530.16 TAY

# Contents

# PART I

3

Preface vii

# CHAPTER 1. Preliminary Description of Error Analysis

- 1.1 Errors as Uncertainties 3
- 1.2 Inevitability of Uncertainty 3
- 1.3 Importance of Knowing the Uncertainties 5
- 1.4 More Examples 7
- 1.5 Estimating Uncertainties when Reading Scales 9
- 1.6 Estimating Uncertainties in Repeatable Measurements 11

### CHAPTER 2. How to Report and Use Uncertainties 14

- 2.1 Best Estimate ± Uncertainty 14
- 2.2 Significant Figures 15
- 2.3 Discrepancy 18
- 2.4 Comparison of Measured and Accepted Values 19
- 2.5 Comparison of Two Measured Numbers 21
- 2.6 Checking Proportionality 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 35

### CHAPTER 3. Propagation of Uncertainties 40

- 3.1 Uncertainties in Direct Measurements 41
- 3.2 Sums and Differences; Products and Quotients 44
- 3.3 Independent Uncertainties in a Sum 52

١

- 3.4 More About Independent Uncertainties 56
- 3.5 Arbitrary Function of One Variable 59
- 3.6 Propagation Step by Step 63
- 3.7 Examples 64
- 3.8 A More Complicated Example 68
- 3.9 General Formula for Error Propagation 70 Problems 74

### CHAPTER 4. Statistical Analysis of Random Uncertainties 81

- 4.1 Random and Systematic Errors 81
- 4.2 The Mean and Standard Deviation 83
- 4.3 The Standard Deviation as the Uncertainty in a Single Measurement 87
- 4.4 The Standard Deviation of the Mean 89
- 4.5 Examples 91
- 4.6 Systematic Errors 93 Problems, 95

#### CHAPTER 5. The Normal Distribution 99

- 5.1 Histograms and Distributions 100
- 5.2 Limiting Distributions 104
- 5.3 The Normal Distribution 108
- 5.4 The Standard Deviation as 68 Percent Confidence Limit 114
- 5.5 Justification of the Mean as Best Estimate 117
- 5.6 Justification of Addition in Quadrature 121
- 5.7 Standard Deviation of the Mean 127
- 5.8 Confidence 130 Problems 133

# PART II

CHAPTER 6. Rejection of Data 141

- 6.1 The Problem of Rejecting Data 141
- 6.2 Chauvenet's Criterion 142
- 6.3 An Example 144 Problems 145

## CHAPTER 7. Weighted Averages 147

- 7.1 The Problem of Combining Separate Measurements 147
- 7.2 The Weighted Average 148
- 7.3 An Example 151 Problems 151

## CHAPTER 8. Least-Squares Fitting 153

- 8.1 Data That Should Fit a Straight Line 153
- 8.2 Calculation of the Constants A and B 155
- 8.3 Uncertainty in the Measurements of y 157
- 8.4 Uncertainty in the Constants A and B 159
- 8.5 An Example 159
- 8.6 Least-Squares Fits to Other Curves 162 Problems 168

### CHAPTER 9. Covariance and Correlation 173

- 9.1 Review of Error Propagation 173
- 9.2 Covariance in Error Propagation 175
- 9.3 Coefficient of Linear Correlation 178
- 9.4 Quantitative Significance of r 182
- 9.5 Examples 185 Problems 185

## CHAPTER 10. The Binomial Distribution 188

- 10.1 Distributions 188
- 10.2 Probabilities in Dice Throwing 189
- 10.3 Definition of the Binomial Distribution 190
- 10.4 Properties of the Binomial Distribution 193
- 10.5 The Gauss Distribution for Random Errors 197
- 10.6 Applications; Testing of Hypotheses 199 Problems 204

#### CHAPTER 11. The Poisson Distribution

207

- 11.1 Definition of the Poisson Distribution 207
- 11.2 Properties of the Poisson Distribution 209
- 11.3 Examples 212 Problems 214

# CHAPTER 12. The $\chi^2$ Test for a Distribution 218

12.1 Introduction to  $\chi^2$ 21812.2 General Definition of  $\chi^2$ 22212.3 Degrees of Freedom and Reduced  $\chi^2$ 22612.4 Probabilities for  $\chi^2$ 23012.5 Examples233Problems237

# Appendixes 243

۲

Appendix A. Normal Error Integral, I 244 Appendix B. Normal Error Integral, II 246 Appendix C. Probabilities for Correlation Coefficients 248 Appendix D. Probabilities for  $\chi^2$  250 Bibliography 253

Answers to Selected Problems 254

Index 266