Mathematics for Engineers

Description: This book offers comprehensive coverage of all the mathematical tools needed by engineers in the field of processing and transport of all forms of information, data and images – as well as many other engineering disciplines. It provides essential theories, equations and results in probability theory and statistics, which constitute the basis for the presentation of signal processing, information theory, traffic and queueing theory, and reliability. The mathematical foundations of simulation are also covered.

The book's accessible style will enable students, engineers and researches new to this area to advance their knowledge of communication and other engineering technologies; however, it will also serve as a useful reference guide to anyone wishing to further explore this field.

Contents:

Preface 15

Chapter 1. Probability Theory 19

1.1. Definition and properties of events 19

1.1.1. The concept of an event 19

1.1.2. Complementary events 21

1.1.2.1. Basic properties 21

1.1.3. Properties of operations on events 21

1.1.3.1. Commutativity 21

1.1.3.2. Associativity 21

1.1.3.3. Distributivity 21

1.1.3.4. Difference 21

1.1.3.5. DeMorgan’s rules 22

1.2. Probability 23

1.2.1. Definition 23

1.2.2. Basic theorems and results 23

1.2.2.1. Addition theorem 23

1.2.2.2. Conditional probability 24

1.2.2.3. Multiplication theorem 25

1.2.2.4. The posterior probability theorem 26

1.3. Random variable 27

1.3.1. Definition 27

1.3.2. Probability functions of a random variable 27
1.3.2.1. Notations 27
1.3.2.2. Cumulative distribution function 27
1.3.2.3. Probability density function 27
1.3.3. Moments of a random variable 28
1.3.3.1. Moments about the origin 29
1.3.3.2. Central moments 29
1.3.3.3. Mean and variance 29
1.3.3.4. Example applications 31
1.3.4. Couples of random variables 32
1.3.4.1. Definition 32
1.3.4.2. Joint probability 32
1.3.4.3. Marginal probability of couples of random variables 33
1.3.4.4. Conditional probability of a couple of random variables 34
1.3.4.5. Functions of a couple of random variables 34
1.3.4.6. Sum of independent random variables 36
1.3.4.7. Moments of the sum of independent random variables 37
1.3.4.8. Practical interest 39
1.4. Convolution 40
1.4.1. Definition 40
1.4.2. Properties of the convolution operation 41
1.4.2.1. The convolution is commutative 41
1.4.2.2. Convolution of exponential distributions 41
1.4.2.3. Convolution of normal (Gaussian) distributions 41
1.5. Laplace transform 42
1.5.1. Definition 43
1.5.2. Properties 43
1.5.2.1. Fundamental property 43
1.5.2.2. Differentiation property 43
1.5.2.3. Integration property 44
1.5.2.4. Some common transforms 44
1.6. Characteristic function, generating function, z-transform 47
1.6.1. Characteristic function 47
1.6.1.1. Definition 47
1.6.1.2. Inversion formula 48
1.6.1.3. The concept of event indicator and the Heaviside function 48
1.6.1.4. Calculating the inverse function and residues 49
1.6.1.5. The residue theorem 50
1.6.1.6. Asymptotic formula 51
1.6.1.7. Moments 52
1.6.1.8. Some common transforms 53
1.6.2. Generating functions, z–transforms 54
1.6.2.1. Definition 54
1.6.2.2. Moments 54
1.6.2.3. Some common transforms 55
1.6.3. Convolution 56
Chapter 2. Probability Laws 57
2.1. Uniform (discrete) distribution 58
2.2. The binomial law 58
2.3. Multinomial distribution 60
2.4. Geometric distribution 61
2.5. Hypergeometric distribution 62
2.6. The Poisson law 63
2.7. Continuous uniform distribution 65
2.8. Normal (Gaussian) distribution 66
2.9. Chi–2 distribution 70
2.10. Student distribution 71
2.11. Lognormal distribution 72
2.12. Exponential and related distributions 72
2.12.1. Exponential distribution 72
2.12.2. Erlang–k distribution 73
2.12.3. Hyperexponential distribution 75
2.12.4. Generalizing: Coxian distribution 77
2.12.5. Gamma distribution 77
2.12.6. Weibull distribution 78
2.13. Logistic distribution 79
2.14. Pareto distribution 81
2.15. A summary of the main results 82
2.15.1. Discrete distributions 82
2.15.2. Continuous distributions 83
Chapter 3. Statistics 87
3.1. Descriptive statistics 88
3.1.1. Data representation 88
3.1.2. Statistical parameters 90
3.1.2.1. Fractiles 90
3.1.2.2. Samplemean 91
3.1.2.3. Sample variance 91
3.1.2.4. Moments 91
3.1.2.5. Mode 91
3.1.2.6. Other characterizations 92
3.2. Correlation and regression 92
3.2.1. Correlation coefficient 93
3.2.2. The regression curve 94
3.2.2.1. The least squares method 94
3.3. Sampling and estimation techniques 96
3.4. Estimation 97
3.4.1. Point estimation 98
3.4.1.1. Average 99
3.4.1.2. Variance 99
3.4.1.3. Estimating the mean and variance of a normal distribution 100
3.4.1.4. Example: estimating the average lifetime of equipment 101
3.4.2. Estimating confidence intervals 102
3.4.2.1. Example 1: estimating the mean of a normal distribution 104
3.4.2.2. Example 2: Chi–2 distribution in reliability 104
3.4.2.3. Estimating proportion 106
3.4.2.4. Estimating the parameter of a Poisson distribution 108
4.7.1.3. Discrete convolution 138
4.7.1.4. Inversion 139
4.7.2. Fourier transform of a discrete signal 140
4.7.3. Discrete Fourier transform 141
4.7.3.1. Definition 141
4.7.3.2. Properties 143
4.7.4. Cosine transform 144
4.7.5. The fast Fourier transform (FFT) 145
4.7.5.1. Cooley–Tukey FFT algorithm 145
4.8. Filter design and synthesis 146
4.8.1. Definitions and principles 147
4.8.1.1. Principle 147
4.8.1.2. Causality and stability 148
4.8.2. Finite impulse response (FIR) filters 148
4.8.2.1. Design methodology 149
4.8.2.2. FIR filter synthesis 152
4.8.2.3. Low-pass, high-pass and band-pass filters 154
4.8.3. Infinite impulse response (IIR) filters 154
4.8.3.1. Filter design from models of the s plane 156
4.8.3.2. Butterworth model 158
4.8.3.3. Chebychev model 160
4.8.3.4. Synthesis of IIR filters 161
4.8.3.5. Low-pass, high-pass and band-pass filters 162
4.8.4. Non-linear filtering 163
4.8.4.1. Median filtering at rank N 163
4.8.5. Filter banks and multirate systems 164
4.8.5.1. Sub- and up-sampling 165
4.8.5.2. Multirate filtering and polyphase bank 168
4.8.5.3. Signal decomposition and reconstruction 169
4.8.5.4. Half-band filters 171
4.8.5.5. Quadrature mirror filters 172
4.9. Spectral analysis and random signals 173
4.9.1. Statistical characterization of random signals

