

# **CONTENTS**

---

<i>Preface</i> .....	(v)
----------------------	-----

## **CHAPTER 1**

### **BASIC CONCEPTS**

1.1 Types of Statistics .....	2
1.2 Parameters and Statistics.....	2
1.3 Sampling and Independent Observations.....	3
1.4 Variables and Variation.....	3
1.4.1 Discrete Variables.....	4
1.4.2 Continuous Variables.....	4
1.4.3 Measurement of variables.....	5
1.4.4 Independent and Dependent Variables .....	5
1.5 Applications of statistics in pharmacy .....	6

## **CHAPTER 2**

### **MEASURES OF CENTRAL TENDENCY AND MEASURES OF DISPERSION**

2.1 Measures of Central Tendency.....	7
2.1.1 The Objectives of Average .....	7
2.1.2 Characteristics of a Good Average .....	8
2.1.3 Types of Averages .....	8
2.1.4 Arithmetic Average (Mean).....	8
2.1.5 Mode .....	13
2.1.6 Median .....	19
2.1.7 Comparison of Mode, Median and Mean Values .....	23
2.1.8 Geometric Mean .....	25
2.1.9 Harmonic Mean (H.M) .....	28

**(viii) *Contents***

---

2.2 Measures of Dispersion.....	29
2.2.1 Objectives of Measuring Dispersion .....	29
2.2.2 Methods of Measuring Dispersion.....	30
2.2.3 Precision and Accuracy .....	42
2.2.4 Standard Error of Statistics .....	44

**CHAPTER 3**  
**DATA PRESENTATION**

3.1 Tabulation of Data .....	51
3.1.1 Components of a Table.....	51
3.1.2 Types of Tables .....	52
3.2 Stem and Leaf Plot.....	53
3.3 Back to Back Stem and Leaf Plot .....	54
3.4 Graphical Representation of Data .....	56
3.4.1 Histograms.....	60
3.4.2 Construction and Labeling of Graphs.....	64

**CHAPTER 4**  
**PROBABILITY AND DISTRIBUTIONS**

4.1 Some Basic Definitions.....	78
4.2 Relative Frequency (or Statistical or Empirical) Definition of Probability ....	84
4.3 Baye's Theorem .....	95
4.4 Probability Distributions .....	98
4.4.1 Discrete Random Variable – Continuous Random Variable .....	100
4.4.2 Binomial Distribution .....	100
4.4.3 Poisson Distribution.....	104
4.4.4 Normal Distribution.....	107

**CHAPTER 5**  
**CORRELATION AND REGRESSION**

5.1 Correlation .....	118
5.1.1 Types of Correlation .....	119

5.1.2 Methods of Studying Correlation .....	121
5.1.3 Statistical Significance of a Correlation Coefficient .....	124
5.1.4 Pair Wise Correlations Involving more than Two Variables.....	134
5.1.5 Partial Correlations .....	137
5.1.6 Standard Error of the Coefficient of Correlation.....	138
5.1.7 Correlation in Bivariate Frequency Table .....	139
5.2 Regression Analysis.....	141
5.2.1 Differences between Correlation and Regression.....	141
5.2.2 Regression Lines.....	142
5.2.3 Method of Least Squares .....	145
5.2.4 Regression Equation in Group Frequency Distribution.....	158

## **CHAPTER 6**

### **TRANSFORMATIONS AND OUTLIERS**

6.1 Transformations .....	169
6.1.1 The Logarithmic Transformation .....	169
6.1.2 Square Root Transformation.....	182
6.1.3 Reciprocal Transformations.....	185
6.1.4 The Arcsin Transformations for Proportions.....	185
6.2 Outliers.....	186

## **CHAPTER 7**

### **SAMPLE CHOOSING**

7.1 Sampling Procedures.....	192
7.2 Precision, Accuracy and Bias.....	194
7.3 Reliability and Validity of Sampling Data.....	196
7.4 Sampling and Non-Sampling Errors .....	196
7.5 Objectives of Sampling .....	197
7.6 Sampling Distribution of a Statistic .....	197

## CHAPTER 8

### STATISTICAL INFERENCE: SIGNIFICANCE OF TESTING

8.1 Introduction.....	198
8.2 Hypothesis Testing.....	201
8.3 Parametric Tests .....	203
8.4 Z test.....	203
8.4.1 Test of Significance of a Mean and Large Sample.....	203
8.4.2 Test of Significance of Difference between Two Means of Large Samples .....	205
8.4.3 Test of Significance of Difference between Two Standard Deviations. ....	207
8.4.4 Test of Significance of a Sample Proportion .....	209
8.4.5 Comparison of a Sample Proportion to a known Proportion.....	210
8.4.6 Comparison of Two Proportions .....	212
8.5 ‘t’ test .....	214
8.5.1 Comparison of Sample Mean with Population Mean .....	218
8.5.2 Comparison of Two Sample Means .....	220
8.5.3 Comparison of Two Samples Means having Different Variance ..	225
8.5.4 Paired t-Test.....	227
8.6 Comparison of Variances (F-test) .....	231
8.7 Chi-square Test of Significance.....	270
8.7.1 Test of Goodness of Fit.....	272
8.7.2 Test of Independence .....	280
8.7.3 Test for the Population Variance .....	282

