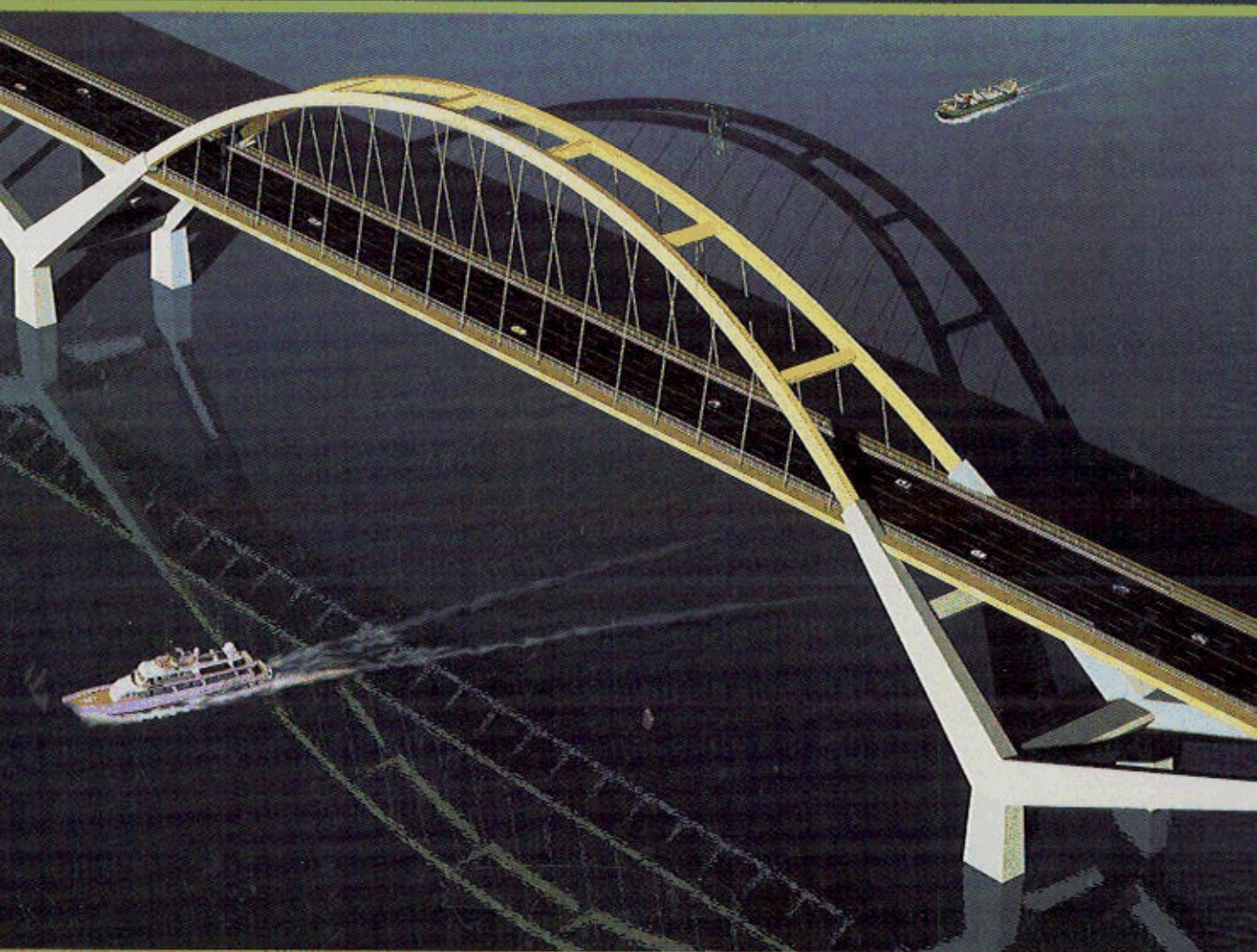


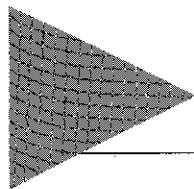
2nd Edition

# PROBABILITY CONCEPTS IN ENGINEERING

*Emphasis on Applications to Civil and Environmental Engineering*



ALFREDO H-S. ANG • WILSON H. TANG



# Contents

Preface	vii	3.1.2 Probability Distribution of a Random Variable	82
►CHAPTER 1		3.1.3 Main Descriptors of a Random Variable	88
Roles of Probability and Statistics in Engineering	1	3.2 Useful Probability Distributions	96
1.1 Introduction	1	3.2.1 The Gaussian (or Normal) Distribution	96
1.2 Uncertainty in Engineering	2	3.2.2 The Lognormal Distribution	100
1.2.1 Uncertainty Associated with Randomness— The Aleatory Uncertainty	2	3.2.3 The Bernoulli Sequence and the Binomial Distribution	105
1.2.2 Uncertainty Associated with Imperfect Knowledge—The Epistemic Uncertainty	17	3.2.4 The Geometric Distribution	108
1.3 Design and Decision Making under Uncertainty	19	3.2.5 The Negative Binomial Distribution	111
1.3.1 Planning and Design of Transportation Infrastructures	20	3.2.6 The Poisson Process and the Poisson Distribution	112
1.3.2 Design of Structures and Machines	20	3.2.7 The Exponential Distribution	118
1.3.3 Planning and Design of Hydrosystems	22	3.2.8 The Gamma Distribution	122
1.3.4 Design of Geotechnical Systems	23	3.2.9 The Hypergeometric Distribution	126
1.3.5 Construction Planning and Management	23	3.2.10 The Beta Distribution	127
1.3.6 Photogrammetric, Geodetic, and Surveying Measurements	24	3.2.11 Other Useful Distributions	131
1.3.7 Applications in Quality Control and Assurance	24	3.3 Multiple Random Variables	132
1.4 Concluding Summary	25	3.3.1 Joint and Conditional Probability Distributions	132
References	25	3.3.2 Covariance and Correlation	138
►CHAPTER 2		3.4 Concluding Summary	141
Fundamentals of Probability Models		Problems	141
2.1 Events and Probability		References	150
2.1.1 Characteristics of Problems Involving Probabilities	27	►CHAPTER 4	
2.1.2 Estimating Probabilities	27	Functions of Random Variables	151
2.2 Elements of Set Theory—Tools for Defining Events	30	4.1 Introduction	151
2.2.1 Important Definitions	31	4.2 Derived Probability Distributions	151
2.2.2 Mathematical Operations of Sets	31	4.2.1 Function of a Single Random Variable	151
2.3 Mathematics of Probability	39	4.2.2 Function of Multiple Random Variables	157
2.3.1 The Addition Rule	44	4.2.3 Extreme Value Distributions	172
2.3.2 Conditional Probability	45	4.3 Moments of Functions of Random Variables	180
2.3.3 The Multiplication Rule	49	4.3.1 Mathematical Expectations of a Function	180
2.3.4 The Theorem of Total Probability	52	4.3.2 Mean and Variance of a General Function	183
2.3.5 The Bayes' Theorem	57	4.4 Concluding Summary	190
2.4 Concluding Summary	63	Problems	190
Problems	65	References	198
References	66	►CHAPTER 5	
►CHAPTER 3		Computer-Based Numerical and Simulation Methods in Probability	199
Analytical Models of Random Phenomena	80	5.1 Introduction	199
3.1 Random Variables and Probability Distribution	81	5.2 Numerical and Simulations Methods	200
3.1.1 Random Events and Random Variables	81	5.2.1 Essentials of Monte Carlo Simulation	200
		5.2.2 Numerical Examples	201