4.9.1.1. Average

4.9.1.2. Autocorrelation function

4.9.1.3. Power spectral density

4.9.2. Filtering a random signal

4.9.2.1. Spectral density of a filtered signal

4.9.2.2. Filtering white noise

4.9.3. Sampled random signals

4.9.3.1. Autocorrelation function

4.9.3.2. Cross-correlation function

4.9.3.3. Power spectral density

4.9.4. Filtering a sampled random signal

4.9.4.1. Spectral density of the filtered signal

4.9.4.2. Correlation between input and output signals (cross-correlation)

4.9.4.3. Colored noise

4.9.5. Spectral estimation

4.9.5.1. Estimating the autocorrelation function

4.9.5.2. Non-parametric spectral estimation with periodogram

4.9.5.3. Parametric spectral estimation: ARMA, AR, MA

4.9.5.4. Toeplitz matrix and Levinson algorithm

4.10. Linear prediction, coding and speech synthesis, adaptive filtering

4.10.1. Linear prediction

4.10.1.1. Variance minimization

4.10.1.2. Example of speech processing: coding and synthesis

4.10.2. Adaptive filtering

4.10.2.1. The least squares method with exponential forgetting

4.10.2.2. The stochastic gradient descent algorithm

4.10.2.3. Example: echo cancelation

Chapter 5. Information and Coding Theory

5.1. Information theory

5.1.1. The basic diagram of a telecommunication system
5.2. Information measurement 202
5.2.1. Algebraic definition of information 203
5.2.2. Probabilistic definition of information 203
5.2.3. Self–information 204
5.2.4.Unit of information 204
5.2.5. Conditional information 205
5.2.6. Mutual information 205
5.3. Entropy 206
5.3.1. Entropy of a memoryless source 206
5.3.2. Entropy of a binary source 206
5.3.3. Maximumentropy 207
5.3.4. Joint entropy of random variables 208
5.3.5. Average conditional entropy 208
5.3.6. Additivity and joint entropy 209
5.3.7. Average mutual information 210
5.3.8. Conditional average mutual information 210
5.3.9. Extension to the continuous case 210
5.4. Source modeling 211
5.4.1. Concept of sources with and without memory 211
5.4.2. Discrete Markov source in discrete time 212
5.4.3. The main types of source 215
5.4.3.1. The binary source 215
5.4.3.2. Text, or alphabetic source 216
5.4.4. Information rate of the source 217
5.5. Source coding 217
5.5.1. Code efficiency 217
5.5.2. Redundancy of a code 219
5.5.3. Instantaneous and uniquely decipherable codes 220
5.6. Shannon’s first theorem 220
5.6.1. Optimal coding 220
5.6.2. Shannon’s first theorem 222
5.7. Coding and data compression 224
5.7.1. Huffman coding algorithm 224
5.7.2. Retrieval algorithms and decision trees 226
5.7.3. (Reversible) data compression 227
5.7.3.1. The Huffman method 228
5.7.3.2. Fano method 229
5.7.3.3. Shannon’s method 230
5.7.3.4. Arithmetic coding 230
5.7.3.5. Adaptive and dictionary methods 233
5.7.4. Image compression 234
5.7.4.1. Describing an image: luminance and chrominance 234
5.7.4.2. Image redundancy 236
5.7.4.3. The discrete cosine transform (DCT) 237
5.7.4.4. Quantization and coding 242
5.7.4.5. Recent methods: wavelets 244
5.7.4.6. JPEG2000 250
5.8. Channel modeling 252
5.8.1. Definition of the channel 252
