	366	0.1315

NOTE: F Statistic for Roy's Greatest Root is an upper bound.
 NOTE: F Statistic for Wilks' Lambda is exact.

Prediction of Performance in First-year Calculus 20
 Manova with proc glm and proc reg
 Test Parallel planes with proc glm

The GLM Procedure

Class Level Information

Class	Levels	Values
course	3	Catch-up Elite Mainstrm

Number of Observations Read 579
 Number of Observations Used 375

Prediction of Performance in First-year Calculus 21
 Manova with proc glm and proc reg
 Test Parallel planes with proc glm

The GLM Procedure

Dependent Variable: precalc Number precalculus correct

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	190.078385	23.759798	9.81	<.0001
Error	366	886.310948	2.421615		
Corrected Total	374	1076.389333			

R-Square Coeff Var Root MSE precalc Mean
0.176589 33.86870 1.556154 4.594667

Source	DF	Type I SS	Mean Square	F Value	Pr > F
hsgpa	1	132.6126772	132.6126772	54.76	<.0001
hscal	1	37.8578531	37.8578531	15.63	<.0001
course	2	14.5041385	7.2520693	2.99	0.0513
hsgpa*course	2	3.0986872	1.5493436	0.64	0.5280
hscal*course	2	2.0050293	1.0025146	0.41	0.6613

Source	DF	Type III SS	Mean Square	F Value	Pr > F
hsgpa	1	10.43433342	10.43433342	4.31	0.0386
hscal	1	10.62892032	10.62892032	4.39	0.0369
course	2	2.95471560	1.47735780	0.61	0.5439
hsgpa*course	2	0.65782532	0.32891266	0.14	0.8730
hscal*course	2	2.00502929	1.00251465	0.41	0.6613

Prediction of Performance in First-year Calculus
Manova with proc glm and proc reg
Test Parallel planes with proc glm

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The GLM Procedure

Dependent Variable: calc Number calculus correct

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	531.334954	66.416869	13.63	<.0001
Error	366	1783.769046	4.873686		
Corrected Total	374	2315.104000			

R-Square Coeff Var Root MSE calc Mean
0.229508 61.59717 2.207643 3.584000

Source	DF	Type I SS	Mean Square	F Value	Pr > F
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hsgpa	1	297.8573151	297.8573151	61.12	<.0001
hscal	1	185.1085439	185.1085439	37.98	<.0001
course	2	16.1008817	8.0504409	1.65	0.1931
hsgpa*course	2	0.8866151	0.4433075	0.09	0.9131
hscal*course	2	31.3815985	15.6907992	3.22	0.0411

Source	DF	Type III SS	Mean Square	F Value	Pr > F
hsgpa	1	3.97323060	3.97323060	0.82	0.3672
hscal	1	23.07613897	23.07613897	4.73	0.0302
course	2	0.37721365	0.18860683	0.04	0.9620
hsgpa*course	2	6.81073185	3.40536592	0.70	0.4979
hscal*course	2	31.38159845	15.69079923	3.22	0.0411

Prediction of Performance in First-year Calculus

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Manova with proc glm and proc reg
 Test Parallel planes 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 hsgpa
 E = Error SSCP Matrix

Characteristic Root	Percent	Characteristic Vector precalc	V'EV=1 calc
0.01184169	100.00	0.03249132	0.00193919
0.00000000	0.00	-0.01563911	0.02534384

MANOVA Test Criteria and Exact F Statistics for
 the Hypothesis of No Overall hsgpa Effect

H = Type III SSCP Matrix for hsgpa
 E = Error SSCP Matrix

S=1 M=0 N=181.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.98829689	2.16	2	365	0.1167
Pillai's Trace	0.01170311	2.16	2	365	0.1167
Hotelling-Lawley Trace	0.01184169	2.16	2	365	0.1167
Roy's Greatest Root	0.01184169	2.16	2	365	0.1167