5.2.3	Problems Involving Aleatory and Epistemic Uncertainties	223	8.3	8.2.3 Confidence Intervals in Regression Correlation Analysis	309 311
5.2.4	MCS Involving Correlated Random Variables	231		8.3.1 Estimation of the Correlation Coefficient 8.3.2 Regression of Normal Variates	312 313
5.3	Concluding Summary Problems References and Softwares	242	8.4	Linear Regression with Nonconstant Variance	318
		242	8.5	Multiple Linear Regression	321
		244	8.6	Nonlinear Regression	325
			8.7	Applications of Regression Analysis in Engineering	333
			245	Concluding Summary Problems	339 339
			246	References	344
			246		
			255	►CHAPTER 9	
			258	The Bayesian Approach	346
			258	9.1 Introduction	346
			259	9.1.1 Estimation of Parameters	346
			262	9.2 Basic Concepts—The Discrete Case	347
6.4	Confidence Intervals	262	9.3	The Continuous Case	352
	6.4.1 Confidence Interval of the Mean	268	9.3.1 General Formulation	352	
	6.4.2 Confidence Interval of the Proportion	269	9.3.2 A Special Application of the Bayesian Updating Process	357	
	6.4.3 Confidence Interval of the Variance	270			
6.5	Measurement Theory	273	9.4	Bayesian Concept in Sampling Theory	360
6.6	Concluding Summary Problems References	274	9.4.1 General Formulation	360	
		277	9.4.2 Sampling from Normal Populations	360	
			9.4.3 Error in Estimation	362	
			9.4.4 The Utility of Conjugate Distributions	365	
		278	9.5	Estimation of Two Parameters	368
		278	9.6	Bayesian Regression and Correlation Analyses	372
7.2	Probability Papers	279	9.6.1	Linear Regression	372
	7.2.1 Utility and Plotting Position	279	9.6.2	Updating the Regression Parameters	374
	7.2.2 The Normal Probability Paper	280	9.6.3	Correlation Analysis	375
	7.2.3 The Lognormal Probability Paper	281	9.7	Concluding Summary Problems	377
	7.2.4 Construction of General Probability Papers	284		References	377
7.3	Testing Goodness-of-Fit of Distribution Models	289	289	►CHAPTER 10*	
	7.3.1 The Chi-Square Test for Goodness-of-Fit	289		Elements of Quality Assurance and Acceptance Sampling	
	7.3.2 The Kolmogorov–Smirnov (K–S) Test for Goodness-of-Fit	293			
	7.3.3 The Anderson–Darling Test for Goodness-of-Fit				
7.4	Invariance in the Asymptotic Forms of Extremal Distributions	300	296	►APPENDICES:	
7.5	Concluding Summary Problems References	301		Appendix A: Probability Tables	383
		302		Table A.1 Standard Normal Probabilities	383
		302		Table A.2 CDF of the Binomial Distribution	387
		305		Table A.3 Critical Values of <i>t</i> -Distribution at Confidence Level $(1-\alpha) = p$	392
				Table A.4 Critical Values of the $\chi^2$ Distribution at probability Level $\alpha$	393
		306		Table A.5 Critical Values of $D_n^\alpha$ at Significance Level $\alpha$ in the K-S Test	395
		306			
		306			
		308		*Available online at the Wiley Web site <a href="http://www.wiley.com/college/ang">www.wiley.com/college/ang</a>	

Table A.6 Critical Values of the Anderson-Darling Goodness-of-Fit Test	395	B.4: The Multinomial Coefficient	399
Appendix B: Combinatorial Formulas	397	B.5: Stirling's Formula	399
B.1: The Basic Relation	397	Appendix C: Derivation of the Poisson Distribution	400
B.3: The Binomial Coefficient	398	Index	403