

Contents

Part I Primer to Modeling with MATLAB®

1	Introduction	3
1.1	Environmental Modeling Using MATLAB®	3
1.2	Introduction to MATLAB®	7
1.2.1	Getting Started with MATLAB®	8
1.2.2	Matrices in MATLAB®	15
1.2.3	Basic Matrix Operations	19
1.3	A Simple Environmental Model	25
1.4	MATLAB® Graphics – The Figure Editor	29
1.5	MATLAB® Help System	32
	References	32
2	Fundamentals of Modeling, Principles and MATLAB®	35
2.1	Model Types	35
2.2	Modeling Steps	36
2.3	Fundamental Laws	40
2.3.1	Conservation of Mass	40
2.3.2	Conservation of Momentum	41
2.3.3	Conservation of Energy	41
2.4	Continuity Equation for Mass	42
2.5	MATLAB® M-files	46
2.6	Ifs and Loops in MATLAB®	51
2.7	Debugging of M-files	55
	Reference	56
3	Transport	57
3.1	The Conservation Principle	57
3.2	Fick's Law and Generalizations	59
3.2.1	Diffusion	59
3.2.2	Dispersion	63

3.3	The Transport Equation	64
3.3.1	Mass Transport	64
3.3.2	Fourier's Law and Heat Transport	68
3.4	Dimensionless Formulation	71
3.5	Boundary and Initial Conditions	71
	References	73
4	Transport Solutions	75
4.1	1D Transient Solution for the Infinite Domain	75
4.2	A Simple Numerical Model	80
4.3	Comparison Between Analytical and Numerical Solution	88
4.4	Numerical Solution Using MATLAB® pdepe	90
4.5	Example: 1D Inflow Front	93
	References	95
5	Transport with Decay and Degradation	97
5.1	Decay and Degradation	97
5.2	1D Steady State Solution	100
5.3	Dimensionless Formulation	102
5.4	Transient Solutions	108
	References	110
6	Transport and Sorption	111
6.1	Interphase Exchange	111
6.2	Retardation	117
6.3	Analytical Solution	120
6.4	Numerical Solutions	122
6.5	Slow Sorption	126
6.6	MATLAB® Animations	130
	References	132
7	Transport and Kinetics	133
7.1	Introduction	133
7.2	Law of Mass Action for Kinetic Reactions	136
7.3	Monod, Michaelis–Menten and Blackwell Kinetics	137
7.4	Bacteria Populations	138
7.5	Steady States	140
	References	145
8	Transport and Equilibrium Reactions	147
8.1	Introductory Example	147
8.2	The Law of Mass Action for Equilibrium Reactions	151
8.3	Speciation Calculations	153
8.4	Sorption and the Law of Mass Action	157
8.5	Transport and Speciation	160
	References	166

9 Ordinary Differential Equations: Dynamical Systems	169
9.1 Streeter-Phelps Model for River Purification	170
9.2 Details of Michaelis–Menten or Monod Kinetics	173
9.3 1D Steady State Analytical Solution	176
9.4 Redox Sequences	184
References	188
10 Parameter Estimation	191
10.1 Introduction	191
10.2 Polynomial Curve Fitting	193
10.3 Exponential Curve Fitting	196
10.4 Parameter Estimation with Derivatives	198
10.5 Transport Parameter Fitting	206
10.6 General Procedure	209
References	213
 Part II Advanced Modeling Using MATLAB®	
11 Flow Modeling	217
11.1 The Navier-Stokes Equations for Free Fluids	218
11.2 The Euler Equations and the Bernoulli Theorem	224
11.3 Darcy’s Law for Flow in Porous Media	228
11.4 Flow in Unsaturated Porous Media	232
References	237
12 Groundwater Drawdown by Pumping	239
12.1 Confined Aquifer	239
12.2 Unconfined Aquifer	242
12.3 Half-confined Aquifer	245
12.4 Unsteady Drawdown and Well Function	246
12.5 Automatic Transmissivity Estimation	248
References	252
13 Aquifer Baseflow and 2D Meshing	253
13.1 1D Analysis	253
13.2 1D Implementation	255
13.3 2D Implementation	257
13.4 Meshs and Grids	260
Reference	263
14 Potential and Flow Visualization	265
14.1 Definition and First Examples	265
14.2 Potential and Real World Variables	268
14.3 Example: Groundwater Baseflow and Well	270
14.4 MATLAB® 2D Graphics	273
14.5 MATLAB® 3D Graphics	278
References	279

15	Streamfunction and Complex Potential	281
15.1	Streamfunction	281
15.2	The Principle of Superposition	285
15.2.1	The Doublette	286
15.2.2	Mirror Wells	287
15.3	Complex Analysis and Complex Potential	291
15.4	Example: Vortices or Wells Systems	295
15.5	Example: Thin Objects in Potential Flow	299
	References	301
16	2D and 3D Transport Solutions (Gaussian Puffs and Plumes)	303
16.1	Introduction	303
16.2	2D Instantaneous Line Source	308
16.3	2D Constant Line Source	309
16.4	3D Instantaneous Source	309
16.5	3D Constant Source	311
	References	315
17	Image Processing and Geo-Referencing	317
17.1	Introduction	317
17.2	Reading and Display	318
17.3	Geo-Referencing	319
17.4	Digitizing	322
17.5	MATLAB® Functions	324
	References	325
18	Compartment Graphs and Linear Systems	327
18.1	Compartments and Graphs	327
18.2	Linear Systems	331
18.3	Eigenvalues and Phase Space	341
	References	346
19	Nonlinear Systems	347
19.1	Logistic Growth	347
19.2	Competing Species	350
19.3	Predator–Prey Models	356
19.4	Chaos (Lorenz Attractor)	360
	References	362
20	Graphical User Interfaces	363
20.1	The MATLAB® Guide	363
20.2	The Transport GUI	371
	References	375
21	Numerical Methods: Finite Differences	377
21.1	Introductory Example	378
21.2	Finite Differences	381
21.3	A Finite Difference Example	386

21.4	Solution for the 2D Poisson equation	389
21.5	Solution for the 2D Diffusion-Decay Equation	392
	References	393
Supplements		395
	Supplement 1: MATLAB® Data Import	395
	Supplement 2: Data Export	398
	Supplement 3: Data Presentation in a Histogram	398
	Epilogue	399
	References	400
MATLAB1 Command Index		401
Companion Software List		405
Index		407

Environmental Modeling

Using MATLAB

Holzbecher, E.

2012, XIX, 410 p. 273 illus. in color. With online
files/update., Hardcover

ISBN: 978-3-642-22041-8