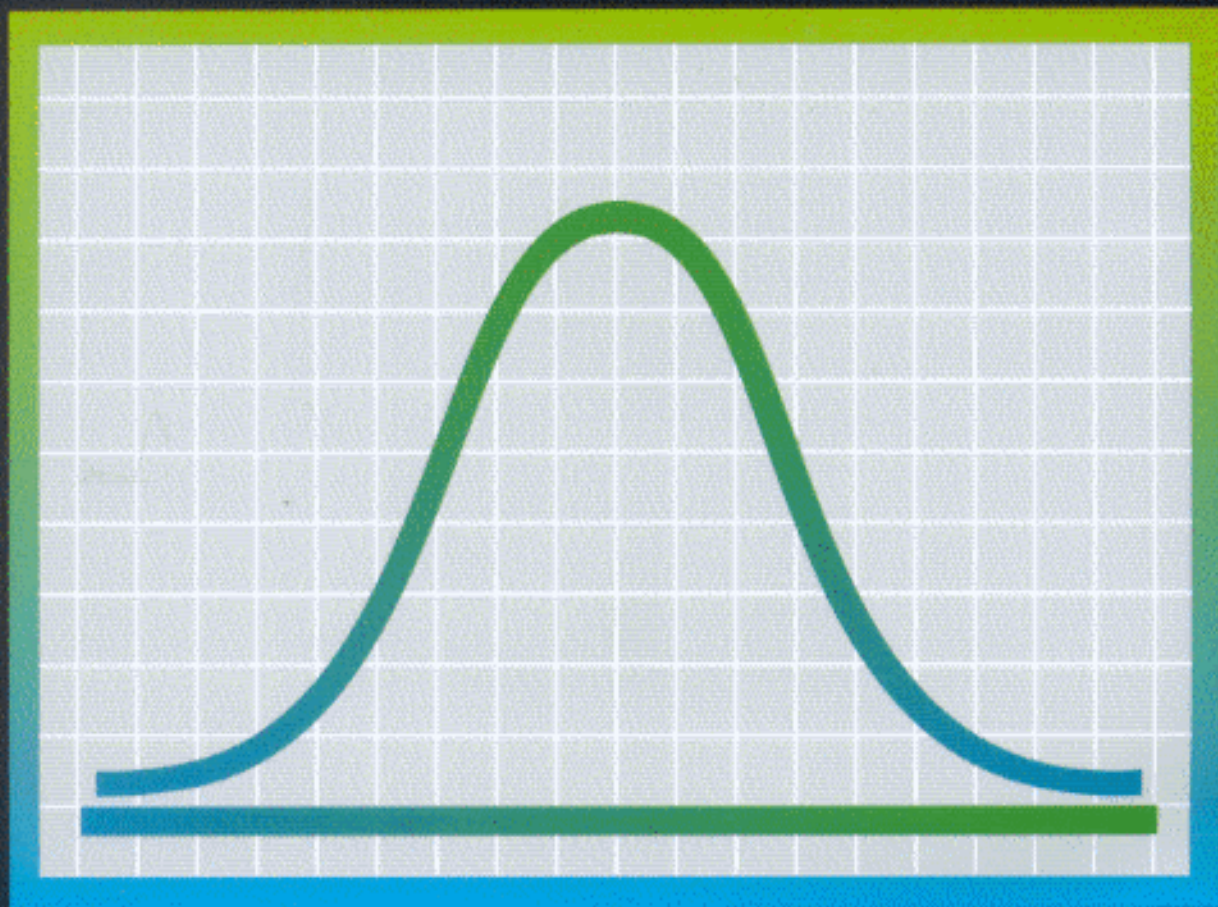


INTERNATIONAL EDITION

*Miller & Freund's*

# Probability and Statistics for Engineers

Sixth Edition



Richard A. Johnson

Preface xi

## 1 Introduction 1

- 1.1 Why Study Statistics 1
- 1.2 Modern Statistics 2
- 1.3 Statistics and Engineering 3
- 1.4 The Role of the Scientist and Engineer in Quality Improvement 3
- 1.5 A Case Study: Visually Inspecting Data to Improve Product Quality 4
- 1.6 Two Basic Concepts—Population and Sample 6
  - Review Exercises 10
  - Key Terms 11

## 2 Treatment of Data 12

- 2.1 Pareto Diagrams and Dot Diagrams 12
- 2.2 Frequency Distributions 15
- 2.3 Graphs of Frequency Distributions 18
- 2.4 Stem-and-Leaf Displays 22
- 2.5 Descriptive Measures 27
- 2.6 Quartiles and Other Percentiles 32
- 2.7 The Calculation of  $\bar{x}$  and  $s$  36
- 2.8 A Case Study: Problems with Aggregating Data 44
  - Review Exercises 47
  - Key Terms 50

## 3 Probability 51

- 3.1 Sample Spaces and Events 51
- 3.2 Counting 56

- 3.3 Probability 64
- 3.4 The Axioms of Probability 66
- 3.5 Some Elementary Theorems 68
- 3.6 Conditional Probability 77
- 3.7 Bayes' Theorem 83
- 3.8 Mathematical Expectation and Decision Making 90
  - Review Exercises 95
  - Key Terms 98