## CHAPTER 9

### ANALYSIS OF VARIANCE (ANOVA)

9.1 One-way Analysis of Variance .....	288
9.1.1 ANOVA vs t-test .....	291
9.1.2 Multiple Comparisons in ANOVA .....	292

9.1.3	Multiple Correlated Outcomes .....	302
9.1.4	One-way ANOVA with Unequal Sample Sizes .....	304
9.2	Two-way ANOVA.....	305
9.2.1	Fixed and Random Effects in the Two-way ANOVA.....	307
9.2.2	Two-way ANOVA with Replication .....	308
9.3	Three way ANOVA .....	313
9.4	Analysis of Covariance (ANCOVA) .....	315

## **CHAPTER 10**

### **NON PARAMETRIC METHODS**

10.1	Introduction.....	321
10.2	Sign Test .....	324
10.2.1	Sign Test Following Normal Probability.....	324
10.2.2	Paired Sample Sign Test.....	326
10.2.3	Sign Test for Large Samples.....	327
10.3	Wilcoxon Signed Rank Test.....	329
10.4	Wilcoxon Matched-pairs Test.....	330
10.5	Wilcoxon Rank Sum Test (Test for Differences between Two Independent Groups).....	332
10.6	Kruskal-Wallis Test (One-way ANOVA).....	336
10.7	Friedman Test (Two-way Analysis of Variance).....	340
10.8	Multiple Comparisons for the Modified Friedman Test .....	342
10.9	Quade Test .....	343
10.10	Rank Correlation .....	345
10.11	Test of Randomness: Runs.....	346

## **CHAPTER 11**

### **STATISTICAL QUALITY CONTROL**

11.1	Introduction.....	350
11.2	Statistical Quality Control.....	350

**(xii) *Contents***

---

11.3 Advantages of Statistical Quality Control.....	351
11.4 Causes of Variation.....	351
11.5 Types of Statistical Quality Control.....	351
11.6 Control Charts .....	352
11.6.1 Variables Control Charts .....	355
11.6.2 Attribute Control Charts .....	360
11.7 Acceptance Sampling.....	365

## **CHAPTER 12**

### **FACTORIAL DESIGNS**

12.1 Introduction.....	368
12.2 Advantages of Factorial Design.....	371
12.3 Notation in Factorial Experiments .....	371
12.4 Guidelines in Factorial Design.....	372
12.5 Interpretation of the Factorial Design Experimental Results .....	374
12.6 Fractional Factorial Design .....	378
12.6.1 Homogenous Fractional Factorial Design .....	378
12.6.2 Mixed Level Fractional Factorial Designs.....	381
12.6.3 Box, Hunter Fractional Factorial Design.....	382
12.6.4 Plackett-Burman Designs .....	382

## **CHAPTER 13**

### **OPTIMIZATION TECHNIQUES AND SCREENING DESIGNS**

13.1 Introduction.....	386
13.2 Design of Experiments.....	387
13.3 Replication (Sample Size).....	391
13.4 Composite Designs to Estimate Curvature .....	393

---

***Contents (xiii)***

13.5	The Simplex Lattice Design.....	399
13.6	Sequential Optimization.....	403
13.7	Process Optimization by Surface Response Analysis .....	405
13.7.1	Central Composite Design.....	406
13.7.2	Formulation Optimization with Box-Bhenken Design .....	412

**CHAPTER 14****DESIGN OF EXPERIMENTS**

14.1	Principles of Experimental Design.....	418
14.2	Selection of Design .....	419
14.3	Parallel Design .....	419
14.4	Randomized Block Design.....	427
14.5	Crossover Designs.....	430
14.6	Balanced Incomplete Block Design (BIBD) .....	437
14.7	Latin Square Designs .....	441
14.8	Carryover Effects in Crossover Designs .....	445
14.9	ANOVA in Crossover Designs .....	450
14.10	Sample Size in BA/BE Studies .....	452
14.11	Replicate Designs for BE Studies .....	453

**CHAPTER 15****VALIDATION**

15.1	Introduction.....	454
15.2	Sampling in Process Validation .....	455
15.3	Example for Retrospective Validation .....	455
15.4	Example for Prospective Validation .....	461
15.5	Analytical Method Validation.....	466

<b>INDEX.....</b>	<b>473</b>
-------------------	------------