5.8.2. Channel capacity 253
5.8.3. Binary symmetric channel 254
5.9. Shannon’s second theorem 254
5.9.1. The noisy-channel coding theorem (Shannon’s second theorem) 255
5.10. Error-detecting and error-correcting codes 256
5.10.1. Algebraic coding 257
5.10.1.1. Principles 257
5.10.1.2. Hamming distance 258
5.10.1.3. Detection and correction capability 260
5.10.1.4. Additional definitions and properties 261
5.10.1.5. Linear block codes, group codes 262
5.10.1.6. Cyclic codes 267
5.10.2. Convolutional codes 272
5.10.2.1. D-transform 273
5.10.2.2. Graphical representation, graphs and trellis 273
5.10.2.3. Viterbi’s algorithm 275
5.10.3. Combined codes and turbo codes 276
5.10.3.1. Interleaving 277
5.10.3.2. Product codes 278
5.10.3.3. Concatenation 278
5.10.3.4. Parallelization 278
5.10.3.5. Turbo codes 278
5.11. Cryptology 282
5.11.1. Encryption 282
5.11.1.1. Symmetric-key encryption 282
5.11.1.2. Public-key encryption 284
5.11.2. Digital signature 286
5.11.3. Signature and hashing 286
Chapter 6. Traffic and Queueing Theory 289
6.1. Traffic concepts 289
6.1.1. The Erlang concept 290
6.1.2. Traffic modeling 291
6.2. The concept of processes 292
6.2.1. Arrival process 292
6.2.1.1. Renewal process 292
6.2.1.2. Poisson arrivals 293
6.2.1.3. The use of the Poisson process 296
6.2.2. Service process 296
6.2.2.1. Exponential distribution 297
6.2.2.2. Residual service time 297
6.2.2.3. Erlang distribution 299
6.2.2.4. Hyperexponential distribution 299
6.2.3. General arrival and service processes 300
6.3. Markov and birth/death processes 301
6.3.1. State concept 302
6.3.2. Markov chains 302
6.3.3. Birth and death processes 303
6.4. Queueing models 306
6.4.1. Introduction 306
6.4.2. A general result: the Little formula 307
6.4.3. PASTA property (Poisson arrivals see time averages) 309
6.4.4. The elementary queue: the M/M/1 system 310
6.4.4.1. Resolution of the state equations 310
6.4.4.2. Using generating functions 312
6.4.4.3. Waiting time distribution 313
6.4.5. The M/M/R/R model (Erlang model) 317
6.4.6. The M/M/R queue and the Erlang-C formula 318
6.4.7. The M/M queue and the Poisson law 321
6.4.8. The M(n)/M/R/R queue and the Engset formula 322
6.4.9. Models with limited capacity 325
6.5. More complex queues 325
6.5.1. Multi-bitrate Erlang model 325
6.5.2. The embedded Markov chain 326
6.5.3. The number of clients in a system 327
6.5.4. Waiting times: Pollaczek formulae 330
6.5.4.1. Introduction: calculation of residual service time 330
6.5.4.2. The Pollaczek-Khintchine formula 332
6.5.4.3. Example 1: the M/M/1 queue 333
6.5.4.4. Example 2: the M/D/1 queue 333
6.5.4.5. Generalization: Takacs formula 333
6.5.5. The Benešs method: application to the M/D/1 system 333
6.6. The G/G/1 queue 334
6.6.1. Pollaczek method 335
6.6.2. Application to the stochastic relation of the queue to one server (GI/G/1 queue) 337
6.6.3. Resolution of the integral equation 339
6.6.3.1. Application to the M/G/1 queue 339
6.6.3.2. Application to the G/M/1 queue 343
6.6.4. Other applications and extension of the Pollaczek method 346