## 4 Probability Distributions 99

- 4.1 Random Variables 99
- 4.2 The Binomial Distribution 102
- 4.3 The Hypergeometric Distribution 106
- 4.4 The Mean and the Variance of a Probability Distribution 112
- 4.5 Chebyshev's Theorem 119
- 4.6 The Poisson Approximation to the Binomial Distribution 124
- 4.7 Poisson Processes 127
- 4.8 The Geometric Distribution 129
- 4.9 The Multinomial Distribution 133
- 4.10 Simulation 134
  - Review Exercises 138
  - Key Terms 141

## 5 Probability Densities 142

- 5.1 Continuous Random Variables 142
- 5.2 The Normal Distribution 150
- 5.3 The Normal Approximation to the Binomial Distribution 156
- 5.4 Other Probability Densities 161
- 5.5 The Uniform Distribution 161
- 5.6 The Log-Normal Distribution 163
- 5.7 The Gamma Distribution 165
- 5.8 The Beta Distribution 168
- 5.9 The Weibull Distribution 170
- 5.10 Joint Distributions—Discrete and Continuous 173
- 5.11 Checking if the Data Are Normal 188
- 5.12 Transforming Observations to Near Normality 189
- 5.13 Simulation 192
  - Review Exercises 196
  - Key Terms 198

## 6 Sampling Distribution 199

- 6.1 Populations and Samples 199
- 6.2 The Sampling Distribution of the Mean ( $\sigma$  Known) 204
- 6.3 The Sampling Distribution of the Mean ( $\sigma$  Unknown) 212
- 6.4 The Sampling Distribution of the Variance 215
  - Review Exercises 218
  - Key Terms 220

## 7 Inferences Concerning Means 221

- 7.1 Point Estimation 221
- 7.2 Interval Estimation 227
- 7.3 Tests of Hypotheses 233
- 7.4 Null Hypotheses and Tests of Hypotheses 235
- 7.5 Hypotheses Concerning One Mean 241
- 7.6 The Relation Between Tests and Confidence Intervals 247
- 7.7 Operating Characteristic Curves 248
- 7.8 Inferences Concerning Two Means 255
- 7.9 Design Issues—Randomization and Pairing 268
  - Review Exercises 270
  - Key Terms 272

## 8 Inferences Concerning Variances 274

- 8.1 The Estimation of Variances 274
- 8.2 Hypotheses Concerning One Variance 277
- 8.3 Hypotheses Concerning Two Variances 279
  - Review Exercises 282
  - Key Terms 283

## 9 Inferences Concerning Proportions 284

- 9.1 Estimation of Proportions 284
- 9.2 Hypotheses Concerning One Proportion 291
- 9.3 Hypotheses Concerning Several Proportions 292
- 9.4 The Analysis of  $r \times c$  Tables 301
- 9.5 Goodness of Fit 304
  - Review Exercises 309
  - Key Terms 311

## 10 Nonparametric Tests 312

- 10.1 Introduction 312
- 10.2 The Sign Test 313
- 10.3 Rank-Sum Tests 314
- 10.4 Tests of Randomness 321
- 10.5 The Kolmogorov–Smirnov and Anderson–Darling Tests 324
- Review Exercises 327
- Key Terms 329

## 11 Curve Fitting 330

- 11.1 The Method of Least Squares 330
- 11.2 Inferences Based on the Least Squares Estimators 337
- 11.3 Curvilinear Regression 350
- 11.4 Multiple Regression 355
- 11.5 Checking the Adequacy of the Model 359
- 11.6 Correlation 366
- 11.7 Multiple Linear Regression 379
- Review Exercises 384
- Key Terms 387

## 12 Analysis of Variance 388

- 12.1 Some General Principles 388
- 12.2 Completely Randomized Designs 391
- 12.3 Randomized-Block Designs 406
- 12.4 Multiple Comparisons 414
- 12.5 Some Further Experimental Designs 419
- 12.6 Analysis of Covariance 428
- Review Exercises 433
- Key Terms 436

## 13 Factorial Experimentation 438

- 13.1 Two-Factor Experiments 438
- 13.2 Multifactor Experiments 447
- 13.3  $2^n$  Factorial Experiments 460
- 13.4 The Graphic Presentation of  $2^2$  and  $2^3$  Experiments 468
- 13.5 Confounding in a  $2^n$  Factorial Experiment 484

- 13.6 Fractional Replication 489
- Review Exercises 495
- Key Terms 499

## 14 The Statistical Content of Quality-Improvement Programs 500

- 14.1 Quality-Improvement Programs 501
- 14.2 Starting a Quality Improvement Program 504
- 14.3 Experimental Designs for Quality Improvement 506
- 14.4 Quality Control 509
- 14.5 Control Charts for Measurements 511
- 14.6 Control Charts for Attributes 516
- 14.7 Tolerance Limits 524
- 14.8 Acceptance Sampling 526
- Review Exercises 536
- Key Terms 538

## 15 Applications to Reliability and Life Testing 540

- 15.1 Reliability 541
- 15.2 Failure-Time Distributions 543
- 15.3 The Exponential Model in Reliability 546
- 15.4 The Exponential Model in Life Testing 550
- 15.5 The Weibull Model in Life Testing 554
- Review Exercises 560
- Key Terms 561

## Bibliography 562

## Statistical Tables 564

## Answers to Odd-Numbered Exercises 599

## Index 615