

Table of Contents

Preface	ix
Chapter 1. Introduction	1
1.1. Brief introduction to MATLAB	1
1.1.1. MATLAB software presentation	1
1.1.2. Important MATLAB commands and functions	3
1.1.3. Operating modes and programming with MATLAB	8
1.1.4. Example of work session with MATLAB	10
1.1.5. MATLAB language	13
1.2. Solved exercises	13
Chapter 2. Discrete-Time Signals	23
2.1. Theoretical background	23
2.1.1. Mathematical model of 1D and 2D discrete-time signals	23
2.1.2. Basic 1D and 2D discrete-time signals	25
2.1.3. Periodic 1D and 2D discrete-time signal representation using the discrete-time Fourier series	26
2.1.4. Representation of non-periodic 1D and 2D discrete-time signals by discrete-time Fourier transform	27
2.1.5. Analytic signals	27
2.2. Solved exercises	29
2.3. Exercises	51
Chapter 3. Discrete-Time Random Signals	55
3.1. Theoretical background	55
3.1.1. Introduction	55
3.1.2. Real random variables	56
3.1.3. Random processes	60

3.2. Solved exercises	64
3.3. Exercises	80
Chapter 4. Statistical Tests and High Order Moments	83
4.1. Theoretical background.	83
4.1.1. Moments	84
4.1.2. Cumulants	84
4.1.3. Cumulant properties	85
4.1.4. Chi-square (Chi2) tests.	86
4.1.5. Normality test using the Henry line	86
4.2. Solved exercises	88
4.3. Exercises	99
Chapter 5. Discrete Fourier Transform of Discrete-Time Signals	103
5.1. Theoretical background.	103
5.1.1. Discrete Fourier transform of 1D digital signals.	104
5.1.2. DFT of 2D digital signals	105
5.1.3. Z-transform of 1D digital signals	106
5.1.4. Z-transform of 2D digital signals	106
5.1.5. Methods and algorithms for the DFT calculation	106
5.2. Solved exercises	109
5.3. Exercises	134
Chapter 6. Linear and Invariant Discrete-Time Systems.	137
6.1. Theoretical background.	137
6.1.1. LTI response calculation.	137
6.1.2. LTI response to basic signals	139
6.2. Solved exercises	141
6.3. Exercises	169
Chapter 7. Infinite Impulse Response Filters	173
7.1. Theoretical background.	173
7.1.1. Transfer function and filter specifications for infinite impulse response (IIR) filters.	173
7.1.2. Design methods for IIR filters	174
7.1.3. Frequency transformations	180
7.2. Solved exercises	182
7.3. Exercises	194

Chapter 8. Finite Impulse Response Filters	197
8.1. Theoretical background.	197
8.1.1. Transfer function and properties of FIR filters.	197
8.1.2. Design methods	199
8.1.3. General conclusion about digital filter design	203
8.2. Solved exercises	204
8.3. Exercises	213
Chapter 9. Detection and Estimation	215
9.1. Theoretical background.	215
9.1.1. Matched filtering: optimal detection of a known noisy signal.	215
9.1.2. Linear optimal estimates.	216
9.1.3. Least squares (LS) method	221
9.1.4. LS method with forgetting factor	222
9.2. Solved exercises	223
9.3. Exercises	239
Chapter 10. Power Spectral Density Estimation	241
10.1. Theoretical background	241
10.1.1. Estimate properties	241
10.1.2. Power spectral density estimation	242
10.1.3. Parametric spectral analysis	245
10.1.4. Super-resolution spectral analysis methods	250
10.1.5. Other spectral analysis methods	256
10.2. Solved exercises	257
10.3. Exercises	277
Chapter 11. Time-Frequency Analysis	279
11.1. Theoretical background	279
11.1.1. Fourier transform shortcomings: interpretation difficulties	279
11.1.2. Spectrogram	280
11.1.3. Time-scale analysis – wavelet transform	281
11.1.4. Wigner-Ville distribution	284
11.1.5. Smoothed WVD (SWVD)	287
11.2. Solved exercises	288
11.3. Exercises	304
Chapter 12. Parametrical Time-Frequency Methods	307
12.1. Theoretical background	307
12.1.1. Fractional Fourier transform	307

12.1.2. Phase polynomial analysis concept	309
12.1.3. Time-frequency representations based on warping operators	314
12.2. Solved exercises	317
12.3. Exercises	338
Chapter 13. Supervised Statistical Classification	343
13.1. Theoretical background	343
13.1.1. Introduction	343
13.1.2. Data analysis methods	344
13.1.3. Supervised classifiers	348
13.2. Solved exercises	362
13.3. Exercises	379
Chapter 14. Data Compression	383
14.1. Theoretical background	383
14.1.1. Transform-based compression methods	384
14.1.2. Parametric (predictive) model-based compression methods	385
14.1.3. Wavelet packet-based compression methods	386
14.1.4. Vector quantization-based compression methods	387
14.1.5. Neural network-based compression methods	388
14.2. Solved exercises	390
14.3. Exercises	403
References	405
List of Authors	407
Index	409