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

Characteristic Root	Percent	Characteristic Vector precalc	V'EV=1 calc
0.01828797	100.00	0.01950566	0.01491343
0.00000000	0.00	-0.03032815	0.02058301

MANOVA Test Criteria and Exact F Statistics for
the Hypothesis of No Overall hscalc Effect

H = Type III SSCP Matrix for hscalc

E = Error SSCP Matrix

S=1 M=0 N=181.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.98204048	3.34	2	365	0.0366
Pillai's Trace	0.01795952	3.34	2	365	0.0366
Hotelling-Lawley Trace	0.01828797	3.34	2	365	0.0366
Roy's Greatest Root	0.01828797	3.34	2	365	0.0366

Prediction of Performance in First-year Calculus

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Manova with proc glm and proc reg

Test Parallel planes 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 course

E = Error SSCP Matrix

Characteristic Root	Percent	Characteristic Vector precalc	V'EV=1 calc
0.00436145	97.20	0.03569213	-0.01252023
0.00012567	2.80	0.00513215	0.02212046

MANOVA Test Criteria and F Approximations for
the Hypothesis of No Overall course Effect

H = Type III SSCP Matrix for course

E = Error SSCP Matrix

S=2 M=-0.5 N=181.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.99553238	0.41	4	730	0.8022
Pillai's Trace	0.00446816	0.41	4	732	0.8017
Hotelling-Lawley Trace	0.00448712	0.41	4	436.96	0.8021
Roy's Greatest Root	0.00436145	0.80	2	366	0.4509

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

NOTE: F Statistic for Wilks' Lambda is exact.

Characteristic Roots and Vectors of: E Inverse * H, where

H = Type III SSCP Matrix for hsgpa*course

E = Error SSCP Matrix

Characteristic Root	Percent	Characteristic Vector precalc	V'EV=1 calc
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0.00442304	85.75	-0.01460297	0.02539252
0.00073484	14.25	0.03297000	0.00113612

Prediction of Performance in First-year Calculus 25
 Manova with proc glm and proc reg
 Test Parallel planes with proc glm

The GLM Procedure
 Multivariate Analysis of Variance

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

S=2 M=-0.5 N=181.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.99486537	0.47	4	730	0.7575
Pillai's Trace	0.00513786	0.47	4	732	0.7568
Hotelling-Lawley Trace	0.00515788	0.47	4	436.96	0.7576
Roy's Greatest Root	0.00442304	0.81	2	366	0.4459

NOTE: F Statistic for Roy's Greatest Root is an upper bound.
 NOTE: F Statistic for Wilks' Lambda is exact.

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

Characteristic Root	Percent	Characteristic Vector precalc	V'EV=1 calc
0.01808305	91.78	-0.00622219	0.02491724
0.00162002	8.22	0.03551833	-0.00502018

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

S=2 M=-0.5 N=181.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.98064947	1.79	4	730	0.1286
Pillai's Trace	0.01937926	1.79	4	732	0.1288
Hotelling-Lawley Trace	0.01970307	1.80	4	436.96	0.1285
Roy's Greatest Root	0.01808305	3.31	2	366	0.0376

NOTE: F Statistic for Roy's Greatest Root is an upper bound.
 NOTE: F Statistic for Wilks' Lambda is exact.

The REG Procedure

Model: MODEL1

Dependent Variable: precalc Number precalculus correct

Number of Observations Read 579
 Number of Observations Used 375
 Number of Observations with Missing Values 204

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	184.97467	46.24367	19.19	<.0001
Error	370	891.41466	2.40923		
Corrected Total	374	1076.38933			

Root MSE 1.55217 R-Square 0.1718
 Dependent Mean 4.59467 Adj R-Sq 0.1629
 Coeff Var 33.78197

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value
Intercept	Intercept	1	-2.28644	1.10791	-2.06
hsgpa	High School GPA	1	0.05875	0.01723	3.41
hscal	HS Calculus	1	0.02835	0.00868	3.26
c1	Catch-up	1	-0.34743	0.36447	-0.95
c3	Elite	1	0.66739	0.29952	2.23

