
Contents

Preface	VII
1 Introduction to the SAS Language	1
1.1 Introduction	1
1.2 Basic Language: Rules and Syntax	5
1.3 Creating SAS Data Sets	8
1.4 The INPUT Statement	11
1.5 SAS Data Step Programming Statements and Their Uses	16
1.6 Data Step Processing	24
1.7 More on INPUT Statement	31
1.7.1 Use of pointer controls	31
1.7.2 The <code>trailing @</code> line-hold specifier	33
1.7.3 The <code>trailing @@</code> line-hold specifier	35
1.7.4 Use of RETAIN statement	36
1.7.5 The use of line pointer controls	38
1.8 Using SAS Procedures	40
1.9 Exercises	48
2 More on SAS Programming and Some Applications	55
2.1 More on the DATA and PROC Steps	55
2.1.1 Reading data from files	56
2.1.2 Combining SAS data sets	58
2.1.3 Saving and retrieving permanent SAS data sets	64
2.1.4 User-defined informats and formats	69
2.1.5 Creating SAS data sets in procedure steps	74
2.2 SAS Procedures for Computing Statistics	79
2.2.1 The UNIVARIATE procedure	81
2.2.2 The FREQ procedure	88
2.3 Some Useful Base SAS Procedures	103
2.3.1 The PLOT procedure	104
2.3.2 The CHART procedure	113

2.3.3	The TABULATE procedure	119
2.4	Exercises	122
3	Statistical Graphics Using SAS/GRAFH	129
3.1	Introduction	129
3.2	An Introduction to SAS/GRAFH.....	129
3.2.1	Useful SAS/GRAFH procedures.....	130
GPLOT procedure	130	
GCHART procedure	133	
3.2.2	Writing SAS/GRAFH programs.....	136
3.3	Quantile Plots	146
3.4	Empirical Quantile-Quantile Plots	151
3.5	Theoretical Quantile-Quantile Plots or Probability Plots.....	154
3.6	Profile Plots of Means or Interaction Plots	159
3.7	Two-Dimensional Scatter Plots and Scatter Plot Matrices	163
3.7.1	Two-Dimensional Scatter Plots.....	163
3.7.2	Scatter Plot Matrices	166
3.8	Histograms, Bar Charts, and Pie Charts.....	169
3.9	Other SAS Procedures for High-Resolution Graphics	175
3.10	Exercises	181
4	Statistical Analysis of Regression Models	187
4.1	An Introduction to Simple Linear Regression.....	187
4.1.1	Simple linear regression using PROC REG	189
4.1.2	Lack of fit test using PROC ANOVA	195
4.1.3	Diagnostic use of case statistics	197
4.1.4	Prediction of new y values using regression	204
4.2	An Introduction to Multiple Regression Analysis	208
4.2.1	Multiple regression analysis using PROC REG	211
4.2.2	Case statistics and residual analysis.....	217
4.2.3	Residual plots.....	222
4.2.4	Examining relationships among regression variables	225
4.3	Types of Sums of Squares Computed in PROC REG and PROC GLM	231
4.3.1	Model comparison technique and extra sum of squares ..	231
4.3.2	Types of sums of squares in SAS	233
4.4	Subset Selection Methods in Multiple Regression	235
4.4.1	Subset selection using PROC REG	241
4.4.2	Other options available in PROC REG for model selection	249
4.5	Inclusion of Squared Terms and Product Terms in Regression Models	251
4.5.1	Including interaction terms in the model	252
4.5.2	Comparing slopes of regression lines using interaction ..	253

4.5.3	Analysis of models with higher-order terms with PROC REG	254
4.6	Exercises	261
5	Analysis of Variance Models	275
5.1	Introduction	275
5.1.1	Treatment Structure	278
5.1.2	Experimental Designs	279
5.1.3	Linear Models	280
5.2	One-Way Classification	282
5.2.1	Using PROC ANOVA to analyze one-way classifications	291
5.2.2	Making preplanned (or a priori) comparisons using PROC GLM	297
5.2.3	Testing orthogonal polynomials using contrasts	302
5.3	One-Way Analysis of Covariance	309
5.3.1	Using PROC GLM to perform one-way covariance analysis	312
5.3.2	One-way covariance analysis: Testing for equal slopes ..	321
5.4	A Two-Way Factorial in a Completely Randomized Design ..	328
5.4.1	Analysis of a two-way factorial using PROC GLM ..	331
5.4.2	Residual analysis and transformations	336
5.5	Two-Way Factorial: Analysis of Interaction	338
5.6	Two-Way Factorial: Unequal Sample Sizes	346
5.7	Two-Way Classification: Randomized Complete Block Design ..	358
5.7.1	Using PROC GLM to analyze a RCB	361
5.7.2	Using PROC GLM to test for nonadditivity	367
5.8	Exercises	369
6	Analysis of Variance: Random and Mixed Effects Models ..	389
6.1	Introduction	389
6.2	One-Way Random Effects Model	393
6.2.1	Using PROC GLM to analyze one-way random effects models	396
6.2.2	Using PROC MIXED to analyze one-way random effects models	400
6.3	Two-Way Crossed Random Effects Model	407
6.3.1	Using PROC GLM and PROC MIXED to analyze two-way crossed random effects models	410
6.3.2	Randomized complete block design: Blocking when treatment factors are random	417
6.4	Two-Way Nested Random Effects Model	418
6.4.1	Using PROC GLM to analyze two-way nested random effects models	421

XII Contents

6.4.2	Using PROC MIXED to analyze two-way nested random effects models	425
6.5	Two-Way Mixed Effects Model	427
6.5.1	Two-way mixed effects model: Randomized complete blocks design	430
6.5.2	Two-way mixed effects model: Crossed classification ..	441
6.5.3	Two-way mixed effects model: Nested classification ..	453
6.6	Models with Random and Nested Effects for More Complex Experiments	465
6.6.1	Models for nested factorials	466
6.6.2	Models for split-plot experiments	472
6.6.3	Analysis of split-plot experiments using PROC GLM ..	474
6.6.4	Analysis of split-plot experiments using PROC MIXED	481
6.7	Exercises	488

APPENDICES

A	SAS/GRAFH	503
A.1	Introduction	503
A.2	SAS/GRAFH Statements	513
A.2.1	Goptions statement	516
A.2.2	SAS/GRAFH global statements	516
A.3	Printing and Exporting Graphics Output	526
B	Tables	529
References		549
Index		553