

Contents

Preface to the Second Edition xi

Preface to the First Edition xv

Part I

Chapter 1. Preliminary Description of Error Analysis	3
1.1 Errors as Uncertainties	3
1.2 Inevitability of Uncertainty	3
1.3 Importance of Knowing the Uncertainties	5
1.4 More Examples	6
1.5 Estimating Uncertainties When Reading Scales	8
1.6 Estimating Uncertainties in Repeatable Measurements	10
Chapter 2. How to Report and Use Uncertainties	13
2.1 Best Estimate \pm Uncertainty	13
2.2 Significant Figures	14
2.3 Discrepancy	16
2.4 Comparison of Measured and Accepted Values	18
2.5 Comparison of Two Measured Numbers	20
2.6 Checking Relationships with a Graph	24
2.7 Fractional Uncertainties	28
2.8 Significant Figures and Fractional Uncertainties	30
2.9 Multiplying Two Measured Numbers	31
Problems for Chapter 2	35
Chapter 3. Propagation of Uncertainties	45
3.1 Uncertainties in Direct Measurements	46
3.2 The Square-Root Rule for a Counting Experiment	48
3.3 Sums and Differences; Products and Quotients	49
3.4 Two Important Special Cases	54
3.5 Independent Uncertainties in a Sum	57
3.6 More About Independent Uncertainties	60
3.7 Arbitrary Functions of One Variable	63
3.8 Propagation Step by Step	66
3.9 Examples	68
3.10 A More Complicated Example	71
3.11 General Formula for Error Propagation	73
Problems for Chapter 3	79
Chapter 4. Statistical Analysis of Random Uncertainties	93
4.1 Random and Systematic Errors	94

4.2	The Mean and Standard Deviation	97
4.3	The Standard Deviation as the Uncertainty in a Single Measurement IO I	
4.4	The Standard Deviation of the Mean	102
4.5	Examples	104
4.6	Systematic Errors	106
	Problems for Chapter 4	110
Chapter 5. The Normal Distribution 121		
5.1	Histograms and Distributions	122
5.2	Limiting Distributions	126
5.3	The Normal Distribution	129
5.4	The Standard Deviation as 68% Confidence Limit	135
5.5	Justification of the Mean as Best Estimate	137
5.6	Justification of Addition in Quadrature	141
5.7	Standard Deviation of the Mean	147
5.8	Acceptability of a Measured Answer	149
	Problems for Chapter 5	154

Part II

Chapter 6. Rejection of Data 165		
6.1	The Problem of Rejecting Data	165
6.2	Chauvenet's Criterion	166
6.3	Discussion	169
	Problems for Chapter 6	170
Chapter 7. Weighted Averages 173		
7.1	The Problem of Combining Separate Measurements	173
7.2	The Weighted Average	174
7.3	An Example	176
	Problems for Chapter 7	178
Chapter 8. Least-Squares Fitting 181		
8.1	Data That Should Fit a Straight Line	181
8.2	Calculation of the Constants A and B	182
8.3	Uncertainty in the Measurements of y	186
8.4	Uncertainty in the Constants A and B	188
8.5	An Example	190
8.6	Least-Squares Fits to Other Curves	193
	Problems for Chapter 8	199
Chapter 9. Covariance and Correlation 209		
9.1	Review of Error Propagation	209
9.2	Covariance in Error Propagation	211
9.3	Coefficient of Linear Correlation	215
9.4	Quantitative Significance of r	218
9.5	Examples	220
	Problems for Chapter 9	222

Chapter 10. The Binomial Distribution	227
10.1 Distributions	227
10.2 Probabilities in Dice Throwing	228
10.3 Definition of the Binomial Distribution	228
10.4 Properties of the Binomial Distribution	231
10.5 The Gauss Distribution for Random Errors	235
10.6 Applications: Testing of Hypotheses	236
Problems for Chapter 10	241
Chapter 11. The Poisson Distribution	245
11.1 Definition of the Poisson Distribution	245
11.2 Properties of the Poisson Distribution	249
11.3 Applications	252
11.4 Subtracting a Background	254
Problems for Chapter 11	256
Chapter 12. The Chi-Squared Test for a Distribution	261
12.1 Introduction to Chi Squared	261
12.2 General Definition of Chi Squared	265
12.3 Degrees of Freedom and Reduced Chi Squared	268
12.4 Probabilities for Chi Squared	271
12.5 Examples	274
Problems for Chapter 12	278

Appendixes	285
Appendix A. Normal Error Integral, I	286
Appendix B. Normal Error Integral, II	288
Appendix C. Probabilities for Correlation Coefficients	290
Appendix D. Probabilities for Chi Squared	292
Appendix E. Two Proofs Concerning Sample Standard Deviations	294
Bibliography	299

Answers to Quick Checks and Odd-Numbered Problems	301
Index	323