

CONTENTS

Page

Preface	v
---------------	---

1. Introduction	1
The Book and the Course it Follows	3
Statistics in Geology	6
Measurement Systems	7
A False Feeling of Security	9
Selected Readings	10

2. Elementary Statistics	11
Probability	11
Continuous Random Variables	25
Statistics	29
Summary Statistics	34
Joint Variation of Two Variables	40
Induced Correlations	46
Logratio Transformation	50
Comparing Normal Populations	55
Central Limits Theorem	58
Testing the Mean	60
P-Values	64
Significance	65
Confidence Limits	66
The t -Distribution	68
Degrees of freedom	69
Confidence intervals based on t	72
A test of the equality of two sample means	72
The t -test of correlation	74
The F -Distribution	75
F -test of equality of variances	76
Analysis of variance	78
Fixed, random, and mixed effects	83
Two-way analysis of variance	84

Contents

Nested design in analysis of variance	88
The χ^2 Distribution	92
Goodness-of-fit test	93
The Logarithmic and Other Transformations	97
Other transformations	102
Nonparametric Methods	102
Mann-Whitney test	103
Kruskal-Wallis test	105
Nonparametric correlation	105
Kolmogorov-Smirnov tests	107
Exercises	112
Selected Readings	119
3. Matrix Algebra	123
The Matrix	123
Elementary Matrix Operations	125
Matrix Multiplication	127
Inversion and Solution of Simultaneous Equations	132
Determinants	136
Eigenvalues and Eigenvectors	141
Eigenvalues	141
Eigenvectors	150
Exercises	153
Selected Readings	157
4. Analysis of Sequences of Data	159
Geologic Measurements in Sequences	159
Interpolation Procedures	163
Markov Chains	168
Embedded Markov chains	173
Series of Events	178
Runs Tests	185
Least-Squares Methods and Regression Analysis	191
Confidence belts around a regression	200
Calibration	204
Curvilinear regression	207

Reduced major axis and related regressions	214
Structural analysis and orthogonal regression	218
Regression through the origin	220
Logarithmic transformations in regression	221
Weighted regression	224
Looking at residuals	227
Splines	228
Segmenting Sequences	234
Zonation	234
Seriation	239
Autocorrelation	243
Cross-correlation	248
Cross-correlation and stratigraphic correlation	254
Semivariograms	254
Modeling the semivariogram	261
Alternatives to the semivariogram	264
Spectral Analysis	266
A quick review of trigonometry	266
Harmonic analysis	268
The continuous spectrum	275
Exercises	278
Selected Readings	288

5. Spatial Analysis 293

Geologic Maps, Conventional and Otherwise	293
Systematic Patterns of Search	295
Distribution of Points	299
Uniform density	300
Random patterns	302
Clustered patterns	307
Nearest-neighbor analysis	310
Distribution of Lines	313
Analysis of Directional Data	316
Testing hypotheses about circular directional data	322
Test for randomness	322
Test for a specified trend	325
Test of goodness of fit	326
Testing the equality of two sets of directional vectors	326
Spherical Distributions	330

Contents

Matrix representation of vectors	334
Displaying spherical data	338
Testing hypotheses about spherical directional data	341
A test of randomness	341
Fractal Analysis	342
Ruler procedure	343
Grid-cell procedure	346
Spectral procedures	351
Higher dimensional fractals	353
Shape	355
Fourier measurements of shape	359
Spatial Analysis by ANOVA	366
Computer Contouring	370
Contouring by triangulation	374
Contouring by gridding	380
Problems in contour mapping	391
Extensions of contour mapping	394
Trend Surfaces	397
Statistical tests of trends	407
Two trend-surface models	412
Pitfalls	414
Kriging	416
Simple kriging	418
Ordinary kriging	420
Universal kriging	428
Calculating the drift	433
An example	435
Block kriging	437
Exercises	443
Selected Readings	452

6. Analysis of Multivariate Data

Multiple Regression	462
Discriminant Functions	471
Tests of significance	477
Multivariate Extensions of Elementary Statistics	479
Equality of two vector means	483
Equality of variance-covariance matrices	484
Cluster Analysis	487

Introduction to Eigenvector Methods, Including Factor Analysis	500
Eckart-Young theorem	502
Principal Component Analysis	509
Closure effects on principal components	523
<i>R</i> -Mode Factor Analysis	526
Factor rotation	533
Maximum likelihood factor analysis	538
<i>Q</i> -Mode Factor Analysis	540
A word about closure	546
Principal Coordinates Analysis	548
Correspondence Analysis	552
Multidimensional Scaling	560
Simultaneous <i>R</i> - and <i>Q</i> -Mode Analysis	566
Multigroup Discriminant Functions	572
Canonical Correlation	577
Exercises	584
Selected Readings	594

Appendix	601
Table A.1. Cumulative probabilities for the standardized normal distribution	601
Table A.2. Critical values of t for ν degrees of freedom and selected levels of significance	602
Table A.3. Critical values of F for ν_1 and ν_2 degrees of freedom and selected levels of significance	603
Table A.4. Critical values of χ^2 for ν degrees of freedom and selected levels of significance	607
Table A.5. Probabilities of occurrence of specified values of the Mann-Whitney W_x test statistic	608
Table A.6. Critical values of Spearman's ρ for testing the significance of a rank correlation	613
Table A.7. Critical values of D in the Kolmogorov-Smirnov goodness-of-fit test	614
Table A.8. Critical values of the Lilliefors test statistic, T , for testing goodness-of-fit to a normal distribution	617
Table A.9. Maximum likelihood estimates of the concentration parameter κ for calculated values of $\bar{R}$	618

Contents

Table A.10. Critical values of $\overline{R}$ for Rayleigh's test for the presence
of a preferred trend 619

Table A.11. Critical values of $\overline{R}$ for the test of uniformity of
a spherical distribution 620

Index 621