Parameter Estimates

Variable	Label	DF	Pr > t
Intercept	Intercept	1	0.0397
hsgpa	High School GPA	1	0.0007
hscal	HS Calculus	1	0.0012
c1	Catch-up	1	0.3411
c3	Elite	1	0.0265

The REG Procedure

Model: MODEL1

Dependent Variable: calc Number calculus correct

Number of Observations Read	579
Number of Observations Used	375
Number of Observations with Missing Values	204

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	499.06674	124.76669	25.42	<.0001
Error	370	1816.03726	4.90821		
Corrected Total	374	2315.10400			

Root MSE	2.21545	R-Square	0.2156
Dependent Mean	3.58400	Adj R-Sq	0.2071
Coeff Var	61.81495		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard Error	t Value
Intercept	Intercept	1	-5.92944	1.58135	-3.75
hsgpa	High School GPA	1	0.05506	0.02460	2.24
hscalc	HS Calculus	1	0.06739	0.01239	5.44
c1	Catch-up	1	-0.72064	0.52022	-1.39
c3	Elite	1	0.47902	0.42751	1.12

Parameter Estimates

Variable	Label	DF	Pr > t
Intercept	Intercept	1	0.0002
hsgpa	High School GPA	1	0.0258
hscalc	HS Calculus	1	<.0001
c1	Catch-up	1	0.1668
c3	Elite	1	0.2632

Prediction of Performance in First-year Calculus
 Manova with proc glm and proc reg
 Test Course Controlling for HS and HS Controlling for Course

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The REG Procedure
 Model: MODEL1

Test course results

Dependent Variable	Source	DF	Mean Square	F Value	Pr > F
precalc	Numerator	2	7.25207	3.01	0.0505
	Denominator	370	2.40923		

calc	Numerator	2	8.05044	1.64	0.1953

Denominator 370 4.90821

Prediction of Performance in First-year Calculus 29
Manova with proc glm and proc reg
Test Course Controlling for HS and HS Controlling for Course

The REG Procedure
Model: MODEL1
Multivariate Test: course

Multivariate Statistics and F Approximations

S=2 M=-0.5 N=183.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.98034672	1.84	4	738	0.1192
Pillai's Trace	0.01968689	1.84	4	740	0.1194
Hotelling-Lawley Trace	0.02001298	1.84	4	441.76	0.1193
Roy's Greatest Root	0.01812063	3.35	2	370	0.0361

NOTE: F Statistic for Roy's Greatest Root is an upper bound.
NOTE: F Statistic for Wilks' Lambda is exact.

Prediction of Performance in First-year Calculus 30
Manova with proc glm and proc reg
Test Course Controlling for HS and HS Controlling for Course

The REG Procedure
Model: MODEL1

Test High_School results

Dependent Variable	Source	DF	Mean Square	F Value	Pr > F
precalc	Numerator	2	69.88517	29.01	<.0001
	Denominator	370	2.40923		

calc	Numerator	2	196.11343	39.96	<.0001
	Denominator	370	4.90821		

Prediction of Performance in First-year Calculus 31
Manova with proc glm and proc reg
Test Course Controlling for HS and HS Controlling for Course

The REG Procedure
Model: MODEL1
Multivariate Test: High_School

Multivariate Statistics and F Approximations

S=2 M=-0.5 N=183.5

Statistic	Value	F Value	Num DF	Den DF	Pr > F
Wilks' Lambda	0.78078696	24.30	4	738	<.0001
Pillai's Trace	0.22054736	22.93	4	740	<.0001
Hotelling-Lawley Trace	0.27905014	25.72	4	441.76	<.0001
Roy's Greatest Root	0.27278532	50.47	2	370	<.0001

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

NOTE: F Statistic for Wilks' Lambda is exact.