

CONTENTS

Preface	x
1 Experiments, Sample Spaces, and Events	1
1.1 Introduction	1
1.2 Sample Space	2
1.3 Algebra of Events	9
1.4 Infinite Operations on Events	16
2 Probability	25
2.1 Introduction	25
2.2 Probability as a Frequency	25
2.3 Axioms of Probability	26
2.4 Consequences of the Axioms	31
2.5 Classical Probability	36
2.6 Necessity of the Axioms*	37
2.7 Subjective Probability*	42

3	Counting	47
3.1	Introduction	47
3.2	Product Sets, Orderings, and Permutations	47
3.3	Binomial Coefficients	55
3.4	Extension of Newton's Formula	68
3.5	Multinomial Coefficients	69
4	Conditional Probability; Independence	73
4.1	Introduction	73
4.2	Conditional Probability	74
4.3	Partitions; Total Probability Formula	80
4.4	Bayes' Formula	87
4.5	Independence	92
4.6	Exchangeability; Conditional Independence	99
5	Markov Chains*	103
5.1	Introduction and Basic Definitions	103
5.2	Definition of a Markov Chain	106
5.3	n -Step Transition Probabilities	111
5.4	The Ergodic Theorem	114
5.5	Absorption Probabilities	122
6	Random Variables: Univariate Case	125
6.1	Introduction	125
6.2	Distributions of Random Variables	126
6.3	Discrete and Continuous Random Variables	139
6.4	Functions of Random Variables	150
6.5	Survival and Hazard Functions	157
7	Random Variables: Multivariate Case	161
7.1	Bivariate Distributions	161
7.2	Marginal Distributions; Independence	168
7.3	Conditional Distributions	180
7.4	Bivariate Transformations	187
7.5	Multidimensional Distributions	196
8	Expectation	203
8.1	Introduction	203
8.2	Expected Value	204

8.3	Expectation as an Integral*	212
8.4	Properties of Expectation	220
8.5	Moments	228
8.6	Variance	236
8.7	Conditional Expectation	248
8.8	Inequalities	252
9	Selected Families of Distributions	257
9.1	Bernoulli Trials and Related Distributions	257
9.2	Hypergeometric Distribution	270
9.3	Poisson Distribution and Poisson Process	276
9.4	Exponential, Gamma and Related Distributions	290
9.5	Normal Distribution	296
9.6	Beta Distribution	306
10	Random Samples	311
10.1	Statistics and their Distributions	311
10.2	Distributions Related to Normal	313
10.3	Order Statistics	319
10.4	Generating Random Samples	325
10.5	Convergence	330
10.6	Central Limit Theorem	342
11	Introduction to Statistical Inference	351
11.1	Overview	351
11.2	Descriptive Statistics	353
11.3	Basic Model	358
11.4	Bayesian Statistics	360
11.5	Sampling	360
11.6	Measurement Scales	367
12	Estimation	373
12.1	Introduction	373
12.2	Consistency	378
12.3	Loss, Risk, and Admissibility	381
12.4	Efficiency	386
12.5	Methods of Obtaining Estimators	394
12.6	Sufficiency	424
12.7	Interval Estimation	440

13	Testing Statistical Hypotheses	455
13.1	Introduction	455
13.2	Intuitive Background	460
13.3	Most Powerful Tests	469
13.4	Uniformly Most Powerful Tests	481
13.5	Unbiased Tests	487
13.6	Generalized Likelihood Ratio Tests	491
13.7	Conditional Tests	498
13.8	Tests and Confidence Intervals	501
13.9	Review of Tests for Normal Distributions	502
13.10	Monte Carlo, Bootstrap, and Permutation Tests	512
14	Linear Models	517
14.1	Introduction	517
14.2	Regression of the First and Second Kind	519
14.3	Distributional Assumptions	525
14.4	Linear Regression in the Normal Case	528
14.5	Testing Linearity	535
14.6	Prediction	538
14.7	Inverse Regression	540
14.8	BLUE	542
14.9	Regression Toward the Mean	545
14.10	Analysis of Variance	546
14.11	One-Way Layout	547
14.12	Two-Way Layout	550
14.13	ANOVA Models with Interaction	553
14.14	Further Extensions	557
15	Rank Methods	559
15.1	Introduction	559
15.2	Glivenko-Cantelli Theorem	560
15.3	Kolmogorov-Smirnov Tests	564
15.4	One-Sample Rank Tests	571
15.5	Two-Sample Rank Tests	578
15.6	Kruskal-Wallis Test	582
16	Analysis of Categorical Data	585
16.1	Introduction	585
16.2	Chi-Square Tests	587

16.3	Homogeneity and Independence	593
16.4	Consistency and Power	599
16.5	2×2 Contingency Tables	604
16.6	$r \times c$ Contingency Tables	612
Statistical Tables		617
Bibliography		629
Answers to Odd-Numbered Problems		634
Index		642