## **Contents**

FOREWORD		1.8
PREFACE		xi
1 Image	Formation Theory	
1. mage	of mation theory	
1.1	Electron Optics	1
1.2	Beam-Specimen Interaction	5
1.3	Linear Imaging	9
1.4	Nonlinear Imaging	19
1.5	Image Analysis and Object Reconstruction	22
1.6	Resolution, Contrast, Noise, and Radiation Damage	30
2. The Di	screte Fourier Transform	
2.1	Definition and Fundamental Properties	34
2.2	Approximation of Integral Transforms	36
2.3	Multidimensional Forms	41
3. Analyti	ic Images	
3.1	Complex Zeros	44
3.2	Zero Flipping	51
3.3	Periodic Images	52
	Two-Dimensional Forms	55
3.5	The One-Sided Diffraction Plane Constraint	57
	Logarithmic Hilbert Transforms	63
	The Realizability of the One-Sided Constraint	68
3.8	Logarithmic Hilbert Transforms in Dark-Field Conditions	73

vi CONTENTS

4.	The Im	age and Diffraction Plane Problem: Uniqueness	
	4.1	Statement of the Problem	78
		Data Constraints and Trivial Uniqueness Failures	79
		An Important Failure of Uniqueness	81
	4.4	The Continuous Aperiodic Problem	83
		The Periodic and Discrete Problems	89
	4.6	Summary	93
5.	The Im	age and Diffraction Plane Problem: Numerical	
	5.1	Direct Methods	94
		Steepest Descent Methods	96
	5.3	The Iterative Transform Method	106
		Appendix A5	115
6.		age and Diffraction Plane Problem: tational Trials	
	6.1	Real Problems and Mathematical Models	120
	6.2	The Steepest Descent Method	123
		The Iterative Fourier Transform Method	130
	6.4	The Matrix Inversion Method	144
7.	Alterna	tive Data for the Phase Determination	
	7.1	Defocus Pairs	149
	7.2	Bright-Field/Dark-Field Diffraction Pattern Sets	162
	7.3	Further Possible Data	167
	7.4	An Assessment of Phase Determination	169
8.	The Ha	ardware of Digital Image Handling	
	8.1	Optical or Digital Manipulation?	171
		Digitization and Regeneration	173
	8.3	Processors, Representation, and Storage	180
9.	Basic S	oftware for Digital Image Handling	
	9.1	A Processing System	185
	9.2	Input, Output, and Data Selection	187

		CONTENTS	vii
	9.3 9.4	Transformation Correlation and Lateral Alignment	191 200
	9.5	Alignment in Orientation and Magnification	212
	9.6	Averaging Repeated Structures	230
	9.7	Object Reconstruction	236
10.	Impro	c	
	10.1	The Objectives and Environment	249
	10.2	The Implementation Technique	251
	10.3	The Language Structure	253
	10.4	Specimen Programs	255
	10.5	The Improc Macro Definitions	259
	10.6	Recent Extensions	262
		Appendix A10	265
	Refere	ences	279
IND	EX		285