6.7. Queues with priorities 347
6.7.1. Work conserving system 348
6.7.2. The HoL discipline 350

6.8. Using approximate methods 351
6.8.1. Reattempts 352
6.8.2. Peakedness factor method 353
6.8.3. Approximate formulae for the G/G/R system 358

6.9. Appendix: Pollaczek transform 359

Chapter 7. Reliability Theory 363
7.1. Definition of reliability 363
7.2. Failure rate and bathtub curve 364
7.3. Reliability functions 365
7.4. System reliability 366
7.4.1. Reliability of non-repairable systems 366
7.4.1.1. Reliability of the series configuration 367
7.4.1.2. Reliability of the parallel configuration 368
7.4.1.3. Reliability of the series-parallel configuration 369
7.4.1.4. Reliability of the parallel-series configuration 370
7.4.1.5. Complex configurations 370
7.4.1.6. Non-repairable redundant configurations 371
7.4.2. Reliability and availability of repairable systems 373
7.4.2.1. State equations 373
7.4.2.2. Reliability of redundant repairable systems 375
7.4.2.3. Imperfect structures 380
7.4.3. Using Laplace transform 382
7.4.4. Use of matrices 385
7.4.4.1. Exact resolution by inversion 387
7.4.4.2. Approximate solutions 389
7.5. Software reliability 390
7.5.1. Reliability growth model, early-life period 391
7.5.2. Useful-life period model 392
Fax Order Form
To place an order via fax simply print this form, fill in the information below and fax the completed form to 646-607-1907 (from USA) or +353-1-481-1716 (from Rest of World). If you have any questions please visit http://www.researchandmarkets.com/contact/

Order Information
Please verify that the product information is correct.

<table>
<thead>
<tr>
<th>Product Name:</th>
<th>Mathematics for Engineers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Web Address:</td>
<td><a href="http://www.researchandmarkets.com/reports/2183663/">http://www.researchandmarkets.com/reports/2183663/</a></td>
</tr>
<tr>
<td>Office Code:</td>
<td>SCDKA7WQ</td>
</tr>
</tbody>
</table>

Product Format
Please select the product format and quantity you require:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Hard Copy (Hard Back): USD 106 + USD 29 Shipping/Handling</th>
</tr>
</thead>
</table>

* Shipping/Handling is only charged once per order.

Contact Information
Please enter all the information below in BLOCK CAPITALS

<table>
<thead>
<tr>
<th>Title:</th>
<th>Mr [ ] Mrs [ ] Dr [ ] Miss [ ] Ms [ ] Prof [ ]</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Name:</td>
<td></td>
</tr>
<tr>
<td>Email Address: *</td>
<td></td>
</tr>
<tr>
<td>Job Title:</td>
<td></td>
</tr>
<tr>
<td>Organisation:</td>
<td></td>
</tr>
<tr>
<td>Address:</td>
<td></td>
</tr>
<tr>
<td>City:</td>
<td></td>
</tr>
<tr>
<td>Postal / Zip Code:</td>
<td></td>
</tr>
<tr>
<td>Country:</td>
<td></td>
</tr>
<tr>
<td>Phone Number:</td>
<td></td>
</tr>
<tr>
<td>Fax Number:</td>
<td></td>
</tr>
</tbody>
</table>

* Please refrain from using free email accounts when ordering (e.g. Yahoo, Hotmail, AOL)
Payment Information

Please indicate the payment method you would like to use by selecting the appropriate box.

☐ Pay by credit card: You will receive an email with a link to a secure webpage to enter your credit card details.

☐ Pay by check: Please post the check, accompanied by this form, to:

Research and Markets,
Guinness Center,
Taylors Lane,
Dublin 8,
Ireland.

☐ Pay by wire transfer: Please transfer funds to:

Account number 833 130 83
Sort code 98-53-30
Swift code ULSBIE2D
IBAN number IE78ULSB98533083313083
Bank Address Ulster Bank, 27-35 Main Street, Blackrock, Co. Dublin, Ireland.

If you have a Marketing Code please enter it below:

Marketing Code: _______________________

Please note that by ordering from Research and Markets you are agreeing to our Terms and Conditions at http://www.researchandmarkets.com/info/terms.asp

Please fax this form to:

(646) 607-1907 or (646) 964-6609 - From USA
+353-1-481-1716 or +353-1-653-1571 - From Rest of World