

Contents

Preface	vii
CHAPTER 1	
Stationary Time Series	1
§1.1 Examples of Time Series	1
§1.2 Stochastic Processes	8
§1.3 Stationarity and Strict Stationarity	11
§1.4 The Estimation and Elimination of Trend and Seasonal Components	14
§1.5 The Autocovariance Function of a Stationary Process	25
§1.6 The Multivariate Normal Distribution	32
§1.7* Applications of Kolmogorov's Theorem	37
Problems	39
CHAPTER 2	
Hilbert Spaces	42
§2.1 Inner-Product Spaces and Their Properties	42
§2.2 Hilbert Spaces	46
§2.3 The Projection Theorem	48
§2.4 Orthonormal Sets	54
§2.5 Projection in \mathbb{R}^n	58
§2.6 Linear Regression and the General Linear Model	60
§2.7 Mean Square Convergence, Conditional Expectation and Best Linear Prediction in $L^2(\Omega, \mathcal{F}, P)$	62
§2.8 Fourier Series	65
§2.9 Hilbert Space Isomorphisms	67
§2.10* The Completeness of $L^2(\Omega, \mathcal{F}, P)$	68
§2.11* Complementary Results for Fourier Series	69
Problems	73

CHAPTER 3	
Stationary ARMA Processes	77
§3.1 Causal and Invertible ARMA Processes	77
§3.2 Moving Average Processes of Infinite Order	89
§3.3 Computing the Autocovariance Function of an ARMA(p, q) Process	91
§3.4 The Partial Autocorrelation Function	97
§3.5 The Autocovariance Generating Function	102
§3.6* Homogeneous Linear Difference Equations with Constant Coefficients	104
Problems	108
CHAPTER 4	
The Spectral Representation of a Stationary Process	112
§4.1 Complex-Valued Stationary Time Series	112
§4.2 The Spectral Distribution of a Linear Combination of Sinusoids	114
§4.3 Herglotz's Theorem	115
§4.4 Spectral Densities and ARMA Processes	120
§4.5* Circulants and Their Eigenvalues	128
§4.6* Orthogonal Increment Processes on $[-\pi, \pi]$	133
§4.7* Integration with Respect to an Orthogonal Increment Process	135
§4.8* The Spectral Representation	138
§4.9* Inversion Formulae	145
§4.10* Time-Invariant Linear Filters	147
§4.11* Properties of the Fourier Approximation h_n to $I_{(v, \omega]}$	151
Problems	153
CHAPTER 5	
Prediction of Stationary Processes	159
§5.1 The Prediction Equations in the Time Domain	159
§5.2 Recursive Methods for Computing Best Linear Predictors	162
§5.3 Recursive Prediction of an ARMA(p, q) Process	168
§5.4 Prediction of a Stationary Gaussian Process; Prediction Bounds	175
§5.5 Prediction of a Causal Invertible ARMA Process in Terms of X_j , $-\infty < j \leq n$	175
§5.6* Prediction in the Frequency Domain	178
§5.7* The Wold Decomposition	180
§5.8* Kolmogorov's Formula	184
Problems	185
CHAPTER 6*	
Asymptotic Theory	191
§6.1 Convergence in Probability	191
§6.2 Convergence in r^{th} Mean, $r > 0$	195
§6.3 Convergence in Distribution	197
§6.4 Central Limit Theorems and Related Results	202
Problems	208

CHAPTER 7

Estimation of the Mean and the Autocovariance Function	211
§7.1 Estimation of μ	211
§7.2 Estimation of $\gamma(\cdot)$ and $\rho(\cdot)$	213
§7.3* Derivation of the Asymptotic Distributions	218
Problems	229

CHAPTER 8

Estimation for ARMA Models	231
§8.1 The Yule–Walker Equations and Parameter Estimation for Autoregressive Processes	232
§8.2 Preliminary Estimation for Autoregressive Processes Using the Durbin–Levinson Algorithm	234
§8.3 Preliminary Estimation for Moving Average Processes Using the Innovations Algorithm	238
§8.4 Preliminary Estimation for ARMA(p, q) Processes	243
§8.5 Remarks on Asymptotic Efficiency	246
§8.6 Recursive Calculation of the Likelihood of an Arbitrary Zero-Mean Gaussian Process	247
§8.7 Maximum Likelihood and Least Squares Estimation for ARMA Processes	249
§8.8 Asymptotic Properties of the Maximum Likelihood Estimators	251
§8.9 Confidence Intervals for the Parameters of a Causal Invertible ARMA Process	253
§8.10* Asymptotic Behavior of the Yule–Walker Estimates	255
§8.11* Asymptotic Normality of Parameter Estimators	258
Problems	262

CHAPTER 9

Model-Building and Forecasting with ARIMA Processes	265
§9.1 ARIMA Models for Non-Stationary Time Series	266
§9.2 Identification Techniques	276
§9.3 The AIC Criterion	293
§9.4 Diagnostic Checking	296
§9.5 Forecasting ARIMA Models	304
§9.6 Seasonal ARIMA Models	310
Problems	316

CHAPTER 10

Inference for the Spectrum of a Stationary Process	320
§10.1 The Periodogram	321
§10.2 Testing for the Presence of Hidden Periodicities	324
§10.3 Asymptotic Properties of the Periodogram	332
§10.4 Smoothing the Periodogram	340
§10.5 Confidence Intervals for the Spectrum	352
§10.6 Autoregressive, Maximum Entropy, Moving Average and Maximum Likelihood ARMA Spectral Estimators	355
§10.7 The Fast Fourier Transform (FFT) Algorithm	363

§10.8*	Derivation of the Asymptotic Behavior of the Maximum Likelihood and Least Squares Estimators of the Coefficients of an ARMA Process	365
	Problems	386
CHAPTER 11		
	Multivariate Time Series	391
§11.1	Second-Order Properties of Multivariate Time Series	392
§11.2	Estimation of the Mean and Covariance Function	395
§11.3	Multivariate ARMA Processes	407
§11.4	Best Linear Predictors of Second-Order Random Vectors	411
§11.5	Estimation for Multivariate ARMA Processes	417
§11.6	The Cross Spectrum	419
§11.7	Estimating the Cross Spectrum	428
§11.8*	The Spectral Representation of a Multivariate Stationary Time Series	439
	Problems	444
CHAPTER 12		
	Further Topics	447
§12.1	Kalman Filtering and Prediction	447
§12.2	Transfer Function Modelling	454
§12.3	Parameter Estimation for ARMA Processes with Missing Values	462
§12.4	Long Memory Processes	464
§12.5	Linear Processes with Infinite Variance	478
§12.6	Threshold Models	489
§12.7	Estimation of Missing Observations of an ARMA Process	494
	Problems	497
	Appendix: Data Sets	499
	Bibliography	504
	Index	509